

COMMAND OF AERONAUTICS
AERONAUTICAL ACCIDENT
INVESTIGATION AND PREVENTION CENTER



FINAL REPORT
A – Nº 67/CENIPA/2009

OCCURRENCE **AERONAUTICAL ACCIDENT**

AIRCRAFT **PR - MBK**

MODEL **AIRBUS A-320**

DATE **17 JULY 2007**



NOTICE

According to the Law nº 7565, dated 19 December 1986, the Aeronautical Accident Investigation and Prevention System – SIPAER – is responsible for the planning, guidance, coordination and execution of the activities of investigation and prevention of aeronautical accidents.

The elaboration of this Final Report was conducted taking into account the contributing factors and hypotheses raised. The report is, therefore, a technical document which reflects the result obtained by SIPAER regarding the circumstances that contributed or may have contributed to trigger this occurrence.

The document is not focused on quantifying the degree of contribution of the different factors, including the individual, psychosocial or organizational variables that conditioned the human performance, and interacted to create a scenario favorable to the accident.

The exclusive objective of this work is to recommend the study and the adoption of provisions of preventative nature, and the decision as to whether they should be applied belongs to the President, Director, Chief or the one corresponding to the highest level in the hierarchy of the organization to which they are being forwarded.

This Report does not resort to any proof production procedure for the determination of civil or criminal liability, and is in accordance with item 3.1, Annex 13 of the 1944 Chicago Convention, which was incorporated in the Brazilian legal system by virtue of the Decree nº 21713, dated 27 August 1946.

Consequently, the use of this report for any purpose other than that of preventing future accidents, may induce to erroneous interpretations and conclusions.

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ABBREVIATIONS

AAL	Local Airport Administration
ACC-CW	Curitiba Area Control Center
ACR	Delayed Corrective Action
AFU	Artificial Feel Unit
ALD	Actual Landing Distance
ANAC	National Civil Aviation Agency
AP/FD	Autopilot/Flight Director
APP-PA	Porto Alegre Approach Control
APP-SP	São Paulo Approach Control
AQD	Aviation Quality Database
ATIS	Automatic Terminal Information Service
ATS	Air Traffic Services
CA	Airworthiness Certificate
CBT	Computer-Based Training
CCF	Physical Capability Certificate (Medical Certificate)
CENIPA	Aeronautical Accident Investigation and Prevention Center
CFR	Code of Federal Regulations
CGH	Congonhas Airport
CHT	Technical Qualification Certificate
CIAA	Aeronautical Accident Investigation Commission
CL	Climb
CM	Registration Certificate
CPT	Cockpit Procedure Training
CRM	Crew Resource Management
CS	Certification Specifications
CTA	General Command of Airspace Technology
CVR	Cockpit Voice Recorder
DAC	Civil Aviation Department
DECEA	Airspace Control Department
DIRENG	Aeronautics' Directorship of Engineering
DOV	Operational Flight Dispatcher
DOU	Brazilian Federal Government Gazette
EADS	European Aeronautic Defense and Space Company
EASA	European Aviation Safety Agency
ECAM	Electronic Centralized Aircraft Monitoring
EMBRATEL	Brazilian Communications Enterprise
EPR	Engine Pressure Ratio
FAA	Federal Aviation Administration
FADEC	Full Authority Digital Engine Control
FBS	Fixed Base Simulator
FDR	Flight Data Recorder
FFS	Full Flight Simulator
FL	Flight Level
FWC	Flight Warning Computer
GEIV	Special In-flight Inspection Group
IAC	Civil Aviation Instruction

IAE	International Aeronautic Engines
IAM	Annual Maintenance Inspection
ICA	Instruction of the Command of Aeronautics
ILS	Instrument Landing System
IFR	Instrument Flight Rules
INFRAERO	Brazilian Airport Infrastructure Enterprise
LDA	Landing Distance Available
LW	Landing Weight
MEL	Minimum Equipment List
METAR	Meteorological Report
MFTD	Maintenance and Flight Training Device
MGM	General Maintenance-Manual
MMEL	Master Minimum Equipment List
MOA	Airport Operations Manual
MTOW	Maximum Take-Off Weight
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board
OEM	Original Equipment Manufacturer
PAIA	Annual Airport Inspection Program
PIC	Pilot-in-Command
PLA	Airline Pilot
POA	Porto Alegre Airport
POB	Persons On Board
PPAA	Aeronautical Accident Prevention Program
RA	Radio Altitude
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
RCA	Flight Attendant Report
RESA	Runway End Safety Area
REV	Reverse
RLD	Required Landing Distance
RSO	Safety Recommendation (Brazilian taxonomy after 31 October 2008)
RSV	Safety Recommendation (Brazilian taxonomy before 31 October 2008)
RTA	Aircraft Technical Report
RWY	Runway
SBPA	Location Indicator – Porto Alegre Aerodrome
SBSP	Location Indicator – Congonhas Aerodrome
SEC	Spoiler Elevator Computer
SIE	Infrastructure Subdepartment
SOP	Standard Operating Procedures
SPECI	Special Weather Report
SIC	Second-in-Command
SIPAER	Aeronautical Accident Investigation and Prevention System
SRPV-SP	Regional Flight Protection Service – São Paulo
SSCVR	Solid State Cockpit Voice Recorder
SSFDR	Solid State Flight Data Recorder
STAR	Standard Terminal Approach Routes
TAF	Terminal Aerodrome Forecast

TCU	Thrust Control Unit
TLA	Thrust Lever Angle
TWR	Control Tower
TWR-PA	Porto Alegre Control Tower
UTC	Universal Time Coordinated
VOR	VHF Omnidirectional Range Radio Beacon
WOW	Weight On Wheels

This Final Report is available
for prevention purposes only

SYNOPSIS

This report contains the conclusions of the investigation relative to the accident which involved the Airbus A-320 aircraft, registration PR-MBK, on 17 July 2007.

The investigation had the participation of accredited representatives from France, Germany and the United States of America. Peru was also invited to participate, since there was a Peruvian casualty, but it opted to follow the conduction of the investigation through the final report issued by the CENIPA.

The aircraft, which was operated by TAM Linhas Aéreas, was flying as JJ3054, and had departed from Porto Alegre (SBPA) at 17:19 local time (20:19 UTC) destined to São Paulo/Congonhas (SBSP).

The approach to runway 35L of Congonhas occurred uneventfully. The aircraft was operating with the number 2 engine reverser de-activated. The runway was wet and slippery, according to information provided by the Tower to the crew. After the touch-down, which occurred already at night-time, at 18:54 local time (21:54 UTC), the aircraft did not slow down as expected. The aircraft veered to the left, overran the left edge of the runway near the departure end, crossed over the Washington Luís Avenue and hit a fuel service station and the air cargo service building of the very operator.

All persons on board – six active crewmembers, and 181 passengers – perished. The crash also caused 12 fatalities on the ground among the people that were in the building.

The aircraft was completely destroyed as a result of the impact and the raging fire, which lasted for many hours.

AIRCRAFT	Model: AIRBUS A-320 Registration: PR – MBK	OPERATOR: TAM Linhas Aéreas S/A
ACCIDENT	Date/time: 17 JULY 2007 – 21:54 UTC Location: Congonhas Airport (SBSP) County, State: São Paulo – SP.	TYPE: Loss of Control on the Ground

1. FACTUAL INFORMATION

1.1 History of the flight

On 17 July 2007, at 17:19 local time (20:19 UTC), the Airbus aircraft, model A-320, registration PR-MBK, operating as flight JJ3054, departed from Porto Alegre (SBPA) destined to Congonhas Airport (SBSP) in São Paulo city, São Paulo State.

There were a total of 187 souls on board the aircraft, being six active crewmembers and 181 passengers, including 2 infants and 5 extra crew members (not on duty).

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

The aircraft was operating with the number 2 engine reverser de-activated, in accordance with the Minimum Equipment List (MEL).

According to information provided to the TWR by crews that had landed earlier, the active runway at Congonhas (35L) was wet and slippery.

During the landing, at 18:54 local time (21:54 UTC), the crew noticed that the ground spoilers had not deflected, and the aircraft, which was not slowing down as expected, veered 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 in which the cargo express service of the very operator (TAM Express) functioned, and with a fuel service station.

All the persons onboard perished. The accident also caused 12 fatalities on the ground among the people that were in the TAM Express 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 TAM Express building sustained structural damages that determined its demolition.

1.2 Personal injuries

Injuries	Crewmembers	Passengers	Third Parties
Fatal	6	181	12
Serious	--	--	--
Minor	--	--	--
Unhurt	--	--	--

1.3 Damages sustained by the aircraft

The aircraft was completely destroyed.

1.4 Other damages

The fuel service station convenience shop area and some of the vehicles parked there sustained severe damage. The TAM Express building sustained structural damages that determined its demolition.

1.5 Information on the flight crew involved

a. Flight hours

	PIC	SIC
Total.....	13,654:40	14,760:00
Total in the last 30 days.....	32:41	88:22
Total in the last 24 hours.....	03:13	08:22
On this type of aircraft.....	2,236:43	237:48
On this type in the last 30 days.....	32:41	88:22
On this type in the last 24 hours.....	03:13	08:22

NB: The information on the SIC flight hours refers to those effectively flown by him as a pilot. His flight hours as a Flight Engineer were not included.

b. Professional formation

No information was found relatively to the training institution where the PIC did the course to become a private pilot. His license was earned on 2 December 1975. He earned his ATP license on 23 August 1991, through the operator.

The SIC was graduated by the "Universidade Mackenzie" Aero Club of São Paulo, and earned his license as a private pilot on 11 December 1974. His ATP license was earned on 12 September 1986.

c. Validity and category of the licenses and certificates

Both pilots held airplane category ATP licenses, and possessed valid certifications for the aircraft type, as well as IFR ratings.

d. Qualification and flight experience for the type of flight conducted

Both pilots were qualified and, according to the regulation in force at the time, possessed experience for the conduction of the type of flight.

The SIC had recently been hired by the company as a captain. He did not have previous experience in the A-319/320 airplanes, and did his A-320 training (already as a captain) at the very company.

e. Validity of the medical certificate

Both pilots held valid medical certificates (CCF).

1.6 Information on the airplane

The airplane (twin-engine A-320, serial number 789) was manufactured in 1998 by the Airbus France S. A. S. It had the Airworthiness Certificate (CA) nº 17222, issued on 30 May 2007, and the Registration Certificate (CM) nº 17222, issued on 30 May 2007. Its registration category was Regular Public Transportation.

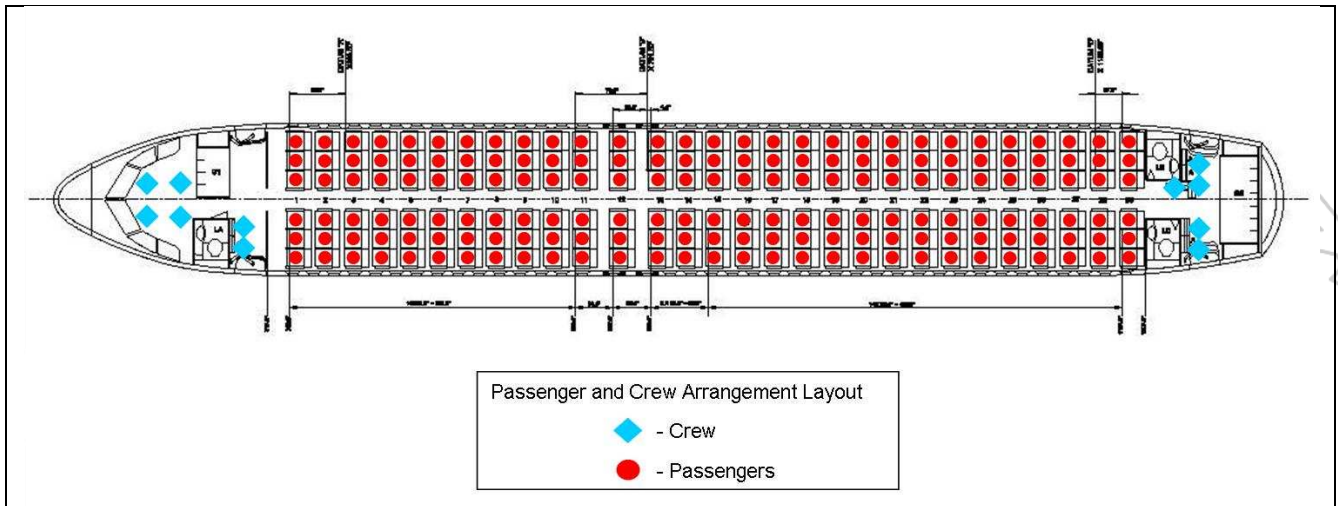


Figure 1 - Certified configuration of the aircraft

The aircraft presented a certified configuration for 174 passengers (with 29 rows of 6 seats), besides eleven crewmember seats, distributed as follows (see figure 1): 4 in the cockpit (2 for the pilots and 2 jump seats); and 7 in the passenger cabin (2 next to the left front door, 2 next to the left rear door, 2 next to the right rear door and 1 next to the right rear toilet).

TAM
Linhas Aéreas

MEL A319/A320

**MINIMUM EQUIPMENT LIST
EXHAUST**

ATA: 78

SEQ N°	ITEM	RECTIFICATION INTERVAL	NUMBER INSTALLED	NUMBER REQUIRED FOR DISPATCH	REMARKS AND / OR EXCEPTIONS
78-30	THRUST REVERSER				
30-01	Thrust reverser	C	2	0	* (O) (M) One or both may be inoperative provided: 1) The inoperative reverser is deactivated and secured in the stowed position, and no operation or procedure is predicated on thrust reversers use and 2) All stow and deploy switches circuits are operative on the inoperative reverser and 3) No REV PRESSURIZED warning is displayed on ECAM. Effectivity: All aircraft A320-214.
		C	2	0	* (O) (M) One or both may be inoperative provided: 1) The inoperative reverser is deactivated in the stowed position, and 2) Both LVDT on the inoperative reverser are checked operative and 3) No REV PRESSURIZED warning is displayed on ECAM E/WD after deactivation and 4) No operation or procedure is predicated on affected thrust reverser use. Effectivity: All aircraft except A320-214.
			2	2	For SBRJ operation it must be operative
30-02	Reverser inhibition relay switch	C	4	0	One or more may be inoperative provided the associated reverser is deactivated. Refer to 78-30-01.
30-03	Reverser indication	C	2	0	One or both may be inoperative provided the associated reverser is deactivated. Refer to 78-30-01. Effectivity: All aircraft except A320-214.
			2	2	For SBRJ operation must be operative.
30-03	T/R indication		2	2	Effectivity: All aircraft A320-214 only.
30-04	Thrust reverser shut off valve	C	2	0	One or both may be inoperative in open position. Effectivity: All aircraft except A320-231 and PT-MZM.

MEL DATE: 16/JAN/07
REV: 09
MMEL DATE: 10/JAN/07

Figure 2 - TAM MEL A-319/320, ATA 78, SEQ 78-30, item "Thrust Reverser".

The aircraft had been last overhauled (type Check C60, by the Pacific Airlines on 27 November 2006. After that, the aircraft flew a total of 2,109 hours up to the moment of the accident.

The last maintenance inspection (type Check A3) was made by the operator on its base of Porto Alegre on 13 June 2007. After the inspection, the aircraft flew a total of 409 hours up to the moment of the accident.

On 13 July 2007, the reverser of the number 2 engine was de-activated by the maintenance, due to a leakage in the inner actuator, and the aircraft was released for operation according to the MEL ATA 78, SEQ 78-30, item "Thrust Reverser", as shown in figure 2.

The procedure prescribed for operation with an inoperative reverser, which was in force on the occasion of the accident, dated from 16 January 2007.

The maintenance sector of the operator had a system of quality composed of several echelons, as prescribed in the General Maintenance Manual (MGM).

The processes of corrective maintenance would be normally initiated after the problem was reported in an appropriate form, which could be either the RTA (aircraft technical record – filled by pilots or mechanics) or the RCA (a report written by the flight attendants).

According to the RBHA (*Regulamento Brasileiro de Homologação Aeronáutica/ Brazilian Aeronautical Certification Regulation*) 43, any maintenance report shall contain a minimum of information items, namely:

"43.9 – CONTENT AND FORMAT OF MAINTENANCE REPORTS, PREVENTATIVE MAINTENANCE, RECONDITIONING, MODIFICATION AND REPAIRS (EXCEPT INSPECTIONS MADE IN ACCORDANCE WITH THE RBHA 91 AND ACCORDING TO THE PARAGRAPHS 135.411 (a) (1) AND 135.419 OF THE RBHA 135).

(a) Entries in the maintenance record. Except as prescribed in the paragraphs (b) and (c) of this section, each person making a maintenance, preventative maintenance, reconditioning, modification or repair of an aircraft, cell, engine, propeller, rotor, equipment or part of the equipment shall write an entry in the maintenance records of this equipment with the following content:

(1) A description (or reference to data acceptable by the competent authority) of the work done.

(2) The date of beginning and completion of work.

(3) The name of the person who did the work, if different from the one specified in (a) (4) of this section.

(4) If the work done in the aircraft, cell, engine, propeller, rotor, equipment or component is satisfactorily accomplished, the signature, number and type of license of the person who approved it. The signature constitutes an approval for a return to service exclusively on account of the work done.

In addition to the entry required by this paragraph, in the case of major repairs or modifications, the person who did such work must fill in a form in the manner established by the appendix B of this regulation.

(b) Each airline company operating in accordance with the operative specifications issued under the RBHA 121 and 135 that require a continued airworthiness program, shall make the entries of maintenance, preventative maintenance, reconditioning, modification and repairs in

aircraft, cells, engines, propellers, equipment or components in accordance with the applicable provisions of the mentioned regulations.

(c) This section does not apply to persons executing inspections in accordance with the RBHA 91 or with the paragraphs 135.411 (a) (1) or 135.419 of the RBHA 135."

The reports made by means of the RTA and RCA were handwritten, and there was not standardization in their composition, and reports were seen that had been written partially in English and in Portuguese, as well as ones that were unreadable, incomplete and with erasures.

Once filled in, the form would prompt an immediate corrective action at the same location where the failure occurred, provided the maintenance infrastructure was appropriate to solve the problem.

For situations in which the solution of the problem could await the conduction of more comprehensive inspections (in Congonhas or São Carlos), that report would turn into a delayed corrective action (ACR), according to the item 4.3.1 of the MGM, and these failures would start being monitored by the maintenance system of quality. This procedure prescribed the management of risk for each failure in an individual fashion, but possible associations of failures were not taken into consideration.

In either case, the RCAs and RTAs would be later forwarded to the operator's base at Congonhas or to the Maintenance Center of São Carlos, where they would be entered in the computerized control system.

The routine records containing no failure reports would not be further entered in the maintenance database.

According to information provided by the operator, several maintenance records initiated in the base of Porto Alegre were destroyed in the accident, because several RCAs and RTAs, some of them relative to the PR-MBK itself, were being transported to Congonhas, in order to be included in the maintenance database.

The operator was not able to recover all the copies of maintenance records destroyed in the accident.

It was also observed that the notification of recurrent failures and malfunctioning, prescribed in the item 4.2.2.4 of the MGM (shown below) was not being regularly forwarded to the Civil Aviation Authority.

"4.2 Maintenance Programs

...

4.2.2 Continuing Airworthiness

...

4.2.2.4 Information for Authorities and OEM

Data concerning failures, malfunctioning, defects and other occurrences capable of affecting the airworthiness and that are detected by the TAM Dependability system are forwarded to manufacturers and authorities, as described in the **Section 5 of the MGM."**

This procedure existed on account of the dispositions of the items 121.703 and 121.704 of the RBHA 121:

“121.703 – SERVICE DIFFICULTY REPORT (OPERATION-RELATED)

[(a) From 31 January 2006 on, every holder of a certificate must report the occurrence or detection of any failure, malfunctioning or defect relative to:]

...

(c) In addition to the reports required by the paragraph (a) of this section, every holder of a certificate must report any other failure, malfunctioning or defect of an aircraft occurring or being detected at any moment, if in his/her opinion such failure, malfunctioning or defect has affected or may affect the safety of the aircraft operation.

...

121.704 – SERVICE DIFFICULTY REPORT (STRUCTURE-RELATED)

(a) [From 31 January 2006 on, every holder of a certificate must report the occurrence or detection of a failure or defect relative to:]

(b) In addition to the reports required by the paragraph (a) of this section, every holder of a certificate must report any other failure or defect in the structure of an aircraft occurring or being detected at any moment, if in his/her opinion such failure or defect has affected or may affect the safety of the aircraft operation.

...”

Although the lack of some aircraft maintenance sheets were an indication of problems in the processing of the records and control of the maintenance, the maintenance services performed in the airplane were considered periodic and appropriate.

1.7 Meteorological information

Both the observed and forecast meteorological items of information relative to the route and destination, necessary for the flight, were available and presented an appropriate degree of dependability.

The weathermen were qualified for the provision of service and the pieces of equipment were calibrated and had appropriate conditions of use.

The following TAF (Aerodrome Forecast) provided a weather forecast for the Congonhas aerodrome:

TAF

*SBSP 171800 - 181800 36005KT 8000 SCT018 TEMPO 1923 7000 RA BKN008
PROB30 TEMPO 0410 3000 RADZ BR BKN004 BECMG 1214 33010KT PROB30
TEMPO 1518 4000 RA SCT010 TN15/09Z TX22/18Z RMK PGN=*

The meteorological information - METAR (Routine Aerodrome Weather Report) and SPECI (Selected Special Weather Report) – originated from the observations made in periods before and after the accident indicated that Congonhas Airport had a situation of light rain on the aerodrome, ceiling varying from 1600 to 800 feet and visibility between 8000 and 6000 meters. The wind strength remained between 12 and 8 knots, practically aligned with the runway in use (RWY 35 – direction between 320° and 350°).

The METAR available moments before the accident presented the following situation:

METAR SBSP 172100 34008KT 6000 – RA BKN009 OVC070 16/14 Q1018=

Shortly after the accident, a special observation was made, with the purpose of demonstrating the real situation at the moment of the crash. The information observed was the following:

LOCAL SBSP 172150Z 35007KT 7000 – RA BKN008 OVC070 15/14 Q1018=

Since the opening of the runway, on 29 June, up to the day of the accident, the following precipitation volumes had been recorded:

Date	Volume
12 July	0.1 mm
15 July	2,6 mm
16 July	31,7 mm
17 July	7,7 mm
Total	42,1 mm

Table 1 - Pluviometric indices.

On the day of the accident, the very aircraft PR-MBK had already landed on the main runway of Congonhas two times: the first landing was at 11:11 local time, as flight JJ3701, when the volume of precipitation recorded was 1.5 mm, and the second landing took place at 14:32 local time, as flight JJ3219, without precipitation. When the accident happened, the volume of precipitation was 0.6 mm.

1.8 Navigational aids

All the navaids of Congonhas aerodrome, such as the ILS (Instrument Landing System) were functioning as expected, according to the report of the Special In-Flight Inspection Group (GEIV), based on an inspection flight conducted one day after the occurrence.

1.9 Communication

The communications with the air traffic control units occurred uneventfully.

During the approach, the crew was informed by the controllers of the APP-SP and Congonhas Tower that the main runway was wet and slippery. This information was also conveyed through the airport ATIS (Automatic Terminal Information Service). The runway condition had been reported to the Tower by the crews that had just landed.

The local air traffic control unit, being unable to evaluate the runway conditions directly, established that the controllers had to inform the aircraft on the approach about the runway conditions reported by the crews that had landed before, according to the ICA 100-12, approved on 16 Feb. 2006 (latest updating on 5 July 2007), which reads:

“10.12 INFORMATION ON THE CONDITIONS OF THE AERODROME

10.12.1 The essential information on the aerodrome conditions is the one necessary for the safety of the aircraft operation, relative to the movement area or associated installations.

10.12.2 The essential information on the aerodrome conditions shall include:

- a) Construction or maintenance works in the area of movement or adjacent to it;*
- b) Irregular or damaged parts of the runway or taxiway surfaces, whether they are signaled or not;*

- c) *Water on the runways, taxiways or aprons;*
- d) *Parked aircraft;*
- e) *Other occasional hazards, including flocks of birds on the ground or in the air;*
- f) *Failure or malfunctioning of the whole or part of the aerodrome lighting system; or*
- g) *Any other pertinent information.*

10.12.3 The essential information on the aerodrome conditions shall be transmitted to all aircraft, except when it is known that an aircraft has already received it from other sources.

NOTE: "Other sources" includes the NOTAMs, ATIS broadcast and display of appropriate signs.

10.12.4 The information shall be transmitted early enough for the aircraft to use it, and the hazards have to be identified as clearly as possible.

10.12.5 The TWR will receive from the airport administration the information relative to the general conditions of the aerodrome, as well as any alterations capable of affecting the safety of the operations".

This practice was adopted with the beginning of significant precipitations, two days before the accident.

1.10 Information on the aerodrome

The São Paulo/Congonhas International Airport is a public airport administered by the INFRAERO (Brazilian Airports Infrastructure Enterprise). It operates day and night VFR/IFR, with an Instrument Landing System (ILS) on both thresholds of the main runway, as well as NDB, VOR/DME, approach lights, night signaling and VASIS.

It has two asphalt landing-and-takeoff runways: the main runway (17R/35L), measures 1945 x 45 meters; and the auxiliary runway (17L/35R), measures 1435 x 45 meters.

At the time of the accident, Congonhas was the busiest Brazilian airport, although its hours of operation were usually restricted to the period from 6 am to 11 pm. It operated international flights, regular domestic air transport and general aviation services.

It is located in the urban area of São Paulo County, in a densely populated zone surrounded by buildings.

As a consequence, part of the population in the vicinity of the airport was demanding the airport to be closed, on account of the noise level and the exposure to the risk of accidents, since the visual traffic, the final approaches and the climbs after departure are conducted over residential areas.

On the other hand, its privileged location has been responsible for the high demand for flights operating to and from the airport, on account of its proximity to the business centers of the city.

In order to match this high demand level with the installed capacity, a system of slots had been implemented, with criteria established in accordance with the operator and time.

Thus, Congonhas passed to the condition of monitored airport on 16 Feb. 2007 (NOTAM D0199/2007) and to the condition of coordinated airport on 27 Feb. 2007 (NOTAM D0200/2007).

According to the Flight Protection Circular (CIRPV) 63-5, "Serviço de Gerenciamento de Fluxo de Tráfego Aéreo" (Air Traffic Flow Management Service), 2005:

“1.3.1 COORDINATED AIRPORT: A monitored airport whose expected traffic demand is bigger than the adopted capacity, and, therefore, has all its landing and takeoff operations conditioned to the obtainment of an ATC Slot.

1.3.2 MONITORED AIRPORT: An airport whose expected air traffic demand reaches 80% of the adopted capacity, so that all the intentions concerning passenger regular flights and/or cargo and mail flights are conditioned to the obtainment of an ATC slot”.

With the objective of augmenting the operational capacity of the Congonhas airport, a new passenger terminal was built and the aircraft apron was reformed.

During the building of the new passengers' terminal, which lasted from August 2002 to October 2007, the lamp posts of the apron were moved closer to the runway.

In relation to the construction works, there was no previous authorization, in discordance with the article 36 of the Civil Aviation Instruction (IAC) 2328-0790 – Instructions for Concession and Authorization to Build, Homologation¹, Registration, Operation, Maintenance and Exploration of Brazilian Civil Aerodromes and Airports, dated 17 July 1990, which reads:

“CHAPTER II
On the construction work

...

Art. 36 – The modification in a public aerodrome or in its installations can only be executed by means of a previous authorization of the DAC Director-General, after the study of the need that advised the intended modification and the study of the Project.

§ 1º - “Projects of Modifications” are those which alter the physical and/or operational characteristics of the aerodrome.

§ 2º - The physical characteristics considered are those referring to the orientation, resistance, dimensions and type of pavement, declivity, elevation and geographical coordinates of the runway, as well as those referring to the location, configuration, dimensions, resistance and type of pavement of the taxiways and aircraft aprons.

...

§ 4º - The building and augmentation of edifications in the airport patrimony area are also considered “Projects of Modification.”

...

CHAPTER III
On the Homologation

Art. 37 – The homologation, modification or homologation revokement of public aerodromes is competence of the DAC.

Art. 38 – The proposals for the homologation of aerodromes or its modification (form of the Annex 4) or its revokement will be made by the ones interested through their respective COMAR, upon completion of the execution of the construction Project, modification of its physical characteristics or on account of a demand of economic order.

Sole Paragraph – The revokement or modification of the aerodrome homologation may be proposed either by the DIRENG or the DEPV to the DAC, if alterations are made in the physical or operational characteristics previously homologated or if required by the safety or the air traffic”.

Still in 2003, the Civil Aviation Department (DAC) notified the INFRAERO for the conduction of the works without previous authorization of the engineering projects. An inspection made by the DAC in October of that year found several non-conformities, mainly

¹ In the context of the IAC 2328-0790, the term “homologation” refers to a process of verification of conformance that is not linked to the certification of aerodromes, eventually established by ICAO.

on account of the creation of new obstacles on the airport, infringing the Specific Plan of Protection Zone and the Annex 14 to the Convention on International Civil Aviation, considerably affecting its operational characteristics.

In the beginning of 2005, the aerodrome of Congonhas was submitted to an Airport Inspection by the DAC, whose report, dated 4 March 2005, mentioned the following non-conformity in item 2.5:

“There is no Runway End Safety Area (RESA) in each end of the runways 17R/35L and 17L/35R.”

In the Plan of Corrective Actions (PAC) of Congonhas Airport, elaborated by the INFRAERO and forwarded to the DAC/SIE on 5 July 2005, the company informed that:

“The solution for the runway end safety areas will be evaluated or an aeronautical study will be elaborated.”

After analyzing the PAC presented by INFRAERO, the DAC issued, on 3 March 2006, the official document number 060/IE-4/02639, which said that:

“The INFRAERO will be held responsible for eventual damages or harm caused to third parties, which may result from the lack of correction of the mentioned irregularity, according to what is established in the Federal Constitution, without prejudice of the application of other pertinent penalties, in accordance with item 7.1 of the IAC 162-1001A, dated 9 November 2005”.

The deadline given by the DAC to the INFRAERO for the correction of that non-conformity was 30 August 2006, therefore, within the period of the inspecting process to be performed by the ANAC.

At the moment of the occurrence, there was no safety area for any of the Congonhas' runways. The obligatoriness of a safety area comes from the prescriptions of the Annex 14, which are presented below:

“INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES CHAPTER 1. GENERAL

1.1 Definitions

...

Runway end safety area (RESA). A symmetrical area about the extended runway centre line and adjacent to the end of the strip primarily intended to reduce the risk of damage to an aeroplane undershooting or overrunning the runway.

...

Runway strip. A defined area including the runway and stopway, if provided, which is intended:

- a) to reduce the risk of damage to aircraft running off a runway; and
- b) to protect aircraft flying over it during take-off or landing operations.

...

Stopway. A defined rectangular area on the ground at the end of take-off run available prepared as a suitable area in which an aircraft can be stopped in the case of an abandoned takeoff.

(see 1.7.2 to 1.7.4)

Code element 1			Code element 2	
Code Number (1)	Aeroplane reference field length (2)	Code letter (3)	Wing span (4)	Outer main gear wheel span (5)
1	Less than 800 m	A	Up to but not including 15 m	Up to but not including 4.5 m
2	800 m up to but not including 1 200 m	B	15 m up to but not including 24 m	4.5 m up to but not including 6 m
3	1 200 m up to but not including 1 800 m	C	24 m up to but not including 36 m	6 m up to but not including 9 m
4	1 800 m and over	D	36 m up to but not including 52 m	9 m up to but not including 14 m
		E	52 m up to but not including 65 m	9 m up to but not including 14 m
		F	65 m up to but not including 80 m	14 m up to but not including 16 m

a. Distance between the outside edges of the main gear wheels.

Note.— Guidance on planning for aeroplanes with wing spans greater than 80 m is given in the Aerodrome Design Manual (Doc 9157), Parts 1 and 2.

CHAPTER 2. AERODROME DATA

...

2.5 Aerodrome dimensions and related information

2.5.1 The following data shall be measured or described, as appropriate, for each facility provided on an aerodrome:

...

b) ...runway-end safety area: length, width to the nearest meter or foot, surface type;

...

CHAPTER 3. PHYSICAL CHARACTERISTICS

3.1 Runways

Location of threshold

3.1.5 Recommendation. — A threshold should normally be located at the extremity of a runway unless operational considerations justify the choice of another location.

Note. — Guidance on the siting of the threshold is given in Attachment A, Section 10.

3.1.6 Recommendation. — When it is necessary to displace a threshold, either permanently or temporarily, from its normal location, account should be taken of the various factors which may have a bearing on the location of the threshold. Where this displacement is due to an unserviceable runway condition, a cleared and graded area of at least 60 m in length should be available between the unserviceable area and the displaced threshold. Additional distance should also be provided to meet the requirements of the runway end safety area as appropriate.

Note. — Guidance on factors which may be considered in the determination of the location of a displaced threshold is given in Attachment A, Section 10.

...

3.5 Runway end safety areas

General

3.5.1 A runway end safety area shall be provided at each end of a runway strip where:

— The code number is 3 or 4; and

— The code number is 1 or 2 and the runway is an instrument one.

Note. — Guidance on runway end safety areas is given in Attachment A, Section 9.

Dimensions of runway end safety areas

3.5.2 A runway end safety area shall extend from the end of a runway strip to a distance of at least 90 m.

3.5.3 **Recommendation.** — A runway end safety area should, as far as practicable, extend from the end of a runway strip to a distance of at least:

— 240 m where the code number is 3 or 4; and

— 120 m where the code number is 1 or 2.

3.5.4 The width of a runway end safety area shall be at least twice that of the associated runway.

3.5.5 **Recommendation.** — The width of a runway end safety area should, wherever practicable, be equal to that of the graded portion of the associated runway strip.

Objects on runway end safety areas

Note. — See 9.9 for information regarding siting of equipment and installations on runway end safety areas.

3.5.6 **Recommendation.** — An object situated on a runway end safety area which may endanger aeroplanes should be regarded as an obstacle and should, as far as practicable, be removed.

Clearing and grading of runway end safety areas

3.5.7 **Recommendation.** — A runway end safety area should provide a cleared and graded area for aeroplanes which the runway is intended to serve in the event of an aeroplane undershooting or overrunning the runway.

Note. — The surface of the ground in the runway end safety area does not need to be prepared to the same quality as the runway strip. See, however, 3.5.11.

Slopes on runway end safety areas

3.5.8 General

Recommendation. — The slopes of a runway end safety area should be such that no part of the runway end safety area penetrates the approach or take-off climb surface.

3.5.9 Longitudinal slopes

Recommendation. — The longitudinal slopes of a runway end safety area should not exceed a downward slope of 5 per cent. Longitudinal slope changes should be as gradual as practicable and abrupt changes or sudden reversals of slopes avoided.

3.5.10 Transverse slopes

Recommendation. — The transverse slopes of a runway end safety area should not exceed an upward or downward slope of 5 per cent. Transitions between differing slopes should be as gradual as practicable.

Strength of runway end safety areas

3.5.11 **Recommendation.** — A runway end safety area should be so prepared or constructed as to reduce the risk of damage to an aeroplane undershooting or overrunning the runway, enhance aeroplane deceleration and facilitate the movement of rescue and fire fighting vehicles as required in 9.2.26 to 9.2.28.

Note. — Guidance on strength of a runway end safety area is given in the Aerodrome Design Manual, Part 1.

...

...

9. Runway end safety areas

9.1 Where a runway end safety area is provided in accordance with Chapter 3, consideration should be given to providing an area long enough to contain overruns and undershoots resulting from a reasonably probable combination of adverse operational factors. On a precision approach runway, the ILS localizer is normally the first upstanding obstacle, and the runway end safety area should extend up to this facility. In other circumstances and on a non-precision approach or non-instrument runway, the first upstanding obstacle may be a road, a railroad or other constructed or natural feature. In such circumstances, the runway end safety area should extend as far as the obstacle.

9.2 Where provision of a runway end safety area may involve encroachment in areas where it would be particularly prohibitive to implement, and the appropriate authority considers a runway end safety area essential, consideration may have to be given to reducing some of the declared distances."

Considering the fact that Congonhas was, at the time, an international airport, the lack of a RESA would be the opportunity for the ANAC to notify the ICAO about a difference regarding the prescription of the Annex 14 (in accordance with the article 38 of the Convention on International Civil Aviation). Such notification was not made. The objective of notifying the differences is to allow the other contracting States – and, therefore, the operators of those States – to have knowledge of the adopted characteristics and/or procedures that depart from the international conventions, so that appropriate preparation may take place for the operation with these differences.

The works in the parking ramp started in May 2005 and finished in September 2007. During that period, the Inspecting Agency did not conduct the special airport inspection prescribed in item 3.4.4, paragraph b, nº 6 of the IAC 162-1001A, which reads:

"3.4 CLASSIFICATION OF THE AIRPORT INSPECTION

3.4.1 The Airport Inspection is classified into two types:

...

b) Special.

...

3.4.3 The Special Airport Inspection is the one that is not in the PAIA, approved by the Chief of the SIE, covering, in the whole or in part, the areas of verification of the airport inspection listed in 3.3.1.

3.4.4 The execution of the Special Airport Inspection is conditioned to the following planning factors:

a) to attend to emergency or specific situations, at the discretion of the DAC or SERAC; and
b) in the interest of the civil aviation operational safety and/or protection against unlawful interference, it may be performed at any moment, even without previous knowledge of the main or local airport administration, in the following cases, among other ones:

...

(4) After incidents and/or accidents;

...

(6) During the execution of works".

São Paulo/Congonhas International Airport did not have the Operational Certificate prescribed in the RBHA 139, although it operated international flights and regular domestic air transport services, utilizing aircraft with a capacity of more than 60 (sixty) passenger seats.

The RBHA 139, approved by the Directive 1351/DGAC, dated 30 September 2003, published in the Brazilian Federal Government Gazette (DOU) nº 192, on 3 October 2003, including the Amendment 139-01, establishes:

“SUBPART A – GENERAL**139.1 – APPLICABILITY**

(a) *This regulation establishes norms and procedures that apply to all Local Airport Administrations which, in accordance with Section 139.101, must hold an Airport Operational Certificate, as well as to those administrations that manifest to the DAC their intention to obtain it.*

...

139.7 – OBJECTIVE

To establish procedures for the Local Airport Administration, aiming at the obtainment of the Airport Operational Certificate, according to the physical and operational characteristics specified in the Airport Operations Manual (MOA), to be elaborated in accordance with the content of the Section 139.311.

139.9 – DEFINITIONS

...

(b) *Local Airport Administration: organization or company responsible for the operation of an airport, possessing a defined organizational structure and dedicated to the management of the airport.*

...

(j) *Certified Airport: an airport whose Local Airport Administration has been granted the Operational Certificate.*

...

(q) *Certification: a process which is complementary to the process of homologation for both international and national airports, in which regular passenger air transport services are operated or are intended to be operated, utilizing aircraft with more than 60 (sixty) seats, through which the DAC, after the verifications made in accordance with the legislation in force, issues the Airport Operational Certificate to the Local Airport Administration, confirming the compliance with the operational safety requirements.*

(r) *Airport Operational Certificate: a document issued by the Civil Aviation Department (DAC), certifying that the airport operational conditions meet the operational safety requirements and the specifications of the Airport Operations Manual (MOA), upon completion of the process established in the Subpart B of this Regulation.*

...

(y) *Homologation: a process in which the DAC issues an administrative act authorizing the opening of a public aerodrome to traffic.*

...

(z) *Airport Operations Manual (MOA): a document required as part of the request for the obtainment of the Airport Operational Certificate, which defines the conditions and standards to be maintained by the Local Airport Administration in its facilities and services.*

...

SUBPART B – AIRPORT OPERATIONAL CERTIFICATION**139.101 – OBLIGATORINESS OF THE OBTAINMENT OF THE AIRPORT OPERATIONAL CERTIFICATE**

(a) *The Operational Certification is required for the Local Airport Administration responsible for the operation of international airports.*

(b) *The Operational Certification is required for the Local Airport Administration of an airport in which regular domestic air transport services are operated, utilizing aircraft with a capacity of more than 60 (sixty) passenger seats.*

...

SUBPART E – DUTIES OF THE LOCAL AIRPORT ADMINISTRATION

...

139.425 – PLANNING AND EXECUTION OF WORKS AT THE AIRPORT

*In the planning and execution of works and maintenance services, the certified Local Airport Administration **must comply with the prescriptions of this regulation and with the following aspects** contained in complementary instructions of the DAC:*

- (a) to elaborate an Operational Plan of Works and Services (POOS) to be approved by the DAC, before the beginning of any work or maintenance service;*
 - (b) to promote actions so as to ensure that no work or maintenance service jeopardize the air operations; and*
 - (c) to designate one or more duly qualified persons to be responsible for the operational safety, during the execution of the works and maintenance services.*
 - (d) Exceptionally, in case of risk for the safety of operations and in emergencies, a summarized technical report must be submitted to the DAC/SIE, justifying the intervention(s) or the work(s), in addition to being duly signed by a qualified professional.*
- (Errata 139-01, 11/Aug/04).**

SUBPART G – TRANSITORY AND FINAL PROVISIONS

139.601 – TRANSITORY PROVISIONS

- (a) Extraordinarily, the airports that fit in Section 139.1 may receive a Provisional Operational Certificate, with a validity of 12 (twelve) months, so as to allow the Local Airport Administration to meet the requirements established in this Regulation.*
- (b) The Local Airport Administrations shall, by November 27, 2003, start the process of operational certification in order to comply with the prescription of item 1.3 of the Amendment 4 of the Annex 14 to the Convention of International Civil Aviation, under penalty of facing, after this transition period, a suspension of the international air services, both regular and non-regular, and the regular domestic passenger air transport, using aircraft with more than 60 (sixty) seats."*

The Amendment 4, mentioned in the RBHA 139, had its text incorporated in the very Annex 14 to the Convention on the International Civil Aviation in its 4th edition (2004). That item, currently number 1.4 of Annex 14, determines that the States must certify the aerodromes utilized for international operations in accordance with the specifications of that Annex from November 27, 2003 on, as can be understood from the original text:

"1.4 Certification of aerodromes

Note. — The intent of these specifications is to ensure the establishment of a regulatory regime so that compliance with the specifications in this Annex can be effectively enforced. It is recognized that the methods of ownership, operation and surveillance of aerodromes differ among States. The most effective and transparent means of ensuring compliance with applicable specifications is the availability of a separate "Safety" oversight entity and a well-defined safety oversight mechanism with support of appropriate legislation to be able to carry out the function of safety regulation of aerodromes.

1.4.1 As of 27 November 2003, States shall certify aerodromes used for international operations in accordance with the specifications contained in this Annex as well as other relevant ICAO specifications through an appropriate regulatory framework.

*1.4.2 **Recommendation.** — States should certify aerodromes open to public use in accordance with these specifications as well as other relevant ICAO specifications through an appropriate regulatory framework.*

1.4.3 The regulatory framework shall include the establishment of criteria for the certification of aerodromes.

Note. — Guidance on a regulatory framework is given in the Manual on Certification of Aerodromes.

1.4.4 As part of the certification process, States shall ensure that an aerodrome manual which will include all pertinent information on the aerodrome site, facilities, services, equipment, operating procedures, organization and management including a safety management system, is submitted by the applicant for approval/acceptance prior to granting the aerodrome certificate."

The entry of the formal request relative to the operational certification of Congonhas Airport in the ANAC occurred on 16 May 2008.

As the airport was not certified, it did not possess an Airport Operations Manual approved by the regulatory organization, prescribed in the Subpart D of the RBHA 139, which reads:

SUBPART D – AIRPORT OPERATIONS MANUAL (MOA)

...

139.309 – REVISIONS AND APPROVALS OF THE AIRPORT OPERATIONS MANUAL

...

(b) As soon as possible, the Local Airport Administration shall submit any alteration to be made in the MOA to the DAC/SIE for approval.

(c) The process of revision and/or modification of the MOA shall be submitted to the DAC/SIE to be formally evaluated. The DAC/SIE, after the analysis of the proposed alteration, shall reply in writing concerning the phases prescribed in Section 139.201.

(d) The MOA and its alterations are approved, provided they meet the requirements established in this Regulation and in complementary instructions, after a thorough analysis of their content in relation to the norms and procedures defined in Section 139.5.

139.311 – CONTENT OF THE AIRPORT OPERATIONS MANUAL

The MOA, besides containing the items of information listed below, shall comply with the complementary instructions of the DAC, DECEA and DIRENG, considering the peculiarities applicable to the airport:

...

(b) Characteristics of the Airport

(3) Airport Specifications

...

(ii) Length, width and type of pavement of the runway and taxiways, runway end safety area (RESA) and stop-way;

...

(c) Operational Safety Procedures

...

(8) Operational Safety Measures regarding the Execution of the Works. The procedures for the planning and execution of construction and maintenance works (including works of an emergency character) in the area of movement or its surroundings and that may interfere in the protection zone, comprising:

(i) Communication with the air traffic control during the execution of the works;

(ii) Names, telephone numbers and function of the persons or organizations responsible for the planning and execution of the works, for contact at any moment; and

(iii) Names and telephone numbers of the supervisors of the airline companies and auxiliary services who must be notified in relation to the works".

Another consequence was that there was not an Operational Plan of Works and Services (POOS) approved by the regulatory agency prior to the beginning of the works in the parking ramp. The elaboration of this plan is prescribed in the item 5.5.8, paragraph “c” of the IAC 139-1001 – Airport Operations Manual, approved by the Directive DAC N° 531/DGAC, dated 2 June 2004, which deals with the elaboration, approval, control, execution, and inspection of the Airport Operations Manual (MOA), establishing important aspects concerning the operational safety procedures, which must be written in the Manual, namely:

“1 PRELIMINARY PROVISIONS

1.1 PURPOSE

To guide the Local Airport Administration in relation to the elaboration of the MOA (Airport Operations Manual), defining its physical characteristics, in addition to the operational conditions and administrative procedures, as well as establishing complementary requisites for the inspection and control by the Civil Aviation Department.

...

5 CONTENT OF THE MOA

...

5.5 OPERATIONAL SAFETY PROCEDURES

This chapter shall contain the following items:

...

h) operational safety measures for the execution of the works;

...

5.5.7 MAINTENANCE OF THE MOVEMENT AREA

This item shall contain:

...

b) post/function of the person responsible for the oversight and for the actions to be taken in the maintenance of the movement area, showing in the list of posts and functions with specific responsibilities in the MOA (according to the example of Annex 5), the name, identity number and issuing organization, income tax number, responsibilities and means of contact, during and outside the administrative working hours of the airport;

c) the description of the system of pavement status monitoring, if implemented;

...

i) the procedures of corrective maintenance to be adopted whenever a depression is observed on the landing runway allowing the water to form a film thicker than 3 mm (three millimeters) on the surface of the pavement, which, according to the ICAO Doc. 9137, Part 2, item 2.4, is the critical depth for aquaplaning;

...

n) procedures of corrective maintenance (immediate removal, before the operation can be reestablished) to be adopted whenever the accumulation of rubber exceeds 95% (ninety-five percent) of the touchdown zone;

o) procedures of corrective maintenance (rubber removal) to be adopted whenever the contamination by rubber in the touch down zone pavement exceeds 40% (forty percent) of the area of the touchdown zone, within 12 m to each side of the runway centerline, with a maximum deadline of 120 (a hundred and twenty) days, from the date of the notification by the internal inspection of the movement area; and

p) procedures of corrective maintenance to be adopted whenever the measured value of the wet friction coefficient is smaller than the minimum friction coefficient established for the airport.

5.5.8 OPERATIONAL SAFETY MEASURES FOR THE EXECUTION OF WORKS

This item shall contain:

...
c) *guidance for the elaboration of the Operational Plan of Works and Services (POOS) for approval by the DAC, before the beginning of each maintenance work or service, in accordance with the RBHA 139 and IMA 58-5, including, at least:*

...
- *procedures of inspection upon completion of the work or services, relative to the operational safety conditions of the spot concerned;*
d) *procedures for the handing of the POOS to the DAC, for approval; and*

...
5.5.8.3 *The NOTAM of the interdiction of the airport component can only be cancelled after its homologation and certification."*

In the years preceding the accident, the runway had been the reason of continuous complaints on the part of the pilots, on account of problems related to operations in rainy conditions, mainly due to the risk of aquaplaning.

Aquaplaning is technically defined as a condition in which the hydrodynamic support force developed between the tread and the fluid which covers the rolling surface equals or surpasses the normal reaction of the vehicle weight that actuates on the tread.

In other words, aquaplaning occurs when the water penetrates the space between the rotating tire and the pavement, and such penetration causes the formation of water pressure, which expands the area of the tire without contact with the runway. The pressure increases with the speed of the aircraft, more and more supporting the tire, up to a critical speed, known as "aquaplaning speed", in which the tire begins to be supported solely by the water, thus losing all friction contact with the pavement.

Relatively to the effects of the pavement texture on the friction and aquaplaning, two terms are commonly used to describe the paved surface: microtexture and macrotexture.

The microtexture refers to the roughness produced by minute individual aggregated particles that compose the pavement surface. These particles are not immediately perceived by the eye, but they become obvious when touched, being similar to fine sandpaper. The microtexture provides the friction properties to aircraft operating at low speeds. Good microtexture furnishes a good level of penetrability for the tire to cross the residual water film which lingers after the main mass of water has drained.

The macrotexture, in turn, refers to the visible roughness of the pavement surface as a whole, being responsible for the friction properties for aircraft operating at high speeds. The main function of the macrotexture is to provide paths for the water to flow off from under the tires. This draining characteristic gets more important as the speed of the aircraft increases, the depth of the tread diminishes, and the thickness of the water layer increases.

Together, they furnish friction properties to the aircraft in their wide speed spectrum during landing and takeoff. Both properties are essential for the obtainment of surfaces resistant to skidding.

The looks of the texture, however, may be deceiving. A surface with a rough look may offer adequate draining grooves for the water to flow off, but the fine aggregate of the pavement may consist of round mineral grains not ground which end up being polished by the aircraft traffic, causing the pavement surface to become slippery when wet. Likewise, a surface with a less rough look, which may even present a bright appearance when wet, will not necessarily be slippery, if it has good microtextural properties.

Under aquaplaning conditions, longer distances are necessary for the aircraft to stop, and it is possible to lose directional control of the aircraft, which presents a higher sensitivity to cross-winds. The most common types of aquaplaning are: reverted-rubber, dynamic, and viscous.

The reverted-rubber aquaplaning results from the locking of the tire during the braking, something that generates a big amount of heat. This heat changes the water which is in the grooves of the tire to vapor, and the resulting pressure in the area of contact between the tire and the runway ends up lifting the tread, thus practically reducing the friction coefficient to zero. The generated heat also reverts the rubber vulcanization process, causing the surface to become sticky.

The dynamic aquaplaning, in turn, normally occurs at higher speeds, over a layer of standing water with a thickness of 1/10 of an inch or more. During this type of aquaplaning, the water cannot flow off through the tire grooves, and the wheel rotates without any traction, literally on a layer of water. By and large, the dynamic aquaplaning has short duration, since the conditions for its occurrence are extreme and are associated with the speed of the aircraft, the accumulation of water and the inappropriate macrotexture of the runway.

Differently from the dynamic type, the viscous aquaplaning occurs when a thin layer of water – whose thickness is in the order of hundredths of millimeters – covers the runway. The water functions as a lubricant, due to its viscosity properties, making the runway slippery and generating hydrostatic pressures which may lift the tires from the ground, causing them to slip.

This type of aquaplaning may occur at low speeds (during taxi, for example,) and with several tire pressures, with a possibility of directional control loss, while drastically reducing the efficiency of the brakes. The likelihood of the occurrence of a viscous aquaplaning increases if the runway does not meet the macrotexture minimum requirements, making the water drainage more difficult and, consequently, favoring the formation of a film. Thus, it is seldom observed on rough pavements or pavements with grooving.

The cutting or formation of grooves on an existing pavement or on a new one is a proven and effective technique for the obtainment of resistance to skidding and prevention of aquaplaning during rainy weather. The function of the grooving is to facilitate the drainage of the water, preventing the formation of a film that would aggravate the risk of aquaplaning. The grooves are transversal, with a depth and width of about 6 millimeters.

In November 2005, the pavement of the main runway (treated with grooving) was replaced with a rugged pavement.

According to information provided by INFRAERO, the work done aimed at reestablishing the desired levels of friction along the most critical segments of the runway, thus guaranteeing its operational safety, mainly on account of the proximity of the rainy period and the constant complaints of the users, until a definitive solution could be implemented, to recover the whole runway pavement, including the correction of the transversal and longitudinal declivities.

Provisionally, as an emergency response, a conventional solution was adopted (pavement milling) with a later installation of a new layer of asphaltic concrete with dosage and texture adequate for the obtainment of the resistance and friction characteristics required.

At the time, the recuperation of the asphaltic cover in the two most critical segments of the landing runway (600m x 30m, next to the threshold 17R, and 300m x 30m, next to the threshold 35L) was considered by the INFRAERO the most operational and technically viable solution.

For the definition of the dosage (proportion of ingredients) of the asphaltic concrete, laboratory technological essays were made for the verification of the compliance with the parameters required by the regulation.

After the approval of the mixture, two experimental segments in the service area of the aerodrome were covered with distinct granulometric characteristics, so as to evaluate the conditions of the mixture in the field, verify the obtainment of the parameters required through the collection of samples and analyses in the laboratory, and make measurements of the friction in order to see whether the desired values were obtained.

The measurement of the friction in the segments already finished showed acceptable values, coherent with those of the experimental segment.

This type of pavement did not keep the original qualities, and a few months later the runway again started to show friction problems. Besides, the problems of declivity continued hindering more efficient water drainage during occurrence of heavy rain.

Then, in spite of the services done months before, various NOTAMs were issued, beginning in January 2006 and continuing all along that year, alerting about the characteristics of the ruggedness and the low friction of the Congonhas main runway, as well as its condition of being slippery when wet.

In the first months of 2006, two incidents occurred which involved regular air transport aircraft, and the runway conditions were considered contributing factors. Among the safety recommendations (RSV) issued by the Aeronautical Accident Investigation and Prevention Center (CENIPA) to the INFRAERO, as a result of the investigations, the following ones are highlighted:

RSV (I) 13 / A / 06 – *With the objective of allowing an adequate planning of the operations on the runway 17R/35L of SBSP, by the various aircraft, the Congonhas airport administration shall publish, by means of NOTAM, all the modifications related to the “friction requisites” and “surface texture” of that runway, based on the dispositions of the IAC 4302, dated 28 MAY 2001;*

RSV (I) 14 / A / 06 – *To comply with the prescriptions of the “caput” of Chapter 2 – CHARACTERISTICS OF THE SURFACE OF THE LANDING AND TAKEOFF RUNWAYS, in accordance with the paragraph 2.1 – FRICTION REQUISITES, items 2.1.1 e 2.1.2, of the Civil Aviation Instruction – IAC 4302, dated 28 MAY 2001;*

RSV (I) 15 / A / 06 – *To promptly initiate the appropriate corrective actions, aiming at recovering the adequate friction level for the operations at SBSP, under both normal and adverse meteorological conditions, fully observing the prescriptions of item 2.1.3 of IAC 4302, dated 28 MAY 2001.*

On 10 April 2006, at the premises of Congonhas Airport, representatives of the ANAC, Airspace Control Department (DECEA) and INFRAERO had a meeting with the objective of identifying the mitigating measures to be adopted by the Local Airport Administration (AAL), in coordination with the Local Air Traffic Control, seeking to preserve the safety of operations at the 17L/35R runway, in case water gathered on the its surface. The meeting minutes nº 02-RJ/SIE-ANAC (IE-3)/06, produced by ANAC (tables 2 and 3) and transcribed below, presents the results of the meeting.

MEETING MINUTES NATIONAL CIVIL AVIATION AGENCY <u>INFRASTRUCTURE SUPERINTENDENCE</u>	
SUBJECT	MEETING MINUTES Nº 02-RJ/SIE-ANAC (IE-3)06

Mitigating measures – Runway 17R/35L Congonhas Airport	Start: 10.00 Finish: 14.00 Date: 10/Apr/2006
<p>Representatives of the ANAC, DECEA and INFRAERO participated in a meeting in the premises of Congonhas Airport (SBSP), and signed the list attached. The objective of the meeting was to identify mitigating measures to be adopted by the Local Airport Administration – AAL, in coordination with the Local Air Traffic Control Unit, aiming at preserving the safety of operations on runway 17R/35L, in the case of occurrence of water on its surface.</p>	
DECISION/ACTION	ORGANIZATION IN CHARGE (DEADLINE)
<p>1- The representative of ANAC read the Minutes of the previous meeting, held in the premises of the ANAC in Rio de Janeiro, on 05/Apr/2006.</p> <p>After informing about the main objective of this meeting, the representative of the ANAC, presented the following proposals of mitigating measures to the audience:</p> <ol style="list-style-type: none"> 1. in case of flooding <ol style="list-style-type: none"> a. suspension of operations 2. in case of wet runway, the air operator shall: <ol style="list-style-type: none"> a. act in accordance with the ACFT's Manual of Operations. <ol style="list-style-type: none"> i. Application of the wet runway performance graph; ii. to place as a requisite in the landing information the maximum weight admissible for the wet runway condition. b. have the following items of equipment in working order: <ol style="list-style-type: none"> i. Anti-skid; ii. Auto-brake (if installed); iii. All thrust reversers. 3. Actions by the AAL: <ol style="list-style-type: none"> a. Definition of the procedures to determine the wet/flooded runway condition; b. Optimize the frequency for the rubber removal and friction measurement. 4. Local Air Traffic Control Unit: <ol style="list-style-type: none"> a. ATIS information; b. maintain close integration with the AAL to identify the water film formation; c. role of the Local Air Traffic Control Unit in wet runway conditions and suspension of operations; 5. Action by the crew after landing: 	
Page 1 of 3	

Table 2 - Meeting Minutes nº 02-RJ/SIE-ANAC (IE-3)/06

DECISION/ACTION	ORGANIZATION IN CHARGE (DEADLINE)
a. To report the aircraft braking performance; Note: It would be desirable that the control of operations kept a record of the reports.	

2 – As a preliminary action, the ANAC and DECEA will evaluate the need to correct the declared distances, mainly in relation to the clearway of both thresholds.	ANAC / DECEA (24 APR 06)
3 – INFRAERO shall evaluate the latest measurement of the friction coefficient of the 17R/35L runway and request the updating of the NOTAM in force, in case there are, for segments of runway more than 100 m long, friction values lower than the maintenance level (0.50), in accordance with the IAC 4302, dated 28/May/01.	INFRAERO (17 APR 06)
4 – In case of rain, the AAL shall, by means of visual inspection and measurement of the water film, evaluate the runway conditions as for the presence of water accumulation, providing the Local Air Traffic Control with the information about a wet/flooded runway. The AAL shall, also, provide this information to the control centers of the airlines at the Congonhas Airport in order to ensure full knowledge of the situation by the operators. To make weekly measurements of the runway friction coefficient, monitoring the results for dissemination through NOTAM, also providing for the removal of rubber whenever necessary.	INFRAERO (17 APR 06)
5 – The AAL shall detail and document, in coordination with the Local Air Traffic Control, the procedures aforementioned, forwarding them to the ANAC and DECEA for purposes of information.	INFRAERO (17 APR 06)
6 – The Local Air Traffic Control Unit, after receiving the information from the AAL about wet/flooded runway condition, shall pass the information to the operators, besides inserting it in the ATIS.	Local Air Traffic Control Unit
7 – ANAC will request the issuance of a NOTAM, containing the following words, which were agreed on by the audience: “A special procedure is in force at Congonhas concerning the condition of wet runway. The operators must comply with the procedures listed in the manuals, publications and applicable legislation”.	ANAC
8 – The airline operators shall comply with the procedures for wet runway operation, observing the NOTAMs in force for Congonhas Airport, the information of wet/flooded runway, obtained through the Local Air Traffic Control Unit and ATIS, as well as through the respective control centers of the airline companies located at the Airport. Also, they shall report the aircraft braking action performance for dissemination and knowledge by the other operators.	Airline Operators
9 – The ANAC, in coordination with the DECEA and the INFRAERO shall call a meeting with the airline operators of Congonhas Airport to consolidate and deliberate about all the procedures to be implemented at the Congonhas Airport.	ANAC/DECEA/ INFRAERO (19 APR 06)

Table 3 - Meeting Minutes nº 02-RJ/SIE-ANAC (IE-3)/06

The weekly measurement of the friction coefficient for the main runway surface pavement, an action that had been listed among the mitigating measures deliberated in the meeting between ANAC, DECEA and INFRAERO, revealed a serious deficiency in the first third of the thresholds, on account of the high degree of rubber accumulation on the pavement.

This problem was due to a high deposition of rubber from the aircraft tires on the surface pavement, resulting from the large number of operations and from the difficulty to remove the rubber through the usual processes of maintenance, since there was intense concentration of the material in some stretches of the runway.

Due to problems in the bid process for the runway recovery works, a re-texturization service was done as a palliative measure, in the months of October and November 2006.

The re-texturization is an abrasive process, carried out by means of the launching of steel granulation with high pressure, whose application was approved only after the conduction of studies and tests at the airport for the confirmation of the effectiveness of such technology.

The services contracted referred to the texturization of an area of 54,000 m² and had the objective of providing the runway with technical characteristics sufficient for the obtainment of the friction coefficients necessary to guarantee safety of operation.

After the re-texturization service, the friction coefficients of the main runway reached values above the established minimums. The runway, however, continued showing problems of water accumulation, on account of its irregular surface.

Despite the RSV 13/A/06, issued by the CENIPA on the 11 April 2006 and forwarded to the INFRAERO, there are not records of a NOTAM with the coefficients of friction and surface macrotexture of the main runway after the service of re-texturization. Nonetheless, on 26 December 2006, a warning about the slippery condition of the runway when wet was published again (NOTAM D1912).

MEETING MINUTES NATIONAL CIVIL AVIATION AGENCY <u>AIRPORT INFRASTRUCTURE SUPERINTENDENCE</u> MINUTES N° 06-RJ/SIE-GGCO/06	
DELIBERATIONS	
The SIE shall propose the DECEA Sub Department of Operations authorization for coordination procedures between the São Paulo Regional Flight Protection Service and the São Paulo/Congonhas Airport Administration, concerning the temporary suspension of takeoff and landing operations for the measurement of the water film on the aforementioned runway, maintaining it impracticable in case it is considered contaminated (in accordance with the IAC 121 – 1011 – Takeoff Traction (Power) Adjustment Procedures).	
The Management of Aircraft Evaluation Standards shall give priority to the elaboration and procedures regarding the approval of a Supplementary Instruction to the RBHA 121, section 189, containing instructions for the dispatch and operation on a wet runway.	
The INFRAERO Congonhas shall establish the procedures for the expeditious measurement of the water film on the runway in question, as well as its drainage, whenever there are precipitations of rain capable of flooding the runway or part of it. At the same time, it shall seek to establish the relationship between the depth of the water film and the pluviometric index of the moment.	
By 15 January 2007, the Airline Companies shall provide the Management of Aircraft Evaluation Standards with the data listed in the sheet distributed during the meeting by Captain Gilberto Schitinni (see copy attached).	
Rio de Janeiro, 13 November 2006.	

Table 4 - Deliberations written in the meeting minutes n° 06-RJ/SIE-GGCO/06.

According to the information provided by the “Superintendência de Infra-estrutura da ANAC”, the ACTION/DECISION n° 9 described in the meeting minutes (table3) was performed eight months later, on 13 December 2006.

On the occasion, in accordance with the meeting minutes n° 06-RJ/SIE-GGCO/06, a representative of the ANAC informed the operators that the Agency was elaborating a Supplementary Instruction for the RBHA 121 (ISR), relative to the operations with a wet runway.

Among the deliberations made on that occasion, the following ones are highlighted:

“The Management of Aircraft Evaluation Standards will prioritize the elaboration and procedures for the approval of a Supplementary Instruction to the RBHA 121, section 189, with instructions for the dispatch and operation with a wet runway.

The INFRAERO at Congonhas shall establish the procedures for the expeditious measurement of the water film on the main runway of the airport in question, as well as its drainage, whenever there is precipitation of rain capable of flooding the runway or part of it. At the same time, it will seek to establish the relationship between the depth of the water film and the pluviometric index of the moment.”

On 28 December 2006, representatives of the ANAC, INFRAERO, DECEA, SRPV-SP (Regional Flight Protection Service of São Paulo), Congonhas AAL and various regular aviation operators gathered for a meeting at the CENIPA's premises to discuss the problems affecting the conditions of operation in Congonhas, mainly during rainy weather.

On the occasion, the ANAC presented a Supplementary Information draft of the RBHA (IS-RBHA) 121-189, the purpose of which would be to present instructions for the dispatch and operation of jet aircraft on a wet runway.

The draft, although having never been officially approved by the ANAC, was published on the official website of the Agency in the beginning of the 2007, and was removed from that page a few weeks later.

4 CONTAMINATED RUNWAY – OPERATIONAL RECOMMENDATIONS

IF THE RUNWAY IS CONTAMINATED, AND CONSIDERING THAT THERE ARE NOT PERFORMANCE DATA IN SUCH A CASE, TAKEOFF AND LANDING OPERATIONS MUST BE DISCONTINUED UNTIL THE RUNWAY IS AGAIN FREE FROM THE CONTAMINATION.

5 WET RUNWAY – OPERATIONAL RECOMMENDATIONS

5.1 OPERATIONS

To insert parts related to the operation on wet runway in the training program and provide training to the pilots.

To prepare specific instructions for the pilots, concerning the operation on a wet runway, with emphasis on certain airports which, on account of their physical characteristics, may be considered as special airports (e.g., SBRJ and SBSP).

5.2 OPERATIONS ENGINEERING

The operations engineering of the Operator must:

Do the analyses of the runway for operation on a wet condition, and keep the results available for the pilots and for the operational dispatch;

To prepare the MEL of the operator, presenting the restriction for operation on a wet runway with inoperative antiskid and/or reverser.

To observe whether, on account of particular characteristics of the airplane, other systems which are relevant for braking the plane (such as lift dumpers and/or spoilers) should be included in the MEL for operation on a wet runway.

Table 5 - Operational recommendations of the draft Supplementary Instruction

Table 5 shows some of the operational recommendations proposed in the draft.

Besides presenting the reversers as a requirement for the operation on a wet runway, the text of the draft also brings guidance for the pilots, favoring the understanding that they have to confirm the opening of the spoilers for the activation of the reversers.

The subject dealt with by this draft Supplementary Instruction was only regulated on the 31 March 2008, with the issuance of the IAC 121-1013, concerning the “Technical-

Operational Procedures and Requirements for the Operation in Congonhas Airport” (Airline Company – RBHA 121).

As a result of meeting held on the 28 Dec 2006, a number of safety recommendations were issued by CENIPA, some of which are highlighted below:

RSV (A) 271 / A / 06 – CENIPA - The SRPV-SP shall promptly suspend the operations at the 17R/35L runway, whenever there is a precipitation of rain (of any intensity) on the vertical of the SBSP aerodrome.

RSV (A) 272 / A / 06 – CENIPA - The SRPV-SP shall instruct the APP-SP so that adverse meteorological conditions affecting the SBSP aerodrome be promptly broadcast through the VHF frequency, highlighting whether the runway is dry or wet.

RSV (A) 273 / A / 06 – CENIPA - The INFRAERO AAL-SBSP shall measure and evaluate the conditions of the runway, right after the suspension of the operations at the SBSP 17R/35L runway by the SRPV-SP, on account of meteorological factors (precipitation of rain), in order to reestablish the operations, whenever it is verified that neither water film nor water patches exist on the runway.

RSV (A) 274 / A / 06 – CENIPA - The ANAC shall coordinate a work group aiming to establish procedures and define parameters to be utilized for the evaluation of the runway conditions in case of precipitations of rain. A deadline of thirty days is defined for the publication of the procedures and parameters.

5.3 OPERATIONAL DISPATCH

The operational dispatch of the Operator shall:

Make sure that the airplanes dispatched have their systems and equipment ready to operate on wet runways when rain is forecast.

...

5.5 GUIDANCE FOR THE CREW

When the runway at the airport is contaminated, the Captain must:

- Wait for the de-contamination of the departure runway. For landing, the aircraft must proceed to the alternate aerodrome, if it is not possible to wait for the de-contamination.

When the runway of the aerodrome of departure is wet, the crew must:

- Make sure that the airplane has all necessary systems in operational condition, mainly the reverser, anti-skid, auto-brake, etc.
- Be sure that the weight of the plane is appropriate for the existing conditions.

...

When the runway of the destination aerodrome is wet, the crew must:

...

- Consider proceeding to an alternate aerodrome with better meteorological conditions on account of the conditions of the plane and of the runway (weight, systems in operation, contaminated runway, etc.)

...

- After touching down, confirm the opening of the ground spoilers and apply the maximum reverser as soon as possible

Table 6 - Operational recommendations of the draft Supplementary Instruction

In compliance with the RSV (A) 274/A/06 – CENIPA, an operational agreement was set by representatives of INFRAERO (HQ, Regional and Congonhas), SRPV-SP and ANAC, for the verification of the runway conditions under rain, which is described below:

“PARAMETERS AND PROCEDURES FOR THE EVALUATION OF THE CONGONHAS AIRPORT RUNWAY 17R/35L CONDITIONS IN CASE OF PRECIPITATION

The words listed below have the following meanings in this document:

Stretch – a segment corresponding to $\frac{1}{4}$ of the total length of the landing and takeoff runway, described as 1st quarter, 2nd quarter, 3rd quarter or 4th quarter, measured from the threshold in operation.

Moist stretch – the surface presents an alteration in its color due to the presence of a small amount of water.

Wet stretch – the surface is soaked with water, but there are not water patches.

Stretch with pools of water – the surface presents pools of water, either contiguous or not, with a water film equal to or thicker than 3 mm.

Contaminated stretch – the surface presents pools of water, either contiguous or not, with a water film equal to or thicker than 3 mm.

Light rain (up to 5 mm/h or 0.8 mm/10 min) – rain precipitation capable of making a runway stretch become moist and, depending on the duration, making the stretch wet or causing the formation of water patches.

Moderate rain (from 5.1 to 25 mm/h or from 0.9 to 4 mm/10 min) – rain precipitation capable of making a stretch become wet and, depending on the duration, may cause the formation of water patches.

Heavy rain (from 25.1 to 50 mm/h or from 4.1 to 8 mm/10 min) – rain precipitation which causes the formation of water patches and, depending on the duration, may cause the stretch to become contaminated.

Procedures in case of precipitation:

In case of heavy rain on any stretch of the landing and takeoff runway, the Local Air Traffic Control Unit (TWR-SP) shall immediately suspend operations.

When the intensity of the precipitation is reduced to moderate or light, the Local Airport Administration (AAL) shall conduct an inspection of the runway, providing the TWR-SP with information about the conditions of each one of the four stretches, detailing whether they are moist, wet, with pools or contaminated.

In case there is a contaminated stretch, the operations on the runway considered will remain suspended until a new measurement done by the AAL shows that the condition of the contaminated stretch(es) has changed due to the water being drained. If there is not a contaminated stretch, the operations shall be resumed.

In case of moderate rain, the TWR-SP shall suspend the operations when the intensity reaches 3 mm/10 minutes.

The AAL shall carry out an inspection of the landing and takeoff runway regarding the situation of the pavement in the presence of water. After the measurement, the AAL shall provide the TWR-SP with information about the condition of each one of the four stretch(es) of the runway relatively to the presence of water.

In case of confirmation of a contaminated stretch, the operations will remain suspended, until a new measurement done by the AAL shows that the draining of the water has changed the condition of the contaminated stretch (es). If there are not contaminated stretches any longer, and the intensity of the precipitation is below 3 mm/10 min, the operations shall be resumed.

In case of continuous light rain, the TWR-SP shall discontinue the operations, so that the AAL can carry out inspections 60 min and 120 min after the beginning of the precipitations.

The AAL, based on the two evaluations mentioned in 2.3, which were conducted during the occurrence of continuous light rain, may propose the period for the next verification to the TWR-SP.

Notwithstanding the information transmitted by the AAL, the TWR-SP shall suspend the operations to allow an inspection of the runway, immediately after receiving information from any aircraft concerning difficulties with the directional control during landing or takeoff operations, which may attributed to the presence of water on the runway.”

The ICA 100-12, approved on 16 February 2006 reads:

“2 DEFINITIONS AND ABBREVIATIONS

2.1 DEFINITIONS

IMPRATICABLE AERODROME

An aerodrome whose runway practicability has been impaired on account of an abnormal condition (crashed aircraft on the runway, flooded runway, pavement in poor condition, etc.), determining the suspension of landing and takeoff operations.

INTERDICTED AERODROME

An aerodrome whose security conditions (arrival and departure of presidential aircraft, military operations, internal order, etc.) determine the suspension of landing and takeoff operations.

...

MANEUVERING AREA

The section of an aerodrome reserved for the landing, takeoff and taxi of aircraft, excluding the aprons.

...

3 RULES OF THE AIR

3.1 COMPETENT AUTHORITY

3.1.1 The following items belong to the competence of the Director-General of the Airspace Control Department:

...

c) Suspension of operations at an aerodrome on account of meteorological conditions, interdiction and impracticability of its maneuvering area, by means of the ATC units;...”

Starting on January 2006, and throughout the year, several NOTAMs were issued (D0035, D0363, D0702, D1149, D1154, D1462 and D1912), warning about the characteristics of rugosity and the low friction coefficients of the Congonhas main runway, as well as its slippery condition when wet.

On 29 January 2007, in replacement of the NOTAM alerting of a slippery runway, the NOTAM D0104 was issued, this time warning of the possibility of a water film buildup as a result of rain precipitation. This alert was in force until 16 May 2007.

SBSP D0104/2007 NOTAMR - SBSP D1912/2006

Q) SBBS/QMRXX///000/999/

A) SBSP - SAO PAULO/CONGONHAS, SP

B) 29/01/07 20:42

C) 25/07/07 00:00

E) RWY 17R/35L SUJEITA A FORMACAO DE LAMINAS DE AGUA QUANDO DA
OCORRENCIA DE PRECIPITACAO PLUVIOMETRICA EM CONSEQUENCIA: OPR CK COND
PERFORMANCE CADA TIPO ACFT
DT EXPED : 29/01/07 20:42:00
STATUS: CANCELED BY D0804/2007
ORIGEM: 13/CGN/290107

SBSP D0804/2007 NOTAMC - SBSP D0104/2007

Q) SBBS/QMRXX////000/999/
A) SBSP - SAO PAULO/CONGONHAS, SP
B) 16/05/07 19:00
E) RWY 17R/35L CNL INFO DIVULGADA
DT EXPED : 16/05/07 19:00:00
STATUS : CANCELED
ORIGEM : D179/CGN/160507

In the first semester of 2007, both landing runways of Congonhas underwent pavement repair work, according to the object of the engineering services contract of INFRAERO nº 041-EG/2007. First the secondary runway was repaired, and then the main runway.

On account of the great importance of this airport in the context of the regular transport in Brazil, during the time the repair work was in progress, changes were made to the airport operation schedule, in order to minimize the impact of the necessary runway interdictions, as follows:

Period	Frequency	Working hours
27 Feb thru 14 May	Daily	05:30P to 00:30P
15 May thru 28 June	Monday thru Friday	05:30P to 24:00P
	Saturdays	06:00P to 23:00P
	Sundays	07:00P to 24:00P

Table 7 - Congonhas Airport operation schedule

The repair work of the main runway started on 14 May, and the runway was reopened for operations on 29 June, without the grooving prescribed in the respective project.

There was not, on the part of the ANAC, any special airport inspection during the repair works on the landing runways (an inspection prescribed in item 3.4.4, paragraph (b), nº 6 of the IAC 162-1001).

The Operational Plan of Works and Services (POOS) relative to the contract 041-EG /2007-0024, dated 18 May 2007, was not submitted to the ANAC, for approval, in discordance with what is prescribed in the item (a) of the section 425, RBHA 139.

That POOS did not establish the inspecting procedures to be performed upon completion of the work or service, regarding the operational safety conditions of the area affected (prescribed by the paragraph (c) of the item 5.5.8, IAC 139-1001). Consequently, no inspection of the main runway was made either by the INFRAERO or by the ANAC, to formally attest its operational condition after the completion of the works, so that the runway could be opened for the operation.

After the reform of the main runway, neither the homologation nor the certification prescribed by the item 5.5.8.3, IAC 139-1001, was made, since, according to the

understanding of the INFRAERO and of the ANAC (manifested respectively by means of the document CF Nº 20168, dated from 19 Sept. 2007, and the Official Document Nº 183/DIR-AGB/2008), there had not been alteration of the physical characteristics of the runway.

The return to operation of the main runway occurred on account of the expiration of the NOTAM D1039/2007 (issued on 27 June 2007), which was the last one to inform about the works:

SBSP D1039/2007 NOTAMR - SBSP D1038/2007

Q) SBBS/QMRLC/IV/NBO/A /000/999/

A) SBSP - SAO PAULO/CONGONHAS, SP

B) 27/06/07 20:27 C) 29/06/07 15:00

E) RWY 17R/35L CLSD DEVIDO WIP

DT EXPED : 27/06/07 20:27:00

STATUS : TERM VAL

ORIGEM : 226/CGN/270607

No significant precipitations were observed from the reopening of the main runway for operations up to the 14 July, and the aerodrome operated in dry runway conditions during that period.

Since 15 July (Sunday), abundant rain had started making operations difficult, and a number of pilots reported slippery runway conditions.

In face of these reports, the local air traffic control unit resorted to the procedure established in January 2007, suspending the operations and requesting INFRAERO to verify the runway conditions.

The reports of the pilots during those three days and the provisions adopted are summarized in table 8 to 10 below:

15 July 2007			
Time	Flight	Report made to the TWR	Provision made
06:05 to 10:05	39 landings. No report was made of the runway condition.		
10:10	-	Slippery runway informed by aircraft. INFRAERO was requested to verify runway conditions.	INFRAERO supervisor informed verification was not necessary, and it was not performed.
10:23 to 22:49	247 landings. No report was made of the runway condition.		

Table 8 - Reports made by pilots and provisions made relative to 15 July 2007.

Along the 15 July, virtually the first day of operation under rain since the completion of the runway pavement works, the reports concentrated on the morning period, and no need was felt to discontinue the operation and verify the runway conditions.

As can be seen, several reports were made regarding the runway conditions between the days 15 and 17, and even an accident involving a regular transport aircraft occurred on the 16.

16 July 2007			
Time	Flight	Report made to the TWR	Provision made
06:04 to 06:55	14 landings. No report was made of the runway conditions.		

07:20	GOL 1879	Runway not “that good”, little adhesion	TWR informed INFRAERO.
07:29	TAM 3020	Runway “slightly slippery”.	
07:32 to 11:13	76 landings. No report was made of the runway conditions.		
11:17	TAM 3461	“runway slippery”.	Information forwarded to the INFRAERO
11:24	GOL 1203	Runway “a lot slippery”.	
12:25 to 12:28	The INFRAERO requested to make inspection of the runway on account of the reports. The inspection was made by the person in charge of the apron (B4) who informed that there were no water patches.		
11:27 to 12:17	19 landings. No report was made of the runway conditions.		
12:19	TAM3006	Runway ‘rather slippery and aquaplaning’.	-
12:21 to 12:23	2 landings. No report was made of the runway conditions.		
12:23 to 12:26	INFRAERO requested verification of the runway on account of the various reports. The INFRAERO Ramp Inspector (B4) verified the runway conditions, informing the “inexistence of water patches or films”. The operations on the main runway were resumed.		
12:26 to 12:40	2 landings. No report was made of the runway conditions.		
12:42	PTN4763	...(Accident with the ATR-42-300, due to aquaplaning).	Runway interdiction up to 13:02 P.
13:34 to 13:44	4 landings. No report was made of the runway conditions..		
13:48	TAM 3215	Reported runway slippery and difficulty stopping the aircraft.	-
13:48 to 13:57	2 landings. No report was made of the runway conditions.		
13:57	GOL 1968	Runway slippery.	-
13:59 to 14:53	11 landings. No report was made of the runway conditions.		
14:56	VRG 2422	Runway slippery.	-
14:59	GOL 1265	Runway slippery.	-
15:02 to 17:52	54 landings. No report was made of the runway conditions.		
17:52	TAM3108	Informed runway a lot slippery.	-
17:52 to 18:22	6 landings. No report of the runway conditions was made.		
18:22 to 18:29	Runway verification conducted by INFRAERO, which reported runway was in operational condition.		
18:30 to 23:57	84 landings. No report of the runway conditions was made.		

Table 9 - Reports from pilots and provisions made on 16 July 2007.

On the day of the accident, the operations were suspended at 17:07 local time, and the INFRAERO reported the same conditions of the day before: runway wet with water being drained, without formation of water patches. The main runway was reopened for operation at 17:20 local time.

Since the reopening of the runway by the AAL (at 17:20P) up to moments before the accident (which occurred at 18:48P), twenty landing operations were carried out on runway 35L, all of them by large size aircraft, including four A-320 and four A-319 airplanes.

17 July 2007			
Time	Flight	Report made to the TWR	Provision made
06:04 to 17:01	206 landings. No report of the runway conditions was made.		
17:04	GOL 1697	Runway slippery.	Operation suspended on main runway, and

		water film measurement requested.
17:07 to 17:20	INFRAERO Ramp Inspector verified the runway conditions, informing "inexistence of water patches on the runway". Main runway operations resumed.	
17:26 to 18:48	25 landings. No report of the runway conditions was made.	

Table 10 - Reports from the pilots and resulting provisions relative to the 17 July 2007.

On the day after the accident, the Engineering Directorship of the Aeronautics (DIRENG), in compliance with a determination of the Commander of the Aeronautics after a request by CENIPA, took measurements of the friction coefficient (with the use of Mu-meter) and of the depth of the macrotexture (through the "sand patch" method).

The IAC 4302 – Requisites of Resistance to Skidding for Landing and Takeoff Runways, dated 29 May 2001, reads:

"CHAPTER 1 – PRELIMINARY PROVISIONS

1.1 OBJECTIVE

To define friction and surface texture requisites for landing and takeoff runway pavements resistant to skidding, and to establish procedures for the continuous monitoring of the evolution of such requisites, aiming at implementing preventative and corrective measures to guarantee appropriate friction levels for the landing and takeoff runways regarding air operations, under both normal and adverse meteorological conditions.

1.2 APPLICABILITY

The requisites and procedures established in this Instruction are recommended by the Civil Aviation Department (DAC) to all national aerodromes, and have compulsory application at civil aerodromes in which regular domestic and international air transport aircraft operate.

1.3 RESPONSIBILITY

It is the duty of the Airport Administration to observe and apply the standards and requisites established in this IAC.

...

CHAPTER 2 - SURFACE CHARACTERISTICS OF THE LANDING AND TAKEOFF RUNWAYS

The landing and takeoff runway pavements of Brazilian aerodromes must be built and maintained so as to meet the friction and surface texture requisites of skidding resistance to skidding recommended in this Instruction, thus preventing the loss of aircraft directional control and braking capability, when operating on wet runways.

2.1 FRICTION REQUISITES

- 2.1.1 *For purposes of application of this Instruction, it is considered as maintenance level the friction level value of 0.50, except in the case of airports which have special plans of maintenance, in which the maintenance level is considered the one defined in those plans.*
- 2.1.2 *The least admissible value for the average friction of any pavement segment with more than 100 m in length, measured in accordance with the methodology established in this Instruction, shall not be smaller than the maintenance level.*
- 2.1.3 *Whenever a segment of more than 100m presents a friction level smaller than the maintenance level, the Airport Administration shall make the following provisions: (1) to request the issuance of a NOTAM containing information that the runway is slippery*

when wet; and (2) to promptly initiate the appropriate corrective actions aiming at reestablishing the required friction level.

2.2 SURFACE TEXTURE REQUISITES

- 2.2.1 The average depth of a landing and takeoff runway pavement macrotexture, measured in accordance with the methodology presented in this Instruction, shall not be less than 0.50 mm, or another specific value established by a special maintenance plan. Appropriate corrective actions must be taken whenever those levels are not reached.
- 2.2.2 The recommended average macrotexture depth for a new pavement is 1 mm.

CHAPTER 3 - MONITORING OF THE SURFACE CHARACTERISTICS

3.1 FRICTION MEASUREMENT

3.1.1 Equipment to be utilized

The measurements of the friction coefficients of landing and takeoff runways shall be taken with the Mu-Meter continuous measurement equipment, containing a water sprinkling system.

...

3.1.3 Measurement Spots on the Runway

The measurements of the friction coefficients of the landing and takeoff runways must be taken along the entire runway in both directions, in parallel alignments, at a distance of 3 m to each side of the runway centerline.

3.2 SURFACE TEXTURE MEASUREMENT

3.2.1 Recommended Methods

The measurements of the pavement surface texture shall be taken based on volumetric essays. It is recommended to use the "sand patch" or "grease patch" methods, described in Annex 1 to these Instructions.

3.2.2 Measurement Spots

The measurements of the surface texture shall be taken every 100m of the runway, in spots located 3 m from the centerline, alternately to the left and to the right, with the first measurement spot located at 100 meters from one of the thresholds.

3.2.3 Measurement Frequency

The texture measurements shall be taken whenever friction measurements are, in accordance with the table established for the friction measurements in this Instruction.

CHAPTER 4 – FINAL PROVISIONS

- 4.1 The execution of the landing and takeoff runway pavement friction and surface texture measurement tests is responsibility of the Airport Administrations.
- 4.2 The Airport Administrations shall forward to the DAC Sub Department of Infrastructure (SIE/DAC) the results obtained in the tests done after the construction, recovering and maintenance, or periodic evaluation of the conditions relative to the landing and takeoff runway pavement friction.
- 4.3 The SIE/DAC will pass information to the Electronics and Flight Protection Directorship (DEPV) about the results obtained in the tests, so that the complementary information relative to the Runway Friction Coefficient (RFC), contained in the Aerodrome Charts (ADC) can be updated.
- 4.4 The maintenance service of the landing and takeoff runway pavements shall be done in such a way that there is the least interference with the air operations at the airport.
- 4.5 Landing and takeoff runways which require special characteristics of skidding resistance to skidding in their pavements for the assurance of operations safety, will have specific requisites concerning friction and surface texture, as well as specific

monitoring procedures, prescribed in special maintenance plans approved by the DAC."

On 19 July, the DIRENG took measurements of the friction coefficient every 3 m, to the right and to the left of the runway centerline. This measurement showed an average friction coefficient of 0.62.

On that same day, 'sand patch' essays were performed every 3 m, to the right and to the left of the runway centerline, and the resulting average depth of the macrotexture was 0.35 mm.

Later, on 26 July, new measurements were done, this time with a bigger battery of essays, at 3 m and 9 m, to the left and to the right of the runway centerline, showing an average depth of 0.42 mm.

According to the Technical Report made by the DIRENG, the macrotexture of the Congonhas main runway pavement surface was below the recommended levels in 78% of the points essayed.

In the Technical Report 95805-205 of the Instituto de Pesquisas Tecnológicas – IPT (Technological Researches Institute), dated 27 July 2007, there are records of the essays performed by the INFRAERO on the main runway, with the utilization of the Mu-meter equipment, on 6 July and 13 July 2007.

On 06 July 2007, the friction coefficient presented in the essay was 0.65, on a longitudinal average of 3 m to the right of the central axis of the runway, and 0.70, to the left.

On 13 July, the results obtained were 0.68 and 0.73, respectively.

In the IPT report afore mentioned, there are also the results of the macrotexture measurements, without mention of the dates on which they were taken. For these measurements, it was verified that for a 7 m central strip of the runway, the average value was 0.63 mm, therefore above the minimum established by the IAC 4302, but below the values recommended by the same IAC for a new pavement.

According to information provided by INFRAERO, these measurements were taken between the months of June and July 2007.

At the second meeting of the CIAA, held at the premises of the CENIPA on 2 October 2007, preliminary analyses of the FDR data presented by technicians of the aircraft manufacturer concerning the braking action, from the first contact with the runway pavement on the touchdown point until the runway excursion, raised the possibility of occurrence of skidding in two segments of the path of the aircraft, each one approximately 50 m long, on the left lateral edge of the runway, on the horizontal marking of the runway edge. Performance calculations made by the very manufacturer showed, however, that the lack of deceleration was on account of the lateral markings of the runway.

The INFRAERO forwarded to the Commission, by means of the CF No 41/SBSP(SPAF)/2007-R, dated 19 November 2007, the Report on the Standard Paint INFRAERO NBR 8169, which attested the conformity of the paints utilized for the horizontal markings with the specifications established in the Congonhas runway pavement recovery project. The report had been elaborated by the *Hot Line Indústria e Comércio Ltda*, and dated from 27 July 2007, therefore, after the reopening of the runway for operations. This goes against the prescription of item 3.3.4.3 of the INFRAERO document of works (code SÃO/GRL/900 ET-247/R2, sheet 210), which requires the presentation of the award before the application of the paint:

"The application shall not be started before the presentation of the paint award, issued by a recognized organization, considering the lot approved, according to the item 3.3.5.1."

According to the FDR data relative to the aircraft braking performance, no evidence of aquaplaning was found.

1.11 Flight recorders

The airplane was equipped with a Solid State Flight Data Recorder, SSFDR Honeywell, P/N 980-4700-003, S/N 6029, capable of recording 50 hours (TSO C124a / ED55), and with a Solid State Cockpit Voice Recorder, SSCVR L3 Communications (former Fairchild), P/N 93A100-80, model A100, S/N 0503, capable of recording 30 minutes in 4 channels.

The readout of both recorders was made at the headquarters of the *National Transportation Safety Board* (NTSB), in the United States, and was witnessed by the persons in charge of this investigation.

The FDR data was validated during the preflight control checks and also during the flight, relatively to the parameters of the aircraft speed.

It was verified that the CVR exceeded the limits of tolerance regarding the exposure to high temperatures established by the manufacturer. Nevertheless, both recorders were readable and had their data retrieved in full, something that was of great importance for the investigation.

In the data of the CVR, it was observed that the "RETARD" auto call-out was announced three times before the nose gear touched down the runway.

According to the data obtained from the CVR and FDR, three seconds after the nose gear touched down the runway, there was a sudden lateral change of course, a moment at which the CVR recorded the first reaction of the pilot in relation to an abnormal situation.

A little before landing, the FDR recorded the motion of the engine number 1 thrust lever, initially to the "IDLE" position and, after the touchdown, to the "REV" position. As for the thrust lever of the engine number 2, no motion was observed, with the FDR showing that it remained in the "CL" position.

The recordings of the FDR relative to the engines indicate that, after landing, the left engine decelerated to 1.03 EPR, while the right engine accelerated to 1.18 EPR. These parameters are compatible with the recordings of the lever positions described above.

The lack of deflection of the ground spoilers was also recorded, as well as the non-actuation of the autobrakes. The Anti-Skid system, in turn, functioned normally, preventing the blocking of the main gear wheels during the braking.

According to the FDR, the speed of the airplane at the touchdown was 142 knots. At the moment of the impact, it was 96 knots.

During the previous leg, while landing at Porto Alegre, the FDR also recorded that the crew accurately performed the procedures established in the MEL/MMEL for the operation with a de-activated reverser.

Among the relevant pieces of information obtained by means of the CVR, the following ones are highlighted: before landing, there was a certain concern on the part of the captain with the condition of the runway on account of the rain; the pilots were aware that engine number 2 had a pinned reverser; and the SIC verified that there was no deflection of the ground spoilers.

The CVR revealed that the “RETARD” auto call-out sounded even when the left lever was moved to the “IDLE” position, when the airplane was crossing 10 feet (radio altimeter) on the approach for landing. It was also observed that when one of the levers was placed in “REV” and the other one was in “CL”, the “RETARD” auto call-out was deactivated by the system.

In accordance with the A-320 design, the purpose of the “RETARD” auto call-out is to remind the pilots (flying with the autothrust engaged) that both levers must be placed in the “IDLE” position.

1.12 Information on the impact and wreckage

The accident occurred just outside Congonhas airport, with the aircraft veering to the left during the run after landing, overrunning the left edge of the runway near the departure end, crossing over the Washington Luís Avenue and colliding with a gas station and with the first floor of a building where a cargo depot of the very aircraft operator was run, at the coordinates 23°37' 11" S and 046°39' 44" W.

The collision of the aircraft occurred at a ground speed of 96 kt, at an angle of 7° roll to the left and a 7° positive pitch. With the impact, the aircraft was completely destroyed and the wreckage was concentrated in an area of about 100 m².



Figure 3 - Wreckage of the aircraft at the site of impact.

The retractable type landing gear was locked in the extended position, and the flaps were also completely extended (landing configuration).

In order to extinguish the fire and take the bodies away, several parts of the aircraft were removed.



Figure 4 - Aerial view of the site of impact.

1.13 Medical aspects

Both pilots had physiological health parameters within acceptable standards, in accordance with the Health Check-up Regulatory Instructions and the specialized medical literature.

During the last thirty minutes of flight, the PIC commented about having a mild headache, but he did not make it clear whether the headache was already present before the flight started. It was not possible to determine the type of the headache, whether tension-related, blood pressure-related, migraine-related, cluster, or any other type of primary headache.

According to the medical sector of the operator, there was not any information in the medical records of the PIC relative to headaches. It was found that in April 2004, the pilot had presented a condition of light to moderate depression, which seemed to have resulted from a failure in the simulator check ride. In September of the same year, the pilot was declared capable by the special health board, and resumed his activities.

The operator informed that the medical service had, at the time, the objective of complying with legal working-demands, thus not getting directly involved with the individual cases of the employees. That was the reason why the PIC was not monitored in the company.

As for the SIC, nothing was found in his medical records that might be relevant for this investigation.

The necropsy awards were dispensed with, due to the condition of the remains, which, as already described, did not allow any analysis to be done.

1.14 Information on the fire

The collision of the airplane with the buildings caused a raging fire, which lasted more than 24 hours, and was hard to be fought by the city's firefighting teams.

Because the aircraft had performed a tankering in Porto Alegre, at the moment of the impact it was carrying a significant amount of fuel, which made it very hard for the firefighters to do their work. The fire ended up severely damaging the aircraft and the buildings with which it collided, burning several of the bodies of victims aboard.

1.15 Aspects of survival and/or evacuation from the aircraft

Due to the impact of the aircraft with the buildings, there were no survivors.

1.16 Exams, tests and researches.

Exams were made in the wreckage of the Artificial Feel Units (AFU) with the purpose of verifying the existence of failures in their quadrants and gears, as well as marks that could confirm the relative position of the thrust levers at the moment of the impact, considering the possibility of a failure of the mechanism that connects the thrust levers to those units.

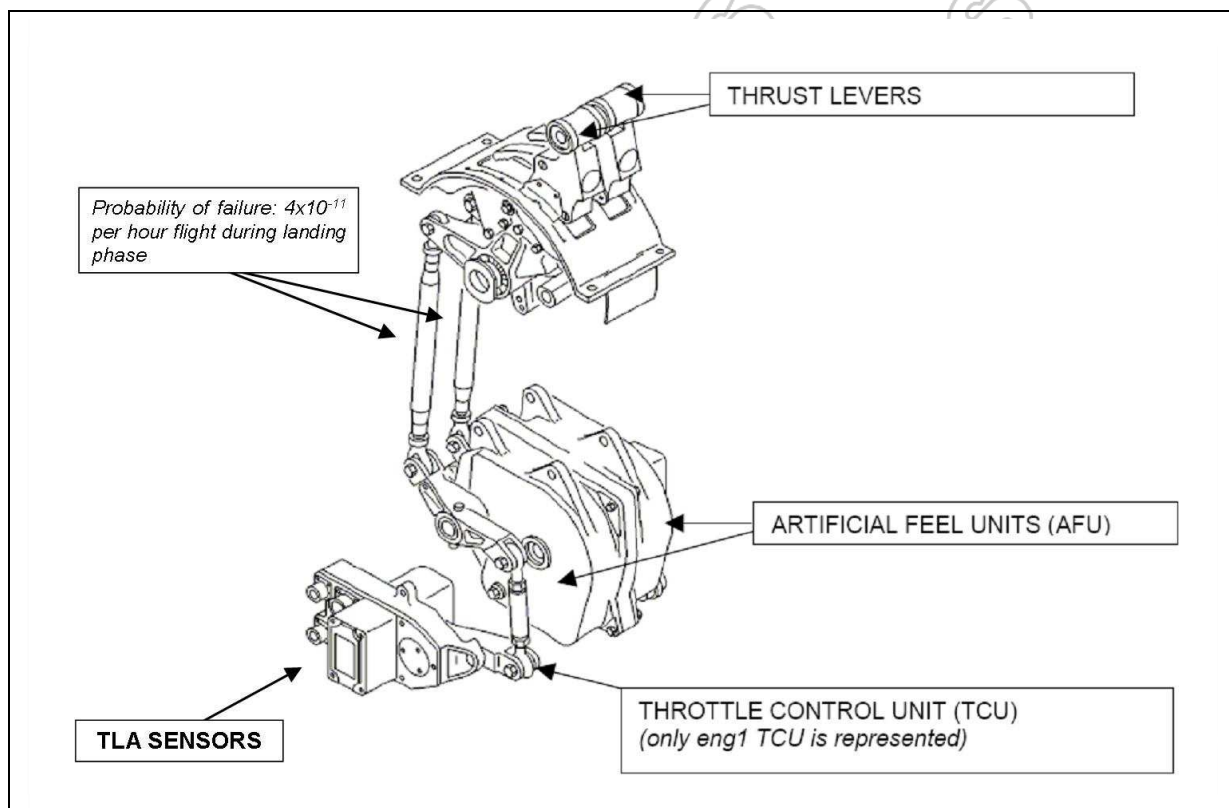


Figure 5 - Scheme of the power control system.

According to information provided by the aircraft manufacturer, the probability of a failure of the mechanism that connects the thrust levers to the AFUs is 4×10^{-8} per flight hour, and the probability of the failure to occur at the moment of the landing is 4×10^{-11} per flight hour. The sensors that record the position of the thrust levers in the flight data recorder (FDR) are located in the AFUs and not directly in the thrust levers.

The aluminum structure of the units was found melted due to the heat of the post-accident fire. In the midst of the melted aluminum mass were the gears and the quadrants made of steel.

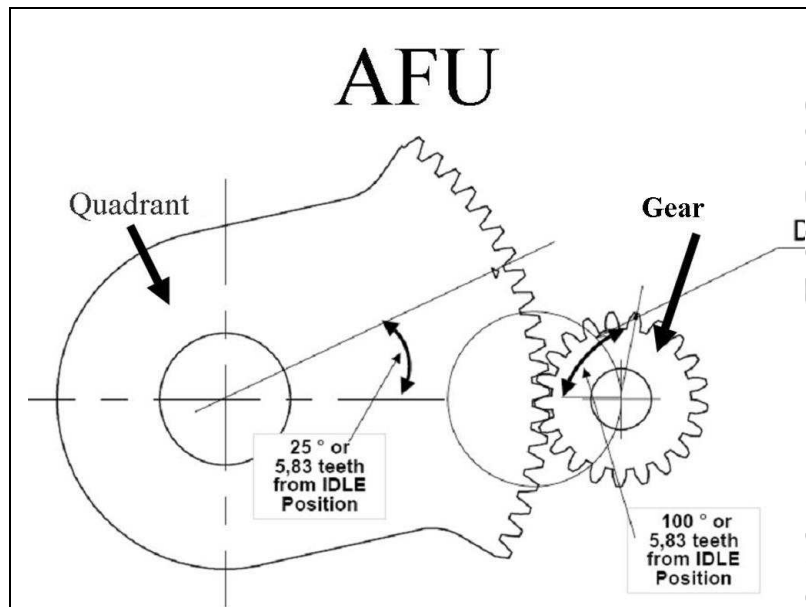


Figure 6 - Quadrant and gear of the AFU.

Initially, the wreckage of the AFUs was sent to the General Command of Airspace Technology (CTA), in São José dos Campos, São Paulo State, where the X-ray exams were conducted. These exams did not reveal any evidence that could allow identifying the position of the thrust levers at the moment of the impact.

Later, the AFU was forwarded to the laboratory of an enterprise of the European Aeronautic Defence and Space Company (EADS) group in Bordeaux, France, to be submitted to 3D tomography exams. On account of the high degree of destruction of the AFUs, such exam did not provide information that could describe either the working condition of the units, or the position of the gears and quadrants at the moment of the accident.

Lastly, back to the laboratories of the CTA, the melted aluminum was removed from the AFU, and a stereoscopic exam was made. The results of this exam did not show any evidence of failures in the gears or in the quadrants, nor any marks that could provide information on the position of the thrust levers at the moment of the accident.

Visual exams conducted by the manufacturer of the engines (IAE - International Aero Engines) in the wreckage of the two V2527E engines of the aircraft, showed that both of them were operating with the power coherent with the selection of the thrust levers recorded in the flight data recorder at the moment of the impact.

It was also observed that the reverser of the number 1 engine was activated, while the reverser of the number 2 engine was not, a situation which was coherent with the aircraft maintenance report, which informed that the reverser of the number 2 engine was de-activated. The exams did not reveal evidence of defects or malfunctioning of the engines prior to the impact.

A total of 23 approaches and landings for the Congonhas runway 35L were conducted by the investigating team in the A-320 aircraft simulator located in Guarulhos. The equipment was adjusted to a configuration similar to the one of the accident aircraft (same weight, same center of gravity). To simulate the inhibition of the reverser in the simulator, a configuration of reverser breakdown was used. As for the operation of the aircraft, procedures were used for the re-creation of the pilots' actions recorded in the FDR, as well as variations of those procedures. Both wet and dry runway parameters were used.

As a result of the several procedures, it was observed that:

- the repetition of the pilots' actions, in the way that they were recorded by the FDR, led to the same result of the accident, including the positions and speeds at which the aircraft left the runway and collided with the buildings;
- although not prescribed by the manufacturer, the two go-around attempts done in the simulator were successful, about 15 seconds after the main gear touched down the runway;
- in a procedure simulating the landing at Congonhas with a wet runway, with the thrust levers at "IDLE" (without the use of the reversers) and without ground spoilers, the aircraft stopped at the limit of the runway, just with the application of manual braking.

The RETARD auto call-out did not always operate as prescribed.

Despite the simulator limitations, the results of the simulations were compatible with the data recorded in the aircraft FDR.

Also, 6 simulations of the accident were conducted by the investigators at the headquarters of the manufacturer in Toulouse. It was verified that the simulation of a landing with the left reverser activated and with the right hand side thrust lever in the position "CL" ("Climb"), under wet runway conditions, did not allow the aircraft to stop within the limits of a runway similar to the one of Congonhas. In addition, it was observed that when the aircraft was provided with the FWC standard H2F3 produced by the manufacturer (advising the pilots about an inappropriate setting of the thrust levers for landing), the same simulation had a different result, with the crew being alerted in time to reduce the lever inadvertently left at "CL", and the aircraft stopped within the limits of the runway.

The visual exams made in the wreckage of the aircraft did not show evidence of failure or malfunctioning in the brakes or tires that could justify the dynamic of the accident.

1.17 Organizational aspects

1.17.1 Introduction

In order to raise the aspects related to the organizational culture and climate, actions were taken, such as: visits of the organizations involved, interviews with employees either formally invited by the CIAA or indicated by the companies, field researches, and analysis of documents made available to the CIAA. The field researches included interviews with other employees of the organizations involved (those employees were not the same ones formally interviewed, but were approximately as many as). They agreed to participate in the interviews and collaborate with the investigation on a voluntary basis, after being assured that the Commission was committed to not revealing their identities.

The results of this study reflect the most important impressions gathered by the CIAA, and despite their subjectivity, are perfectly valid for the purposes of accident prevention. Some aspects which did not denote a significant representability were discarded. Any reference to the emotional climate in the cockpit of the accident aircraft results from a hypothetical construction, based on the context raised by the Commission.

1.17.2 Aviation scenario

In the period preceding the accident, the civil aviation system in Brazil was going through a rather sensitive moment, marked with flight delays and cancellations, overcrowding the waiting lounges of the main Brazilian airports.

Through the mass media, there was criticism of the adequacy regarding the investment policies in the aviation sector, as well as criticism of the operation of the civil aviation regulatory agency (ANAC). There were allegations of interference and pressure from a number of State sectors, exacerbating the passengers' dissatisfaction, which in the end was transferred to the airport administrations' and airline companies' employees.

During this period, there were even occurrences of aggression against check-in clerks and of threats against pilots, on account of passengers fed up with cancellations and delays of their flights. Such hostile climate generated enormous pressure on the crews of the regular aviation, who had to work under strong tension. In the specific case of this operator, the fact that the captain and one of the flight attendants had to wait at the door of the aircraft (a procedure adopted by the company) contributed to exacerbate the tension.

Congonhas – specifically – the busiest airport in the country, had been receiving severe criticism for some years, because of the serious problems associated with the operation in rainy weather, due to the low friction coefficients and accumulation of water on the runway as a result of the unevenness of its surface. Several occurrences of aquaplaning were reported, some of them involving regular passenger transport aircraft.

The situation as a whole was seen as more critical in the operation of a few specific aerodromes - Congonhas, Navegantes, Ilhéus, Vitória and São José do Rio Preto – which were considered troublesome and even dangerous by the regular aviation pilots, as could be learned from some of the interviews.

There were problems of communication between the various systems of the aeronautical infrastructure related to the civil aviation (airport operation, air traffic service provision, regulation and inspection, as well as air operator) which hindered the solution of the issues presented in this report.

1.17.3 Within the operator

The first weeks of 2007 were marked by interruptions in the operations of Congonhas due to the accumulation of water on the runways, causing flight delays and, consequently, inconvenience to passengers. The need to urgently reform the runways was already known, at least since 2005, but only palliative measures were taken before the adoption of the definitive solution in 2007.

During this period, the pilots, in general, when confronted with runway problems, would just report them to the tower in an informal way after the confirmation of landing. It was observed that many pilots regarded this information as sufficient for the necessary measures to be taken.

Such attitude on the part of the pilots denotes a lack of knowledge of the fact that the airport administration (and not the air traffic control agency) was the one responsible for the runway operating conditions and, consequently, for the management of the associated problems. Besides, the shortage of formal reports relative to the operational condition of the runway when wet reflects the existing distance between the crews and the operator's SIPAER-Link ("Safety").

Adding to this scenario, the gradual diminution up to the cessation of the activities of another big company, which had entered a process of judicial recovery, had left, according to the operator, a vacuum in the market that began to be occupied by the other companies, something that generated a moment of growth, which encouraged the operator to order more aircraft.

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.

Taking into account the yearbooks issued by the regulatory agency in the period 2003-2007, one can see that the operator had a growth of 110% in the volume of flight hours, 30% in its fleet, 115% in the number of pilots and 160% in the number of flight attendants.

According to field researches, there was some concern with the tendency of the operator in expediting the qualification process of the crews, possibly on account of the need to place them quickly in the operational line to meet the demand.

Thus, the intention was to analyze the evolution of the operator's training program, by comparing the version that was initially approved by the regulatory agency (Revision 1), dated 7 May 2001, with the version adopted at the time of the accident (Revision 3). It is worth highlighting that the final approval of the training program was granted in the Revision 4 on 14 November 2007.

It is worth pointing out that the regulations establish a minimum training requirement, leaving to the operator the responsibility of adjusting the training program to its real needs in operational terms, on account of the complexity of the operation, in order to make it safer.

Although the CIAA requested a copy of the Revisions 1 and 3 of the pilot training program, by means of the official document no 2/PRES-CIAA/663, dated 17 March 2009, it only received the Revision 6, dated from 1 August 2008, therefore, elaborated after the accident.

By means of the official documents no 5/PRES-CIAA/818, dated 30 March 2009, and no 6/PRES-CIAA/844, dated 3 April 2009, the CIAA tried to solve contingent doubts in the understanding of the official document no 2, requesting again the Revisions 1 and 3, and suggesting a new deadline for the documents to be handed. However, the documents requested were not provided by the Agency.

The operator, on the other hand, provided a copy of the training program in force at the time of the accident, but informed that it did not have the Revision 1 issue (which had granted the initial approval).

Although the lack of access to the Revision 1 of the program hindered an analysis of the training process utilized by the company, it was possible to compare the Revision 3 (in use by the operator at the time of the accident) with the training program utilized by the manufacturer in the same period.

The comparative analysis of the TAM training program for new pilots and the one used by the AIRBUS revealed some important differences in the formation process. The TAM Equipment Training Module is more comprehensive and longer than the equivalent training of the AIRBUS. The same is true for the Performance Training Module, which is much longer in relation to the course given by the AIRBUS.

However, the opposite occurs in the "Cockpit Procedure Training" (CPT) Module, to which the TAM airlines allocates 12 hours of instruction. Even if one considers the additional 12 hours forecast for the "Fixed Base Simulator" (FBS) instruction, the total training presents a number of hours that is quite smaller than the one offered by the AIRBUS, which has about 40 training hours in the "Maintenance and Flight Training Device" (MFTD). It is important to highlight that the MFTD is a type of electronic equipment that allows the

training of normal and emergency procedures with division of tasks and cockpit coordination. On account of these characteristics, the MFTD, in spite of being a piece of equipment inferior to the FBS, allows a more realistic training than the CPT in "Mockup" (aircraft panels with similar size and position).

Besides, in relation to the "Full Flight Simulator" (FFS) training, although both of them offer the same number of sessions (seven), in the AIRBUS program each session lasts 04 hours, while the duration of the session is 03 hours at TAM. Thus, the total hours of simulator training has a difference of 07 hours.

Therefore, it is possible to see that, although the theoretical instruction is more comprehensive at TAM, the practice training established in the AIRBUS training is more gradual, favoring a better assimilation on the part of the pilots.

As for the crews, it was also observed that, at the time of the accident, the number of captains of the operator was disproportionally large in relation to the number of co-pilots. It was not rare for a second captain to be assigned the function of co-pilot (as was the case with the JJ3054).

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 who, despite individually meeting the minimum requirements established by the regulation in force, did not possess the desired experience in the A-320 airplane as captains and/or co-pilots. There are several cases in which an inappropriate composition of the crew contributed for the occurrence of accidents, although the minimum requirements imposed by the legislation had been met.

It was also 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.

For example, 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.

It is important to note that these reports emerged from the field researches, whereas in the formal interviews, the crews emphasized the attitude of the company towards respecting the independence of the captains relatively to the operational decisions during the flight. It must be highlighted that the company had a policy of encouraging go-arounds as a safety tool, and no evidence was found that the crews could have resorted to the "Safety" in search of guidance concerning a possible inobservance of that policy by any of the company's sectors.

Still in relation to the operator: the company was physically spread through various buildings in the city of São Paulo and other locations of the state, suggesting a lack of unity, with difficulty of communication and coordination between the sectors. As a result, actions were taken in each sector in an independent manner, that is, Maintenance, Management, Training, Operations and Safety worked autonomously in practical terms.

This segmentation ended up leading the administrative managers to a lack of knowledge regarding the extent of their responsibilities beyond the context of their own working sectors. The Safety, for instance, would not do his job in conjunction with the Training, which would be deprived of information about occurrences and reports capable of

improving the process of training of the crews. The CRM trainings were set up from scenarios not linked to the occurrences experienced by the operator. There was no feedback from the Operations sector in relation to the quality of the crew member who had been forwarded to it by the Training.

Another consequence of this segmentation was seen in the redundancy of similar activities on the part of the sectors, which did not coordinate adequately among themselves. The maintenance area of the company, for example, had its own training structure, totally independent of the Training sector, with separate procedures, requirements and work methodology.

In addition, there was an impact of that independence on the management of safety, since each sector had a distinct approach and different criteria for the development of the activities related to prevention.

As an aggravating circumstance, since the safety management of each sector was organized independently, there were different approaches and criteria for actuation within the company, denoting a lack of standardization, and diminishing the possibility of crosschecking relevant information with the other sectors, as, for example in the case of lack of communication between the Safety and Training, and between Safety and Maintenance. It is worth pointing out that the Maintenance sector had its own safety parameters that were established in accordance with the standards required by the international certificating organizations, which were a lot more restrictive than those prescribed in the national civil aviation regulations.

On account of this lack of integration, informal communication was prevalent within the company, and was frequently made in a personal manner, in detriment of formal procedures with the use of channels previously established, a fact that did not favor the effective management of operational safety.

In general, the organizational climate may be seen as the working environment within the organization. Signs of the organizational climate may be found in the manner the chain of command is structured, in the delegation of authority and responsibility, in the formal communication channels, and in the form with which the employees are held liable for their own deeds. If the structure of the company is not clearly defined and known by its staff – in other words, if nobody knows who is responsible for a certain activity, - the organizational climate will be certainly influenced and, as this climate is reflected in the actions occurring within the cockpit of the aircraft, safety may be affected.

As for the operator, the lack of integration between its sectors gave the employees the impression that the policies, on account of being decentralized, were not well defined, even contradictory or conflicting, and could be replaced with informal rules and values, thus creating confusion within the company.

During the investigation, it was observed that, in some cases, the pilots would perform a procedure thought to be the most correct, even though it could be different from the one prescribed. The case of operation with a pinned reverser was an example: some of the pilots said that, in spite of the MEL's prescription, they would opt for applying another one no longer in force, just because they considered it better (preventing the additional 55 meters in the landing distance).

According to the standpoint of this Commission, the "Safety" of the operator did not possess human and material resources compatible with the size of the company: there were 21 people qualified in the sector for a total of approximately 19 thousand employees, spread

on 23 bases all over the country and 11 bases abroad. Of these employees, 5.5 thousand were crewmembers, flying about 375 thousand hours with 109 aircraft.

Among the professionals of the sector, only 6 were qualified for the conduction of operational safety investigations in the capacity of Flight Safety Agents (ASV), and another 3 were qualified just for the processing of Air Safety Reports (ASR). During the year 2006, the sector processed a total of 151 incidents and 2,821 Air Safety Reports.

In the months preceding the accident, the company had implemented a system for the management of operational safety information – “Aviation Quality Database” (AQD) – with the purpose of enhancing the sector’s management capability, despite the small number of employees allocated to it. According to the management data provided by the operator, it was possible to observe that the productivity resulting from the use of the tool started increasing only at the end of 2007, possibly due to the need of assimilation by the company’s employees of the resources and functionalities made available by the new system.

As for the psychological aspects associated with the human factors, the “Safety” had only one psychologist linked to the area of response to crises and assistance to families, and another one who worked with the reports made by means of the “AQD”, to meet all the existing demands.

The other SIPAER accredited accident prevention professionals, spread throughout the other sectors of the company and through the various operational bases (including technical and commercial crews), were not linked to the Safety sector, which did not present any control tool that could suggest that it was aware of the existence of such qualified personnel.

According to the Aeronautical Accident Prevention Program (PPAA) of the company for the year 2007, those accredited professionals were not considered for the development of accident prevention actions. Nothing was being done concerning the integration and utilization of the professionals mentioned in the activities carried out by the “Safety”.

This attitude, besides not favoring the dissemination of the accident prevention policy, deprived the very Safety of the capillarity that was indispensable for the management of the operational safety within a company of that size.

In the Maintenance, for example, the team was composed of approximately 900 hundred professionals, although the Safety did not have a formal knowledge of the existence of mechanics possessing formation in the area of accident prevention.

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 very information related to flight safety did not always have an appropriate dissemination (for instance, accidents involving aircraft of models the same as the ones operated by the company were not informed to the crews).

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.

The procedure of consulting the MEL, although formally established, did not ensure due compliance with what was prescribed in the MEL, besides not being always observed.

Thus, even though the internal procedures determined that the operational changes had to be passed to the Training sector – aiming at the standardization of the initial training and refreshers – it can be said that the pilots were not always convinced to adopt them. It is worth pointing out that, according to the data recorded by the FDR, for the last 28 landing operations, five distinct de-activated reverser landing procedures were used, and 4 out of those 5 were not prescribed by the manufacturer.

In accordance with the results of the field researches, the Safety was regarded by the crews as a not very active sector, which did not pay due attention to the information received. Such impression resulted mainly from the lack of feedback regarding the solutions given to the flight safety reports, discouraging the use of these important tools. The lack of feedback, in turn, was caused by a shortage of qualified personnel, thus generating a cycle.

The employees of the company did not feel encouraged to report the problems affecting flight safety, nor convinced in relation to the importance of the utilization of the available preventative tools.

Besides, the company had a reporting tool through the corporative computer net, in which the field relative to the identification of the reporter was a prerequisite for sending the report. Although the use of the corporate net was not the only option for the transmission of the reports to the “Safety”, the obligation to identify the author of the report inhibited the use of the tool in the end.

Except for the RELPREV (Preventative Report: equivalent to the Air Safety Report), the organization did not have any proactive failure detection mechanism with the possibility of reporting problems, incidents, lapses, slips or threats that could be systematically treated and featured with trend analysis. And even the RELPREV had its credibility diminished due to the lack of feedback, contributing to the decrease of its utilization. As a palliative measure, a few of the senior crewmembers – who had political influence on the company – would eventually forward the problems to the company’s crew association.

Some of the procedures adopted by the operator were (informally) questioned by the crews, on account of hindering the flight preparation checks, among them, the “turn around” and the obligation to receive the passengers at the door of the aircraft. It was observed that the company did not tackle any of such questions.

The CRM (Crew Resource Management) training was not linked to the Safety Sector, and was criticized because the scenarios utilized did not have anything to do with the operations of the company, rendering it difficult to perceive the organizational culture. When analyzing the CRM program, the Commission did not find any scenario generated from an occurrence with an aircraft of the company, neither scenarios that pictured the operation of the aircraft with two captains (one of them in the co-pilot function).

According to the person responsible for the CRM training, examples of occurrences experienced by the company were requested to the “Safety”, in order to assist in the elaboration of the training. The requests, however, were not given heed to.

As an aggravating circumstance, despite the large number of crews, for this type of training only one day was set aside, and this was not enough to deal with the subject.

The Flight Instructors Formation Course did not have bonds with the Operations sector, did not appropriately tackle the issue of instruction standardization, and did not have formal feedback of the performance of the newly graduated instructors. In addition, the course was entirely under the responsibility of only one pilot, who was also the only instructor of the course.

There was no systemic evaluation of the training, and most of the time, the instruction was given in an informative (instead of formative) manner. The training in the aircraft was totally disconnected from the instruction received on the ground, aggravating the feedback and internal communication deficiencies. The routine was established without critique or internal audits.

The vast majority of the ground instructors utilized by the company were outsourced, and there was not an evaluation either of their performance or of the classes taught, except for the evaluation of the pertinence of the course content made by the students.

The simulator training was considered appropriate, although it was a process under the responsibility of the Operations sector, disconnected from the remainder of the instruction (and from the Training sector).

1.17.4 Within the civil aviation regulatory and inspecting organization

As for the ANAC, its posture proved away from reality, with an excessively bureaucratic working system, acting more like an observer, demanding procedures and documents, but failing to act as a facilitator of the safety culture.

The regulation process conducted by the Agency was slow in relation to the operation of the regular aviation in Congonhas, if one considers that the establishment of a requisite for the operator to have all the thrust reversers available for the operation with a wet runway was being studied since April 2006 at least.

It took 2 years for this requisite to be effectively transformed in a norm; therefore, a long time after the accident had happened.

In addition, the very actions resulting from the meetings held by the Agency to deal with the problem of Congonhas were not always implemented right away. An example is the ACTION/DECISION nº 9, described in the meeting minutes nº 02-RJ/SIE-ANAC (IE-3)/06, which was implemented only eight months later. During this period, the operators stayed at the margin of the works that were developed for the solution of the problem.

Within the very context of this investigation, this slowness on the part of the ANAC brought difficulties to this Commission for the obtainment of information and documents. The requests made by means of the official documents nº 18, 20 and 31/CIAA/2007, issued between August and September 2007, were only answered about a year later. Other requests were not fully answered, such as the one referring to the training program (Revision 1) aforementioned.

In relation to the inspecting activities, there was a certain distancing of the Agency relative to the renovation works of the Congonhas runway, since the Work Operational Plan was not presented to it for approval [item (a) of the section 425 of the RBHA 139]. It is worth pointing out that the "POOS" did not establish the inspecting procedures upon completion of the work or service, relatively to the operational safety conditions of the area affected [sub-item (c), item 5.5.8 of the IAC 139-1001].

Besides, the Agency did not execute the special airport inspection during the works for the recovery of the landing runways (prescribed in the item 3.4.4, sub-item (b), nº 6 of the IAC 162-1001A).

All these issues could have been mitigated, if the SIPAER-Link of the Agency had performed the activities assigned to it by the CENIPA – the organization responsible for the normative guidance of the aeronautical accident prevention activities in Brazil (paragraph I of the article 3, Decree nº 87,249/82).

According to the understanding of the CENIPA, the prevention of aeronautical accidents assigned to a SIPAER-Link should be executed by means of proactive actions focused on the respective operational activity of its organization.

In other words, the prevention of accidents should be developed on all related processes: the operation of an aircraft, in the case of an airline company; the air traffic control, in the case of an ATS unit; the maintenance services, in the case of a maintenance workshop; the operation of an airport, in the case of an airport services provider; **and the regulation and inspection, in the case of the ANAC.**

Therefore, the understanding of the CENIPA was that the SIPAER-Link of the ANAC should concentrate on the Agency itself, monitoring its processes of regulation and inspection, in order to continuously improve their efficiency.

Such understanding had been reiteratively passed to the Agency both formally and informally in the various meeting which were held to deal with the subject.

The ANAC, in turn, despite the exclusions established by the paragraph XXI of the article 8 of the Law nº 11,182/2005, understood that once having assumed the duties of the former DAC, its SIPAER-Link should perform the activities of investigation and prevention formerly performed by that Department. Thus, the SIPAER-Link of the ANAC did not accept the normative directives forwarded by the CENIPA.

This posture was reinforced by the very nature of special autarchy conferred to the ANAC by the article 4 of the Law nº 11,182 – characterized by administrative independence, financial autonomy, absence of hierarchical subordination, as well as fixed terms of its directors – leading the managers to think that the agency did not have to comply with the norms of the SIPAER, although being part of this System (paragraph XXXIV, article 8, Law nº 11,182).

However, as it can be seen from the reading of the § 2, article 25 of the CBA, the normative guidance is prescribed in the relationship between the organization of a same system, and it does not imply hierarchical subordination. This means that, even if an organization is not subordinate to another, there is still the need to comply with the norms which govern such a system.

1.17.5 Within the airports administration

By and large, several processes within the INFRAERO were centralized in its main office (Brasília), including the reports relative to the prevention of accidents. This centralization favored a delay in the actions taken, hindering the prevention activity.

The modernization of the Congonhas airport took place without due observance of the aeronautical regulations in various aspects, as well as of the observations resulting from the inspecting activities performed by the DAC, hampering the analysis of the Project in relation to the operation safety on the part of that department.

It was observed that, on account of the organizational structure of the Enterprise, the works for the recovery of the Congonhas runways were under the responsibility of the regional office (of the Enterprise) located in Guarulhos, and the local airport administration (CGH) was left at the margin of the process.

1.18 Additional information

1.18.1 Certification

The A-320 Airbus airplane was certified in 1988, based on the requirements established in the JAR-25 (Joint Aviation Requirements 25), change 11, issued by the European Joint Aviation Authorities (JAA).

Currently, the organization responsible for the certification in Europe is the European Aviation Safety Agency (EASA), and the requirements in force are the ones established by means of the Certification Specifications 25 (CS-25).

In Brazil, the Airbus A-320 had its certification validated by the DAC in accordance with the RBHA 25 – Transport Category Airplanes Airworthiness Requisites, equivalent to the requisites of the Federal Aviation Administration (FAA) of the United States of America (“Code of Federal Regulations – Title 14, Chapter I, Part 25 - AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES” - 14CFR25) and to the JAR-25.

From a certification perspective, the airworthiness requisites of the design have to cover the standards and recommended practices of the Annex 8, ICAO, of which Brazil is a signatory State.

The thrust reverser system of the A-320 airplane is considered by its manufacturer as an additional decelerating system and, thus, not a mandatory system for the certification of the design. However, considering that the in-flight activation of the reverser can lead to a catastrophic situation, there are three levels of safety in the A-320 design to prevent its inadvertent activation.

In other words, the system can only be activated when the following conditions are met simultaneously:

- the airplane is on the ground with its right and left landing gears compressed;
- a channel of the FADEC is operating according to the signal of the reverser of its corresponding thrust lever; and
- a signal of TLA is in reverse, being validated by at least one “Spoiler Elevator Computer” (SEC).

Considering the circumstances of the accident, the items of the Annex 8 (highlighted in bold type) became important to this investigation:

“PART II. PROCEDURES FOR CERTIFICATION AND CONTINUING AIRWORTHINESS

CHAPTER 1. TYPE CERTIFICATION

1.2 Design aspects of the appropriate airworthiness requirements

*1.2.1 The design aspects of the appropriate airworthiness requirements, used by a Contracting State for type certification in respect of a class of aircraft or for any change to such type certification, **shall be such that compliance with them will ensure compliance with the Standards of Part II of this Annex and, where applicable, with the Standards of Parts III, IV, V, VI or VII of this Annex.***

*1.2.2 **The design shall not have any features or characteristics that render it unsafe under the anticipated operating conditions.***

...

CHAPTER 3. CERTIFICATE OF AIRWORTHINESS

...

*3.2 Issuance and **continued validity** of a Certificate of Airworthiness*

*3.2.1 A Certificate of Airworthiness shall be issued by a Contracting State on the basis of satisfactory evidence that **the aircraft complies with the design aspects of the appropriate airworthiness requirements.***

...

CHAPTER 4. CONTINUING AIRWORTHINESS OF AIRCRAFT

4.1 Applicability

The Standards of this chapter are **applicable to all aircraft**.

4.2 Responsibilities of Contracting States in respect of continuing airworthiness

4.2.3 State of Registry

The State of Registry shall:

...

b) determine the continuing airworthiness of an aircraft in relation to the appropriate airworthiness requirements in force for that aircraft;

c) **develop or adopt requirements to ensure the continuing airworthiness** of the aircraft during its service life, **including** requirements to ensure that the aircraft:

...

ii) **is maintained in an airworthy condition and in compliance** with the maintenance requirements of Annex 6, and where applicable, Parts III, IV and V of this Annex;

...

PART III. LARGE AEROPLANES

PART IIIA. AEROPLANES OVER 5 700 KG FOR WHICH APPLICATION FOR CERTIFICATION WAS SUBMITTED ON OR AFTER 13 JUNE 1960 BUT BEFORE 2 MARCH 2004

CHAPTER 1. GENERAL

1.1 Applicability

1.1.1 The Standards of this part, except for those specified in 8.4, are applicable in respect of all aeroplanes designated in 1.1.3 that are of types of which the prototype was submitted to the appropriate national authorities for certification on or after 13 June 1960, but before 2 March 2004.

...

1.1.3 Except for those Standards and Recommended Practices which specify a different applicability, the Standards and Recommended Practices of this part shall apply to aeroplanes of over 5 700 kg maximum certificated take-off mass intended for the carriage of passengers or cargo or mail in international air navigation.

Note. — The following Standards do not include quantitative specifications comparable to those found in national airworthiness codes. In accordance with 1.2.1 of Part II, these Standards are to be supplemented by requirements established, adopted or accepted by Contracting States.

1.1.4 The level of airworthiness defined by the appropriate parts of the comprehensive and detailed national code referred to in 1.2.1 of Part II for the aeroplanes designated in 1.1.3 shall be at least substantially equivalent to the overall level intended by the broad Standards of this part.

1.1.5 Unless otherwise stated, the Standards apply to the complete aeroplane including power-units, systems and equipment.

...

1.4 Unsafe features and characteristics

Under all anticipated operating conditions, the aeroplane shall not possess any feature or characteristic that renders it unsafe."

Aspects of certification were also analyzed on account of their relation with the possibility of an inadvertent setting of the thrust levers on the part of the pilots with its

consequences. Relatively to this possibility, and also considering the Annex 8, the following content is relevant:

CHAPTER 2. FLIGHT

2.2 Performance

2.2.1 General

...

2.2.1.2 Achieving the performance scheduled for the aeroplane **shall take into consideration human performance** and in particular **shall not require exceptional skill or alertness** on the part of the flight crew.

...

2.3 Flying qualities

The aeroplane shall comply with the Standards of 2.3 at all altitudes up to the maximum anticipated altitude relevant to the particular requirement in all temperature conditions relevant to the altitude in question and for which the aeroplane is approved.

2.3.1 Controllability

The aeroplane shall be **controllable and maneuverable under all anticipated operating conditions**, and it shall be possible to **make smooth transitions from one flight condition to another** (e.g. turns, sideslips, changes of engine power, changes of aeroplane configurations) **without requiring exceptional skill, alertness or strength on the part of the pilot** even in the event of failure of any power-unit. A technique for safely controlling the aeroplane shall be established for all stages of flight and aeroplane configurations for which performance is scheduled.

...

CHAPTER 4. DESIGN AND CONSTRUCTION

4.1 General

Details of design and construction shall be such as to give **reasonable assurance that all aeroplane parts will function effectively and reliably in the anticipated operating conditions**. They shall be based upon practices that experience has proven to be satisfactory or that are substantiated by special tests or by other appropriate investigations or both. **They shall also consider Human Factors principles.**

...

4.1.6 Systems design features

Special consideration shall be given to design features **that affect the ability of the flight crew to maintain controlled flight**. This shall include at least the following:

a) Controls and control systems. The design of the controls and control systems shall be such as to **minimize the possibility of jamming, inadvertent operations**, and unintentional engagement of control surface locking devices."

Despite the international prescriptions regarding the design and manufacturing of aircraft and their components, mainly in what refers to the fallibility of the human being, there is a history of various accidents, involving a variety of manufacturers, which had as a contributing factor an inadvertent positioning of the thrust levers, as shown in table 11:

DATE	AIRCRAFT	PLACE
08/Apr/1983	B747	Karachi - Pakistan

30/Mar/1985	A300	Perpignan - France
06/Apr/1987	B747-300	Rio de Janeiro – Brazil
12/Sept/1998	DC-10	Denver - USA
22/Mar/1998	A320	Bacolod – Philippines
28/Aug/2002	A320	Phoenix – USA
18/Oct/2004	A320	Taipei – Taiwan
05/Nov/2005	B747	Paris – France
19/Dec/2003	B737	Libreville - Gabon
14/Dec/2005	B747	McGuire AFB – USA
12/Jun/2006	A310	Irkoutsk - Russia

Table 11 - Accidents with inadvertent positioning of thrust levers.

Among the accidents listed in table 11, two are worth being highlighted, on account of the similarities to the accident involving the JJ3054: the ones of Bacolod (Philippines – 1998) and Taipei (Taiwan – 2004). In both cases, the pilots were operating an A-320 with the reverser of one of the engines deactivated and, during the landing, they kept the thrust lever of that engine in the “CL” position, reducing only the thrust lever of the other engine to the “IDLE” position and later to the “REV” position. At that time, neither aircraft possessed in its FWC (Flight Warning Computer) a routine to alert the crew about any inadvertent positioning of the thrust levers.

The RBHA 25, approved by the Directive n° 285/DGAC, dated 06 August 1990, establishes the airworthiness requisites for the granting of the homologation certificate of transport category aircraft type, as follows:

“REGULATION 25
AIRWORTHINESS REQUISITES
TRANSPORT CATEGORY AIRPLANES

1- GENERAL

*For the granting of type homologation certificates regarding transport category airplanes, **the American Regulation FAR 25 will be fully adopted**, with all its amendments and appendices, adding the paragraph 25.729 (e)(5) in accordance with the item 3 of this RBHA.*

2- UPDATING

For the RBHA 25 the updating dates are the dates of the "Amendments" of the FAA FAR 25.

...”

Also, issues related to the functioning of the “RETARD” auto call-out were studied. The “RETARD” auto call-out has the function of reminding the pilots that both thrust levers must be positioned in “IDLE”.

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”.

Concerning this issue, in addition to what has already been cited in the Annex 8 (Part III-A, Chapter 4, item 4.1), the following content of the 14CFR25 (with highlights in bold type) is relevant:

*"Subpart F - Equipment**GENERAL*

§ 25.1301 *Function and installation.*

Each item of installed equipment must:

(a) *Be of a kind and design **appropriate to its intended function;***

...

(d) ***Function properly when installed.***

...

§ 25.1309 *Equipment, systems, and installations.*

...

(a) *The equipment, systems, and installations whose functioning is required by this subchapter, **must be designed to ensure that they perform their intended functions under any foreseeable operating condition.***

(b) *The airplane systems and associated components, considered separately and in relation to other systems, must be designed so that—*

(1) *The occurrence of any failure condition which would prevent the continued safe flight and landing of the airplane is extremely improbable, and*

(2) *The occurrence of any other failure conditions which would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions is improbable.*

(c) ***Warning information must be provided to alert the crew to unsafe system operating conditions, and to enable them to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed to minimize crew errors which could create additional hazards.***

(d) *Compliance with the requirements of paragraph (b) of this section must be shown by analysis, and where necessary, by appropriate ground, flight, or simulator tests. The analysis must consider—*

(1) *Possible modes of failure, including malfunctions and damage from external sources.*

(2) *The probability of multiple failures and undetected failures.*

(3) *The resulting effects on the airplane and occupants, considering the stage of flight and operating conditions, and*

(4) *The crew warning cues, corrective action required, and the capability of detecting faults."*

Also relevant (with highlights in bold type), the JAR 25, change 11, in accordance with which the A-320 was certified, read:

*"Subpart F - Equipment**GENERAL*

JAR 25.1301 *Function and installation.*

Each item of installed equipment must –

(a) *Be of a kind and design **appropriate to its intended function;***

...

(d) Function properly when installed.

...

JAR 25.1309 Equipment, systems and installations

...

(a) The equipment, systems, and installations whose functioning is required by the JAR and national operating regulations must be designed to ensure that they perform their intended functions under any foreseeable operating conditions. (See ACJ Nos. 1 and 2 to JAR 25.1309.) However, systems used for non-essential services need only comply so far as is necessary to ensure that the installations are neither a source of danger in themselves nor liable to prejudice the proper functioning of any essential service.

(b) The aeroplane systems and associated components, considered separately and in relation to other systems, must be designed so that (see ACJ Nos. 1 and 3 to JAR 25.1309)

—

(1) The occurrence of any failure condition which would prevent the continued safe flight and landing of the aeroplane is extremely improbable; and

(2) The occurrence of any other failure condition which would reduce the capability of the aeroplane or the ability of the crew to cope with adverse operating conditions is improbable.

(c) Warning information must be provided to alert the crew to unsafe system operating conditions, and to enable them to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed to minimise crew errors which could create additional hazards. (See ACJ Nos. 1, 4 and 8 to JAR 25.1309.)

Lastly, the current European regulation of certification disposes:

JAR 25.1309 Equipment, systems and installations

...

(a) The aeroplane equipment and systems must be designed and installed so that:

(1) Those required for type certification or by operating rules, or whose improper functioning would reduce safety, perform as intended under the aeroplane operating and environmental conditions.

(2) Other equipment and systems are not a source of danger in themselves and do not adversely affect the proper functioning of those covered by sub-paragraph (a) (1) of this paragraph.

(b) The aeroplane systems and associated components, considered separately and in relation to other systems, must be designed so that —

(1) Any catastrophic failure condition

(i) is extremely improbable; and

(ii) does not result from a single failure; and

(2) Any hazardous failure condition is extremely remote; and

(3) Any major failure condition is remote.

(c) Information concerning unsafe system operating conditions must be provided to the crew to enable them to take appropriate corrective action. A warning indication must be provided if immediate corrective action is required. Systems and controls,

including indications and annunciations must be designed to minimize crew errors, which could create additional hazards."

1.18.2 Coordination between the authorities

During the initial activities of investigation, there were difficulties in the coordination of actions between the SIPAER investigators and representatives of the Federal Police, hampering the initial work of this investigation.

The problems concentrated specifically in the lack of knowledge on the part of the federal police officers of the competences assigned to the SIPAER by means of the Brazilian Code of Aeronautics.

Along the investigation, coordination problems also arose with the Civil Police of the São Paulo State.

Useful and/or effective investigation techniques

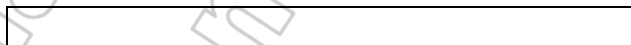
NIL.

1.20 Operational aspects

On the day of the accident, the crew had started their journey with the flight JJ3055, from SBSP to SBPA, operating the A-320 aircraft, registration PR-MBK, which, although being in airworthy conditions, had the number 2 engine thrust reverser inoperative. That situation was in accordance with the MEL.

The flight JJ3055 was uneventful, but at the arrival in Porto Alegre, the crew reported that they had experienced moderate to severe turbulence, between levels 280 and 250, during the descent.

According to the FDR, for the landing in Porto Alegre, which occurred at 16:34 local time (19:34 UTC), the PIC initially set both thrust levers to the "IDLE" position, and, after touching down, set them both to the reverser position. This procedure is in accordance with the MEL prescription for the operation with a deactivated reverser, as shown in figure 10. It is important to highlight that the operator utilizes, as part of its MEL, sheets that were directly extracted from the MMEL.



TAM <small>MASTER MINIMUM EQUIPMENT LIST</small>	OPERATIONAL PROCEDURES EXHAUST	02-78	P 1
		SEQ 001	REV 29

78-30 THRUST REVERSER 30-01 Thrust Reverser When only one thrust reverser is inoperative, apply following procedure : CAUTION : If ENG (affected) REVERSE UNLOCKED caution has been triggered during the flight on ECAM E/WD, do not select thrust reverser on the affected engine. <u>At takeoff :</u> In case of rejected takeoff : REV 1 AND 2 MAX ENG (affected side) REVERSER FAULT caution is displayed on ECAM E/WD after thrust reverser is selected. <u>At landing :</u> <u>Before touchdown :</u> Apply following procedure when one thrust reverser is inoperative : THRUST levers 1 AND 2 IDLE <u>At touchdown :</u> REV 1 AND 2 MAX ENG (affected side) REVERSER FAULT caution is displayed on ECAM E/WD after thrust reverser is selected. <u>Landing performance :</u> <i>Note : Upon selection of the thrust reversers, a temporary increased thrust idle is commanded by the FADEC on the affected side.</i> On contaminated runway, increase required landing distance computed with one reverser inoperative by 55 meters. When both thrust reversers are inoperative apply following procedure : Do not select thrust reversers.
--

TAM ALL

Figure 7 - MMEL A-319/320, "Operational Procedures", "REV" 29, 78-30 "Thrust Reverser"

In accordance with the FDR, in the last 28 landing operations performed, including the one of the accident, five different procedures for landing with a deactivated reverser were performed, four of which not prescribed by the manufacturer. The last three landings were made with distinct procedures.

The study of the communications between the aircraft and the ATC units, done with the help of other crewmembers who knew the pilots involved in the accident, allowed to identify the SIC as the "Monitoring Pilot" both in the flight JJ3055 (SBSP – SBPA) and JJ3054 (SBPA – SBSP).

Flight 3054 (SBPA – SBSP) was carrying a total of 187 persons on board, **being 6 active crewmembers (2 pilots and 4 flight attendants), 5 extra crew members and 176 passengers, 2 of whom were infants.**

All the seats available for passengers and crewmembers were taken.

This flight was dispatched from Porto Alegre with 2.4 tons of exceeding fuel in relation to the minimum fuel necessary for the operation, on account of a practice adopted by the company at certain airports, and which is known as 'tankering', meaning that the aircraft received more than the fuel necessary and prescribed, taking advantage of a lower price. Porto Alegre was one of the refueling places where the price was favorable.

According to the planning prepared by the Porto Alegre Flight Operational Dispatcher (DOV), the PR-MBK had a takeoff weight of 66.9 tons, whereas the maximum structural takeoff weight (MTOW) for that aircraft was 77.4 tons. Still as a planning factor, if one considers that the maximum structural landing weight at Congonhas was 64.5 tons, the maximum takeoff weight from Porto Alegre would be limited to 67.7 tons (LW – Landing Weight).

The required landing distance (RLD) for purposes of dispatch, according to that planning, was 1,781 m, and it considered, in addition to safety factors, a maximum structural landing weight of 64.5 tons and the operation without reversers on a wet runway.

The main runway of Congonhas had 1,880 m of declared landing distance available (LDA), did not have a RESA, and operated under a wet condition during practically the entire day of the accident.

Landing weight	Situation of the Reversers	Situation of the Spoilers	Stop distance
61,1t	Both utilized	All available and utilized	1,228 m
	Both unavailable and not utilized	All available and utilized	1,286 m
	Both unavailable and not utilized	All inoperative	1,929 m
63,5t	Both utilized	All available and utilized	1,265 m
	Both unavailable and not utilized	All available and utilized	1,332 m
	Both unavailable and not utilized	All inoperative	1,998 m
64,5t	Both utilized	All available and utilized	1,281 m
	Both unavailable and not utilized	All available and utilized	1,351 m
	Both unavailable and not utilized	All inoperative	2,027 m

Table 12 - Landing distances.

Table 12 above shows the distances estimated by the manufacturer (representing the aircraft maximum performance capability, not considering the pilot's performance) for a full stop under a wet runway condition ("Actual Landing Distance" – ALD), considering the use/no-use of the reversers and ground spoilers, for the weights of 64.5 tons (maximum structural landing weight), 63.5 tons (estimated landing weight of the JJ3054, according to the FDR) and 61.1 tons (weight without the fuel resulting from tankering).

On the day of the accident, the PR-MBK airplane had already landed on the main runway of Congonhas on two different occasions: the first, at 14:11 UTC, operating as flight JJ3701 (the aircraft carried 116 POB and had an estimated landing weight of 56.5 tons); and the second, at 17:32 UTC, operating as flight JJ3219 (the aircraft had 126 POB and had an estimated landing weight of 59.6 tons).

When contacting the air traffic control unit to request taxi instructions, the crew member did not inform the POB, something that later caused problems for the definition of the number of casualties in the first hours after the accident.

At 20:07 UTC, the RWY 35L landing and takeoff operations were suspended for a verification of the runway conditions. This verification was done according to specific procedures for heavy rain, established by means of an operational agreement, dated from 24 January, between representatives of the ANAC, DECEA (SRPV-SP) and INFRAERO.

The RWY 35R remained available for the aircraft that were willing to “accept” to operate on it, which was not the case of large aircraft, whose flight envelope did not permit operation on that runway under precipitation of rain.

According to the findings, before the repair work, the operation with a wet and slippery condition was usual for the pilots, who knew that the runway paving needed repairs.

About five minutes after the takeoff from SBPA, at the first radio contact with the Porto Alegre Approach Control (APP-PA), the crew was informed that “Congonhas was impracticable, with the runway wet and slippery”.

The en-route meteorological conditions were not favorable to flight JJ3054. During the climb to FL210, the aircraft reported moderate turbulence with peaks of severe intensity. Then, it asked to fly on heading 090° in order to avoid a buildup, and later heading 120° due to severe turbulence. About ten minutes after the request to change to heading 120°, there was another request of heading change to avoid build-ups.

The verifications of the main runway were finished at 20:20 UTC, with the information that there were neither water patches nor water films, and the operations on that runway were resumed.

At 21:03 UTC, the ACC-CW informed the JJ3054 that Congonhas had already resumed normal operation.

The CVR recording available begins when the PIC (“Pilot Flying”) was finishing his speech to the passengers, with the aircraft already descending. Thus, there is no recording of the descent and approach briefing, prescribed in the operational routine of the operator to be made before the descent.

On the approach to São Paulo, below FL100, a yawn (made by the PIC) can be heard in the cockpit, followed by a complaint of a mild headache. Then, the PIC asked the SIC to verify the conditions of Congonhas, stressing that they had only one operating reverser. When they intercepted the localizer, the PIC once again asked that the rain conditions be verified, as well as whether the runway was slippery.

After the call-out of 20 feet, the “RETARD” auto call-out was heard, and the FDR recorded the positioning of the number 1 engine thrust lever at “IDLE”. Just after the touchdown, the same thrust lever is moved to the “REV” position. There is no recording of motions of the number 2 engine thrust lever, which would have remained at the “CL” position, still according to the FDR.

Then, the SIC confirmed the activation of the engine number 1 reverser and the non-deflection of the ground spoilers, thus changing the sequence prescribed for this “call out”. No explicit mention was made relatively to any discrepancies in the engine instruments.

Each engine of the Airbus is managed by a FADEC (“Full Authority Digital Engine Control”) system, which performs a variety of functions, such as the power management and the protection of the operating limits of the engine.

The pilot positions the thrust lever as needed, and this position is transmitted to the FADEC in terms of angle of the thrust lever (“Thrust Lever Angle” – TLA). This information

will be used by the FADEC to define the power limit of the engine on account of the thrust lever position.

The power control system of the Airbus A-320, shown in the figure 8, has 5 positions for the levers: "TOGA" (Takeoff/Go-around), "FLX/MCT" (Flex Takeoff/Maximum Continuous Thrust), "CL" (Climb), "IDLE" (Zero Thrust) and "REV" (Reverser). These positions are defined by means of detents, and correspond to the following TLA values:

MAX T.O./GO AROUND (TOGA)	TLA= 45°
FLEX T.O./MAX CONT (FLX/MCT)	TLA= 35°
MAX CLIMB (CL)	TLA= 25°
"IDLE"	TLA= 0°
MAX REVERSE (REV)	TLA= -20°

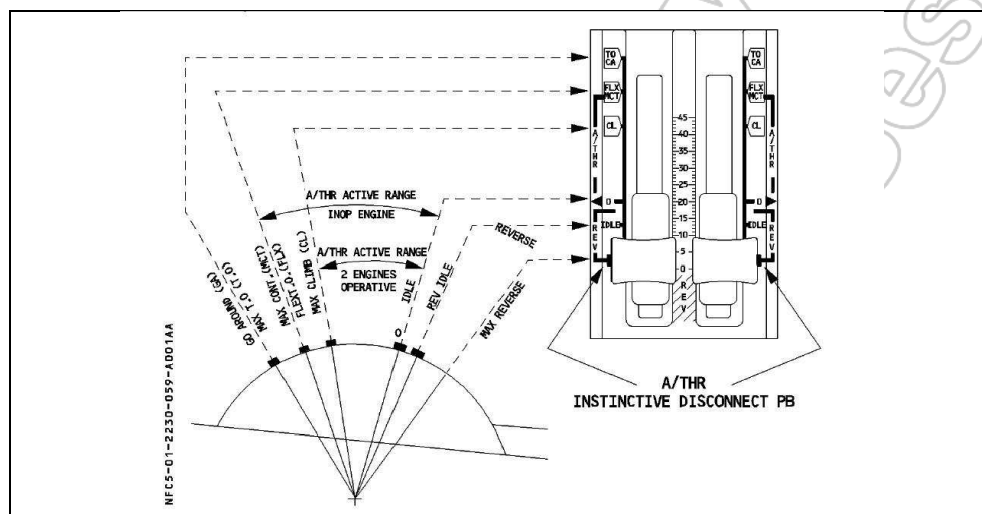


Figure 8 - Positions of the thrust levers.

The autothrust system works from the "IDLE" up to the "FLX/MCT" positions. Basically, when the autothrust system is active, it automatically controls the power, which may vary from "IDLE" up to the limit determined by the lever positioning, that is, "CL" or "FLX/MCT" – so as to maintain a speed or vertical variation rate previously selected by the pilot.

One of the characteristics of the autothrust system is in the fact that, during the variations of thrust commanded by the system, the levers do not move, contrary to the autothrottle system used by aircraft of other manufacturers, in which the variation of thrust determines a corresponding movement of the levers.

The A-320 has five spoilers on each wing (figure 9), which open automatically after landing. The spoilers are devices installed on the upper part of the wings whose objective is to reduce lift and increase the aerodynamic drag. During the landing, the device is activated, significantly reducing lift and allowing for a more efficient braking. Consequently, the landing distance of the aircraft is quite reduced.

The airplane has various computers which command the different control surfaces. The "Spoiler Elevator Computer" (SEC) is one of those computers, and its primary purpose is to control the "spoilers". There are three SECs on the A-320.

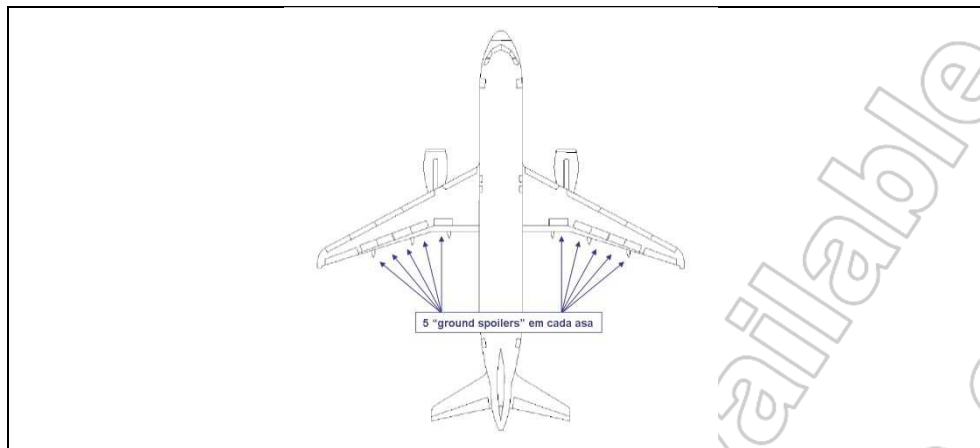


Figure 9 - Ground spoilers: five in each wing.

The automatic ground spoiler function causes the spoilers to open automatically, as soon as the main gears touch the ground, provided the thrust levers are at the "IDLE" position. If one lever stays at the "CL" position during the landing, it deactivates the actuation of the ground spoilers, significantly reducing the aircraft braking capability (between 45% to 50%).

The ground spoiler function has to arm after the landing gear is lowered. To do this, the pilot pulls up the speed brake lever, causing the system to get ready.

The A-320 is also equipped with an automatic brake system, with the purpose to assist the pilot in the deceleration of the aircraft after landing. This system is armed by the crew during the preparation for landing. The "Auto Brake" panel is used for the selection of one of the three braking modes available:

- MAX –used at takeoff in case it is aborted;
- MED or LO – used at landing.

In the modes MED or LO, a progressive pressure is sent to the brakes, respectively two or four seconds after the opening of the ground spoiler. Therefore, the activation of the automatic system requires the deflection of the ground spoiler. Nevertheless, the manual braking is available to the crew, by means of the application of pressure on the pedals.

Shortly after the touch of the nose gear on the runway, there was a sudden lateral yaw to the left, a moment at which the CVR recorded the first reaction of the PIC relative to an abnormal situation.

About seven seconds after the nose gear touched the runway, the pilots perceived that the airplane was not decelerating (SIC: – "Slow down, slow down!"). Two seconds later, they applied maximum deflection on the brake pedals of the aircraft. This procedure, however, was not enough to stop the airplane.

It must be pointed out that the SIC, although flying as the co-pilot ("Monitoring Pilot"), had only a limited experience in the position, restricted to the periodic training in the Simulator (known as "Right Seat Certification"), whose content is described in the figure 10.

The SIC had been recently hired by the operator for the function of captain, and had, at the time of the accident, a little more than 200 flight hours in the A-320. His long previous experience was also consolidated as PIC, but on Boeing aircraft types, which possess an "autothrottle" system.

TRIM LINHAS AÉREAS

AIRBUS A319 / A320
Treinamento Periódico em Simulador

RIGHT SEAT RECERTIFICATION - FOR CAPTAIN ONLY

- ☐ TAKE OFF
- ☐ V1 CUT
- ☐ ILS APPROACH BELOW MIN
- ☐ GO AROUND
- ☐ ILS APPROACH
- ☐ LANDING

ROTE: GR/CT
SBGR, CGO 1, PONTE, UA310, BRETA, IC 1, SBCT
ATIS: Wind 110/05, temp. 18°C, QNH 1014, visibility 0800m, ceiling 100', RWY 09R.

TAKE OFF DATA:
AZFW 55.1; FOB 5.800; ATOW 60.7; ZF CG 29.4%; TO CG 28.6%; CONF 2; TRIM POS 0.0DN;
TFLEX 62°C; PACKS ON
V1 145; VR 145; V2 149.

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Figure 10 - A-319/320 Periodic Simulator Training Program

The PIC, in turn, had a significant experience in the aircraft, but had a history marked by some difficulties in making decisions during emergencies at the Simulator training sessions, showing some degree of slowness in the performance of certain procedures.

1.21 Psychological aspects

Some of the information about the pilots was obtained by means of interviews with other pilots who had worked with them.

According to the information collected, the PIC had been working for the company many years, and had accumulated 2,000 flight hours in the A-320 aircraft.

He was considered by his peers as calm, sensible, studious, concerned with details, serious, formal and competent. However, his standard of flight, according to several reports, was considered as one of median quality. He sought to complement his performance with lots of study and was concerned with strict compliance with the prescribed procedures.

Still according with the data collected, he demonstrated little flexibility adapting to changes, and, in the emergency training, a certain degree of latency was observed in his speed to provide an answer. Nevertheless, he was considered an experienced pilot who was enjoying a moment of personal and professional accomplishment.

The other pilot on board had been working for the company only six months. Although he had complied with the training program for the function of captain, on the JJ3054 flight he was working as a co-pilot. Besides, a significant part of the experience acquired by him along his professional life was based on the operation of aircraft

possessing an autothrottle system, and he had his first contact with the autothrust system after he was hired by this operator.

According to the information collected, he had been supposedly away from the air activity in the period from 2001 to 2005, having resumed piloting in 2006 with an EMB 120. In 2007, he seemed to be happy for being working at TAM. More specific information about the time he was away from the air activity was not found.

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.

The PIC was described by his workmates as a “reserved person at first”, and, on the accident flight, was flying with a recently hired co-pilot not familiar to him, something which may have caused the communication process to become even more limited, creating an excessively formal environment in the cockpit. As can be seen from the CVR recording, any possible concerns relative to the limitations of the operation in Congonhas were not shared or discussed by the crew.

In relation to the communications, it was verified that the phraseology used during the emergency situation was not appropriate. There was not a standard procedure for the lack of deflection of the ground spoilers, particularly after the activation of the reversers.

It was also observed that there was not 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.

Another point raised during the interviews and field researches refers to the fact that the operation in Congonhas caused a widespread feeling of discomfort among the pilots. The airport is located in an intensely populated region of São Paulo, with tall buildings to be over flown by the aircraft during the landing and takeoff operations (phases of flight in which any emergency tends to become critical). Besides, the very dimensions of the runway and the lack of RESA produced a feeling that there were no error margins for the operation.

1.22 Ergonomic aspects

The inclusion of complex protection systems in the pieces of equipment brings, as a collateral effect, more difficulty in its comprehension, originating a number of failures that take longer to be perceived, due to the large numbers of controls and the multiplicity of their interactions.

The complexity of the system is such that it is difficult for the pilot to elaborate an accurate representation of the logic of its automation. As an aggravator, the sophistication of the equipment in the cockpit may bring still more difficulty understanding the actions commanded by the automated system, especially in non-routine or critical situations, making it difficult to foresee what will happen next, thus generating a cognitive inappropriateness (Philippe Polet et al.²).

Since the items of information are very complex, the concept of the automation in the A-320 does not always allow the pilot to know exactly how the operations are being performed by the system. It is as though the pilot received only a partial notion of the

² Philippe Polet, Frédéric Vanderhaegen e René Amalberti, 2002. *Modelling border-line tolerated conditions of use (BTCU) and associated risks*. Em <http://www.elsevier.com/locate/ssci>.

operation of the aircraft, at an amount deemed sufficient by the engineering for him to fly the plane. On the other hand, the aircraft is also given a protection against possible operation errors capable of creating situations of lack of control (which in an automated environment would be beyond the understanding capability of the pilot).

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 not any 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.

The manuals of the A-320 are thick and hard to consult in the cockpit. The way the subjects are shown in the manual is complex, as the same subject can be distributed to several of its sections. Thus, when studying about a certain topic, the pilot is sometimes forced to handle all the volumes on board, which is highly time-consuming. The fact that the cockpit is a restricted space, the need to handle such large volumes, mainly at critical moments, may hinder the access to information.

One possibility was raised, according to which the lights of the apron lamp posts, which had been moved closer to the runway during the airport augmentation work, could have dazzled the pilots at a certain moment of the landing roll. That would mainly affect the SIC, on the right seat, as he would have the apron lights in the back ground when looking at the instrument panel. The consequences of a possible dazzling would be worsened by the fact that the thrust levers of the A-320 are short and do not move with the power variations determined by the 'autothrust' system.

As part of the investigation, in a flight which landed in Congonhas at night, members of the investigating team noticed no signs of dazzling of the pilots' vision on account of the apron lamp posts.

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2. ANALYSIS

2.1 Introduction

The Brazilian aviation was experiencing a special circumstance in the months that preceded the accident, when the climate onboard the regular transport airplanes used to be tense, on account of the relationship with the passengers, stressed as they were due to the frequent flight delays, the long lines at the check-ins, the lack of adequate accommodation in the boarding lounges and, most of all, lack of information.

Within this context, the airport of Congonhas, which was the busiest among the Brazilian airports in terms of passengers, was significantly affected.

From a psychological perspective, the operation in Congonhas represented, for a large part of the crews interviewed during this investigation, a reason of concern, on account of the peculiar characteristics of that aerodrome.

Besides being in the midst of a densely populated area with lots of buildings, Congonhas was seen by many pilots as an aerodrome in which operation was difficult, mainly under rainy conditions.

According to the facts collected, the airport had undergone a prolonged period of troubles, especially in relation to the runway complex.

Since 2005, the main runway of Congonhas had been presenting low coefficients of friction and irregularities on its surface, which favored the accumulation of water. These two characteristics ended up facilitating the occurrence of skidding and aquaplaning.

A number of mitigating solutions were attempted by the airport administration, such as: utilization of grooving, re-texturing and a more frequent runway rubber removal service.

All of these actions, however, focused on the problem of friction, not dealing with the problem of the irregularities on the pavement surface. Thus, even with the coefficients of friction above the established limits, the draining of the rain water remained inefficient, and skidding and aquaplaning continued to be reported.

In the beginning of 2007, the complex of runways at Congonhas was finally subjected to a restoration. The purpose was not only to correct the surface irregularities but also the problems of gradient, so as to prevent water accumulation. With the new pavement, the coefficient of friction of the runway surface was improved.

There was, therefore, a great expectation that the repair work done would once and for all solve the runway chronic problems.

However, since more time would be needed until the tarmac could be ready to receive the grooving, the airport administration decided to put the main runway in operation even without the grooves on 29 June 2007.

In the end, the operational conditions of Congonhas airport brought the pilots a feeling of unease, according to what was learned from the interviews. The reason for the discomfort was precisely the lack of options in case of emergencies. According to the interviewees, the airport offered little or no margin for errors or failures.

This negative influence of the runway on the psychological aspect, perceived during the investigation, occurred within a context in which the management and inspection of the airport infrastructure played important roles, generating a feeling of unsafety in the crews that operated in that airport more frequently.

The issues related to the airport infrastructure management, as well as the regulation and inspection of the civil aviation will be dealt with in the item 2.4 below.

In the months that preceded the accident, the Brazilian air transportation sector was undergoing a period of accommodation, in which the airline companies were fighting to conquer the space left by the closing of the activities of an important competing company.

The growth of the operator took place very quickly and this seems to have caused an unbalance in its organizational structure. The lack of coordination between the various sectors of the company and the prevalence of productivity to the detriment of the other aspects began to be noticed by the employees.

An indication of this prevalence may be observed in the undersizing of the SIPAER-Link (Safety sector), which had 21 people for a total of approximately 19 thousand employees. This ratio ended up compromising the performance of the sector and, consequently, its credibility before the crew members of the company. It seems rather unlikely, for example, that only one professional (psychologist) could be able to deal with all the issues related to the human factors in a company with more than five thousand crewmembers.

In the interviews conducted during this investigation, a huge disparity could be observed between the reality as perceived by the Safety sector and the reality as experienced by the crews. On account of the lack of feedback concerning their reports, the crew members eventually ceased to interact with that prevention sector, thus generating a vicious circle, because the growing shortage of reports contributed to reinforce the idea that all was well.

By and large, the reports concerning the runway conditions were forwarded by the pilots only to the control tower and not to the "Safety" of the company.

This Commission noticed that there was a mistaken perception on the part of the crews that the treatment of the complaints about the airport infrastructure was responsibility of the air traffic control unit. Thus, the pilots considered that transmitting the information to the tower was sufficient to solve the problems, and so they did not interact with the company's "Safety", who was then left in an alienated position.

All these aspects are symptomatic to show the unbalance between the production – which had a tendency to be the focal point of the management actions within the company – and the other activities.

In this unbalance was the origin of a silent pressure on the crews, revealed during the investigation, in that they would not make diversions to alternate airports, on account of the disturbances to the passengers and losses to the company. This pressure, although not formalized by the company, was felt by the crews, something that made its effects become real ones.

In a way, it can be said that the rapid growth and the segmentation of the company sectors started hindering a more efficient oversight in all management levels.

In this case, the role of the "Safety" as a facilitator of the safety actions ended up being inhibited by its inadequate sizing, by the lack of influence before the other sectors and by the lack of credibility before the crews.

With a "Safety" closer to the reality experienced by the crews, it would have been possible to verify the effects of the quick growth of the company and, possibly, either remove or mitigate the risks that got so apparent after the accident.

It would have been possible, for example, to verify that the lack of integration contributed to the existence of failures in the technical formation of the crews. This became evident, mainly, in the lack of a higher degree of standardization of the pilots. Suffice it to say that in each one of the previous landings made with the PR-MBK airplane, a different procedure was performed with the de-activated thrust reverser. Of a total of 28 operations performed with the inoperative reverser, five different procedures were recorded by the FDR.

Likewise, the needs concerning the improvement of the instructors' formation course could have been timely perceived.

A closer interaction between the crews and the "Safety" would favor the establishment of an efficient communication channel, as well as a search for a better use of the various prevention tools available, such as the SIPAER voluntary reporting systems.

As for the operation of the aircraft, it is worth pointing out that the procedure applicable to a landing with an inoperative reverser had been changed by the manufacturer a few months before the accident.

According to the former procedure, the pilot had to reduce both thrust levers to the "IDLE" during the "flare", at about 10 feet and, after touching down, activate only the available reverser, keeping the thrust lever of the other engine at "IDLE". Such procedure, although more efficient from a braking perspective, ended up inducing the crew to committing errors, as there are several records of occurrences in which there was a mistaken setting of the thrust levers (see table 11).

As a matter of fact, there are various reports of errors in the execution of the pinned reverser landing procedures, and these incidents are not restricted to the aircraft of this manufacturer. It is a problem that occurs throughout the aircraft industry.

This reinforces the need of the industry to maintain a continuous attention to the influence of the human factors on issues related with the aircraft designs, mainly in what refers to automation.

As a result of various occurrences, the manufacturer of the A-320 changed the procedure, simplifying the job of the pilot, making it equal to the landing procedure with both reversers available. Thus, at the time of the accident, the landing with an inoperative reverser required 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.

Although simpler, this procedure had a collateral effect, that is, the need to add an extra 55 meters in the calculations of the runway length required for landing if the runway was contaminated, since the calculation of the RLD for a contaminated runway considers the use of the reversers, which is not the case under conditions of wet or dry runway.

The reason is that, immediately after the activation of the reverser, there is an increase of the power of the respective engine, thus increasing the flow of the air reversed and, consequently, taking more advantage of the equipment effectiveness, which is reduced as the aircraft speed is also reduced.

In the case of the de-activated reverser, as soon as the thrust lever is positioned in "REV", the power begins to increase, but then it is electronically blocked by the system, which 'knows' that the reverser is inoperative.

This brief time interval during which there is an increase of the engine power without the air flow being reversed will correspond to those already mentioned 55 meters added to the distance required for the aircraft to stop.

The very simplification of the procedure by the manufacturer, resulting in an increase of the required runway distance when it is contaminated, indicates a certain vulnerability of the former procedure.

And, finally, the adverse weather conditions prevailing along the route and at the destination were known to the crew, since the previous leg had been flown not long before on the same route, on the opposite direction.

It is possible to suppose, in face of the aspects analyzed above, that the scenario in which the accident occurred – the delicate relationship with the passengers, on account of the increase in the air traffic, the adverse weather, the pilots' concern with the operation in Congonhas, the need to add 55 more meters in the calculations of the required distance for landing (if they considered that the runway was contaminated) due to the pinned reverser – may have contributed in some way to this occurrence, mainly in the form of psychological pressure on the members of the crew.

2.2 The accident

The flight JJ3054 departed from Porto Alegre destined to São Paulo (Congonhas), as the second leg of that crew's journey.

The aircraft used in that flight, an A-320 registered as PR-MBK, had the number 2 engine thrust reverser de-activated by the maintenance, a procedure that was in accordance with the MEL.

The FDR did not record any thrust lever movement of the number 2 engine (the one with the pinned reverser), from the moment it was positioned at "CL", up to the collision of the aircraft.

As for the number 1 engine, the FDR recorded the movement of its respective thrust lever to the "IDLE" position moments before the landing, when the "RETARD" auto call-out sounded and the airplane was at a height of about 10 feet above the runway.

At the landing, the touch of the aircraft landing gear on the runway occurred at a speed of approximately 140 kt, while the FDR recording shows that one of the thrust levers was at "IDLE" and the other at "CL".

At that moment, the fact that the number 2 engine thrust lever was positioned at "CL" determined the variation of the parameters of that engine with the purpose of maintaining the speed previously selected. The reason is that, when functioning in isolation (independently of the Autopilot/Flight Director - AP/FD), the "autothrust" function always controls the speed.

Another consequence of this recorded thrust lever positioning ("CL") was the non-deflection of the ground spoilers, since, in accordance with their logic of operation, it is necessary that both thrust levers be at the "IDLE" position, or one of them be at "IDLE" and the other at "REV", for the ground spoilers to be deflected.

The non-deflection of the ground spoilers significantly degrades the aircraft braking capability, increasing the distance necessary for a full stop of the airplane by about 50%, according to data provided by the manufacturer.

As in a cascade effect, the autobrake function, although armed, was not activated, because the opening of the ground spoilers is a prerequisite for such activation.

Thus, after the landing, there was neither deflection of the ground spoilers, nor activation of the autobrake.

When the nose gear touched the runway, about 2.5 seconds after the left main gear, the number 1 engine thrust lever was moved to the "REV" position, according to the FDR.

With this action, the "autothrust" function of the aircraft was disconnected, according to the aircraft design, and the "thrust lock" function was activated, with the purpose of preventing the acceleration to reach the climb power level.

As a result, this function 'froze' the number 2 engine power in the value it was at that moment ($EPR_2=1.18$). The "thrust lock" function is disabled by the movement of the thrust lever, but since this movement did not occur, according to the FDR, the number 2 engine remained with that power until the collision.

The performance parameters of the engines, recorded by the FDR, are consistent with the sequence described above.

Therefore, at that moment, the FDR recorded the actuation of the number 1 engine reverser, and the thrust of the number 2 engine, in a way that was coherent with the positioning of its respective thrust lever at "CL". The FDR also recorded the non-actuation of the ground spoilers and autobrake.

About six seconds after the main gear touched the runway, there was the first activation of the brakes by means of the pedals, which reached the maximum deflection five seconds later.

The FDR also recorded the use of the rudder and the differential braking by the pedals as the aircraft veered to the left (probably in an attempt to maintain the plane on the runway and stop it).

It is worth reminding that the reverser is an additional decelerating device and, as such, it is not a compulsory system for the certification of the aircraft.

Even so, there are three safety levels in the A-320 design to prevent the reverser from being activated in flight, as it would create a potentially catastrophic situation.

Despite this, the system, after having identified that one thrust lever was at the "CL" position and the other at "REV", interpreted that the intention of the pilots was to continue flying and not to land.

In other words, the power control system, 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 the application of maximum braking pressure on the pedals, gave priority to the information that one of the thrust levers was at "CL", a lever that did not have any safety device to prevent an inadvertent wrong positioning.

In this situation, with the information that one of the thrust levers was at "CL", the ground spoiler did not deflect, the autobrake did not actuate, and the braking conditions degraded to the extent of not allowing the aircraft to stop on the runway. The pilots only realized that the aircraft was not decelerating a few seconds before the impact, a time that was insufficient for them to understand what was going on.

2.3 Hypotheses

An explanation for the chain of events described above, which culminated in the accident, may be obtained from the analysis of two hypotheses which presuppose that there were no errors in the recording of data by the FDR, based on the lack of any indications of failure during the checks automatically made by that recording system.

First hypothesis: a failure in the system that controls the power of the engines would have provided the number 2 engine with the information that its respective thrust lever was at the "CL" position, regardless of any other setting determined by the pilot.

Second hypothesis: the pilot would have performed a procedure in discordance with the MMEL.

2.3.1 First hypothesis

Relatively to the first hypothesis, the operation of the engine power control system follows a chain of commands which starts with the activation of the thrust lever by the pilot. The movement of the lever is mechanically transmitted through the AFU to the thrust control unit (TCU). From the TCU, an electronic signal is sent to the FADEC ("Full Authority Digital Electronics Control"), which governs the engine. The recordings made by the FDR have their origin in the data provided by the FADEC.

When this chain of activations from the engine up to the thrust lever is analyzed, the possibility of errors occurring in the process of data recording by the FDR is discarded, as already commented.

Therefore, any recording of data incompatible with the real setting of the thrust lever would have its origin outside the FDR. As mentioned above, the power data recorded by the FDR are provided by the FADEC.

Each engine of the aircraft has its own FADEC, which possesses 2 channels that receive the signals individually, as a way to prevent the dissemination of failures. Each one of these channels has its parameters continually monitored, accommodating the power at "CL" or "IDLE", according to the flight conditions.

According to this logic, for the FADEC to direct the power of the engine to "CL" in response to a possible internal failure, it is necessary that the aircraft be considered by it in a flying condition and that the "slat/flaps" be retracted. If the FADEC interprets that the aircraft is on the ground or that the slat/flaps are extended, the FADEC will direct the power to "IDLE" in the accommodation of the failure.

So, since the PR-MBK was with the "flaps" extended for the landing, it is possible to discard the idea of a failure in the FADEC.

The next stage in the chain of events would then be a failure in the TCU. This unit is responsible for the measuring of the angle made up by the setting of the thrust lever. It has distinct processes for the measuring, and sends information both to the FADEC and to the computers responsible for the activation of the ground spoilers.

The items of information sent to the FADEC come from two rotating transformers ("resolvers") existing in each thrust lever. Any failure or discrepancy between the measurements of the two transformers of a same lever would turn the "Master Caution" light on, and trigger a sound alarm and an alert in the ECAM ("Electronic Centralized Aircraft Monitoring"), announcing a discrepancy in the reading of the thrust lever setting.

There was not any recording either of discrepancies in the measurement of the thrust lever angle or of an activation of the "Master Caution" light by the FDR. The CVR did not record any sound alarm either, or even a mention by the pilots relative to an alert in the ECAM indicating such failure.

As for the ground spoilers, a failure of any of the potentiometers responsible for the information of the positioning of the thrust lever to the respective spoiler elevator computer

(SEC) would result in the non-commandment of the deflection of the respective spoiler, and would display a message in the ECAM with the procedure to be performed by the pilot.

If more than one spoiler had failed to deflect on account of a failure of the potentiometers, then in addition to an alert in the ECAM, there would be a sound alarm and the Master Caution light would be turned on.

The FDR did not record any activation of the Master Caution light, or any failure in the activation of the ground spoilers. In fact, the activation system of the ground spoilers worked as expected, and the deflection of the ground spoilers was inhibited on account of the information that one of the thrust levers was at "CL".

The CVR did not record any sound alarm either, or even a mention by the pilots relative to an alert in the ECAM indicating such failure.

The lack of recordings of failures, or the fact that they are not mentioned, the lack of any aural warnings, according to the recorders, allows a failure in the TCU to be discarded.

As for the possibility of failure of the activation rod which connects the AFU to the TCU, or its connection, it can be discarded, because it would imply to move down the command of the TCU, by means of gravity, moving the thrust lever to the "REV" position. In addition, a failure like this would activate an alerting device in the ECAM.

The lack of evidence concerning this alert, plus the reading of the thrust lever at the "CL" position, allows discarding this possibility.

What remains is, therefore, the possibility of mechanical failure of the activation rod which connects the thrust lever to the AFU, or a failure of this unit. In this case, it would be possible to have an indication of the lever at "CL" no matter which the real setting was.

As a safety device, the disconnection or rupture of the AFU activation rod would result in the loss of the artificial feeling of resistance against the movement of the thrust lever. In other words, the system places total confidence in the motion sensitivity of the pilot for the detection of this type of failure in the device.

Here, it is important to consider that the meteorological conditions, the operation during the night period, the history of the runway of Congonhas, the background of the PIC and even the special moment being experienced by the aviation are factors among those that could impact decisively on the motion sensitivity of the pilot.

This leads us to an analysis of the aspects related to the airworthiness requisites established by the Annex 8 to the Chicago Convention.

In accordance with Part IIIA, Chapter 2 of the Annex 8, item 2.2.1.2, the obtainment of the expected aircraft performance will take into account the human ability and, particularly, will not demand exceptional attention or skills on the part of the pilots.

As for the chapter 4 of the same Part, when referring to the design and manufacturing of large aircraft, the document establishes that the design and manufacturing details must consider the principles related to the human factors (4.1). Moreover, it states that the design has to pay special attention to the aspects that may influence the ability of the crew to maintain a controlled flight (4.1.6), and that the commands and commanding systems must be designed so as to minimize the possibility of inadvertent operations (4.1.6, a).

Thus, it seems that the sensitivity of the pilot does not represent an efficient and/or dependable detecting mechanism of a possible mechanical failure of the activation of the AFU, mainly if this is the only barrier to be overcome.

Despite the various exams made in the wreckage of the AFU, it was not possible to determine the real position of the number 2 engine thrust lever during the final moments of the flight JJ3054.

This failure cannot, therefore, be discarded.

However, according to the data provided by the manufacturer, the possibility that a failure like this can occur exactly at the moment of landing is less than 4×10^{-11} per flight hour.

2.3.2 Second hypothesis

In relation to the second hypothesis, according to which the pilot did not comply with the procedure prescribed in the MMEL for a landing with an inoperative reverser, there are several considerations to be made.

First, it is necessary to take into account that the PIC had performed the prescribed procedure when landing at Porto Alegre in the previous leg.

It is, therefore, necessary to find a motivation to justify the non-application of a known procedure.

Among the aspects of the operation in Congonhas that differed the most from those found on the previous leg in Porto Alegre, there are the following ones: the conditions in which the flight JJ3054 was dispatched, the specific characteristics of Congonhas Airport, and the night period.

The airplane had been dispatched from Porto Alegre with its maximum capacity, with all the passenger and crew seats taken, with a total of 187 POB (of whom, two were infants). Therefore, there were enough seats for everyone, except for the infants, a condition that is in accordance with and authorized by the regulations.

In addition, due to the tankering, the PR-MBK departed from Porto Alegre with an extra 2.4 tons of fuel, having reached a takeoff weight of 66.9 tons. Nevertheless, the aircraft was operating within its envelope, whose maximum structural takeoff weight (MTOW) was 77.4 tons. Even considering the landing structural weight limit (67.7 tons – LW) there was a significant margin.

The weight recorded by the FDR at the landing in Congonhas was 63.5 tons, thus below the landing structural weight established for that aerodrome (64.5 tons).

According to the calculations of the performance at the landing, the runway distance required for the flight dispatch, not considering the utilization of the reverser available and with a wet runway condition, would be approximately 1,781 meters for the aircraft with its maximum landing structural weight.

Considering the fact that for the calculation of the RLD the safety margins are included, it can be observed that the aircraft had an extra margin of one hundred meters of runway, being with a weight that was smaller than the one used for the calculation (approximately one ton lighter).

Besides, the estimated distances for the full stop of the aircraft on a wet runway, not using the reversers and without any unexpected situation (ALD), would be: 1,351 m for a weight of 64.5 tons (maximum landing structural weight); 1,332 m for a weight of 63.5 tons

(which was the weight of the aircraft at the landing in Congonhas); and 1,286 m for a weight of 61.1 tons (the weight of the aircraft if it had not done the tankering).

It must be noted that the tankering represented an increase of about 50 meters to the runway distance that was necessary for a complete stop of the aircraft.

On account of these data, and considering the fact that the main runway of Congonhas had a declared LDA of 1,880 meters, it is possible to affirm that there was a considerable margin for the operation on that runway, even without the utilization of the reversers, and, therefore, from an operational perspective, the dispatch of the aircraft occurred within proper safety parameters.

However, as already commented, the operation in Congonhas represented an enormous concern for the pilots, in psychological terms.

The recording of the CVR indicates that the PIC showed anxiety in relation to the conditions of the runway for the landing, to the point of asking the SIC, on two occasions, to contact the TWR-SP and question about the conditions of the rain and runway, and specifically, whether the runway was slippery.

Having received from the TWR-SP the information that the runway was wet and slippery, the PIC repeated it, exclaiming: "*molhada e escorregadia!*" ("wet and slippery!").

It is worth reminding that, two days before the accident, with the first precipitations of rain after the restart of the runway operations with the pavement recovered, several complaints were made by the pilots just after landing, and even an accident occurred, involving another big size airplane, on the day before the crash of the JJ3054.

So, it is possible to identify that the influence of the runway conditions on the pilots, from a psychological perspective, favoring the creation of a state of anxiety, had probably begun still in the approach phase, and lasted until the confirmation that something more serious was happening – something involving the aircraft systems, since the ground spoilers and the autobrake were not activated.

According to this reasoning, the lack of the expected deceleration after the touchdown might have been initially attributed to the runway conditions by the pilots. Without a correct understanding of the aircraft behavior, they may have been made to believe that the aircraft was aquaplaning.

This would explain the initially timid action taken by the PIC on the left brake pedal, as if by fear of completely losing the control of the aircraft on the runway.

As an aggravating circumstance, the fact that the landing occurred in the night period may have been a contributor, since the visualization of the thrust levers' setting gets more difficult. It is worth pointing out that the autothrust system used in the A-320 has the characteristic of not moving during the changes of power, thus hindering even further the perception of a possible inappropriate setting of those controls.

Another consideration was the possibility that the illumination of the ramp, that had been repositioned during the works for the enlargement of the airport, might have diminished the visual perception of the pilots to some degree, especially the SIC's, seated on the right and, naturally, more susceptible to a possible dazzling, considering the operation on runway 35L.

However potentially viable, no evidence of dazzling (caused by the ramp illumination that could affect the pilots' vision) was perceived during a later flight with the investigators in the cockpit. Even so, during this flight, it was observed that the color and

size of the thrust levers, added to the low luminosity of the cockpit did not favor the visual verification of the positioning of the levers.

Besides the aspects mentioned above, there are other ones that may have somewhat influenced the performance of the crew, in the context of the hypothesis analyzed, and that need to be highlighted.

The crew consisted of two captains, with the senior of the two sitting on the left seat during all the journey and acting as the PIC during the landings at Porto Alegre and Congonhas.

As a personal characteristic, the PIC displayed an average performance in terms of piloting, and had a background marked with minor difficulties in more critical operational situations, something that was counterbalanced by a high degree of standardization and adherence to the prescribed procedures. This characteristic reinforces the evidence that the MMEL had been consulted at the beginning of that flight.

At a certain moment during the approach, the PIC reported having a mild headache, according to the CVR. Although it has not been possible to determine the type of the cephalalgia, or evaluate its intensity, it is extremely plausible that this discomfort may have exerted some influence on his cognitive and psychomotor capabilities during the final moments of the flight, when the unpredictability of the situation demanded a more effective performance.

The other pilot – whose long previous experience as captain had been consolidated in Boeing type aircraft – had been recently hired by the operator, and had, at the time of the accident, approximately 200 flight hours in the A-320. This pilot occupied the right-hand-side seat during the entire journey and acted as SIC during the two landings conducted by that crew. It is worth highlighting that his experience in that function was just the training he did for the “Right Seat Certification”.

Since the role of the SIC is to monitor the flight – as well as the actions taken by the PIC and the flight parameters – 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 MMEL and in the SOP (Standard Operating Procedures).

This fact gets particularly clear at the moment the SIC realizes that the ground spoilers had not deflected. It seems as if he waited for the normal opening of the spoilers and, since it was taking a long time to occur, he advanced the confirmation of the opening of the engine number 1 thrust reverser.

Then, the announcement of the failing of the ground spoilers to open [SIC – “spoiler, nada” (“spoiler, nothing”)] was made in an almost mechanical fashion, as if he did not have the exact notion of the problem that was ahead.

An experienced co-pilot would tend to follow the operational parameters from a different perspective, on account of being more accustomed to doing the call-outs and knowing which answers to expect. Thus, he would likely be more efficient in the recognition of a deviation.

Although there were not any established procedures for the lack of opening of the ground spoilers, the mere reference to this problem to several captains and co-pilots made it clear that there are differences in the interpretation and management of the situation.

It can be questioned whether in a situation like that, in view of the feeble deceleration of the aircraft, a co-pilot would not verify, instinctively, the engine EPR values,

something that would have made him observe the position of the number 2 engine thrust lever.

As a matter of fact, at no moment of the management of that emergency situation was there any indication that either pilot had understood what was going on relatively to the aircraft and its systems.

Since the beginning of the journey, the crew had operated an aircraft which had the number 2 engine reverser disabled by the maintenance service.

Despite the fact that the reverser is a complementary decelerating system not considered for the calculation of the landing distance (dry or wet runway), it is a component whose contribution to the braking of the aircraft is significant, especially when operating on a runway with reduced dimensions and with a problematic historical background, as was the case of the Congonhas runway.

The fact that this equipment was not available to him may have influenced the pilot to some extent, from a psychological perspective, although the flight was being conducted within the operational envelope of the aircraft.

Though it is difficult to determine the level of impact that the lack of a reverser may have on the performance of a pilot, it is indisputable that it may at least generate anxiety, if the situation involves a landing operation in Congonhas with a wet runway.

Probably, the PIC was aware of the prescribed procedure – an increment of 55m in the landing distance required, for a contaminated runway – since it is in the MMEL, which was supposedly read at the beginning of the journey, in compliance with the company operational procedures, and applied for the landing in Porto Alegre. It is worth reminding that the PIC sought to overcome his limitations by means of technical knowledge.

On account of the scenario encountered by the JJ3054, and considering the characteristics of the PIC, it is possible to suppose that a good motivation to not complying strictly with the procedure prescribed in the MMEL for the landing with the pinned number 2 engine reverser would be the 'loss' of the 55m, if he considered that the runway of Congonhas was contaminated, something that would be plausible within that context.

If this was the case, the procedure performed was not the same that was in force before, since both thrust levers should have been set to "IDLE", according to that procedure.

However, considering that in the former procedure there was a moment at which only one thrust lever had to be activated (the one corresponding to the engine whose reverser was operative), it is possible to identify here more room for the occurrence of an error in the execution of the procedure. After all, the change in the procedure prescribed by the manufacturer had been made precisely due to the cases in which the error of moving only one of the levers had been made, and even contributed to the occurrence of the accidents of Bacolod (Filipinas – 1988) and Taipei (Taiwan – 2004). Besides, it is important to highlight that the FWC of the PR-MBK, in the same way of the A-320s of Bacolod and Taipei, did not have the H2F3 standard, an improvement offered by the manufacturer by means of a service bulletin.

Another important aspect, 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.

It is worth pointing out that the operations on the main runway had already been suspended for the evaluation of the water drainage conditions in the presence of rain, while the JJ3054 was still cruising. Later, the crew was informed by the TWR-SP that the runway was wet and slippery.

Therefore, it can be seen that the operation in Congonhas may have represented a source of concern, on account of the scenario within which it was being developed and that included: the 2.4 tons of weight added in the tankering, the crowded airplane, the pressure to proceed to Congonhas, the PIC's physiological condition (headache); a SIC with little experience as co-pilot in the A-320 (and its autothrust system), the wet and slippery runway, and the occurrences on the day before. Certainly, the scenario itself did not favor a better performance by the crew.

Also, it is necessary to consider that the human being makes his/her decisions in accordance with the context perceived by him/her. The way the context is perceived, however, does not always correspond to reality.

According to this line of reasoning, one can imagine that the PIC was willing to perform the old procedure on purpose, on account of considering that the Congonhas runway might be contaminated, so as to obtain a better performance in the deceleration of the aircraft after the landing at Congonhas, avoiding the increase of 55m prescribed in the MEL.

So, on account of all the pressure brought by the circumstances, he may have had his attention focused on the need to set only the number 1 engine thrust lever to the "REV" position (preventing the increase of the landing distance required) and, due to an error of perception, he may have commanded only that thrust lever to the "IDLE" position, letting the other lever remain at "CL".

Thus, the aircraft would have behaved exactly as recorded by the FDR. The lack of understanding of that behavior on the part of the pilots would have prevented the adoption of any corrective measures.

When both hypotheses are compared, the second one appears more likely, because a failure of the AFU activation during the landing seems highly improbable in statistical terms, in addition to the fact that the human error is an expected and frequent component of any complex system, aviation included.

2.4 Other aspects studied

Other issues relevant to accident prevention emerged during the investigation, and will be discussed below.

2.4.1 Aspects related to the A-320 design

First, it is necessary to consider that the ICAO establishes as a standard (Annex 8, Part II, Chapter 1, item 1.2.1) that the certification and continued airworthiness requisites of the national regulations must be conceived so as to ensure conformity with the pertinent dispositions of the Annex 8. This is, therefore, the basic premise that all national regulations have to comply with.

In the course of the investigation, it was verified that during the landing of an A-320 aircraft it is possible to set one of the thrust levers to the "REV" position, and the other one to "CL". In the specific case of the PR-MBK, it was verified that there was not a device on the aircraft to alert the pilots of a conflicting positioning of the levers relative to the condition for a landing.

This situation may place the aircraft in a critical situation and, depending on how long it takes for the aircrew to identify this configuration, and depending on the landing runway parameters, a catastrophic situation may occur.

In the hypothesis that the PIC inadvertently left the number 2 engine thrust lever in the "CL" position, the aircraft systems would not be able to provide any alerts relative to this potentially dangerous situation.

Once more, it is worth mentioning the dispositions of the Annex 8 (item 2.2.1.2, Chapter 2, and item 4.1 of the Part IIIA), which condition the design to the observation of the limitations imposed by the human performance: skill, strength, attention, inadvertent operations, etc.

The A-320 automation system is rather complex and induces the pilot to unconsciously create a mental model in the attempt to understand the way the operation of the aircraft is processed, and, thus, facilitate his interaction with the aircraft.

As already seen, the human mind is able to create only simplified mental models, which may even help understand the normal operations, but which are inadequate for the more complex and non-routine situations.

Consequently, during an abnormal situation, there is an increase of the importance of the alert systems of the very aircraft as sources of information for the maintenance of the situational awareness by the crew, on account of the fragility of their mental model.

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.

From the moment the aircraft touched the runway up to the collision, the pilots showed signs that they had not understood what was going on, and were not aware of how the system was preventing the aircraft from stopping.

In the same way, the importance of training to deal with abnormal situations is reinforced.

According to the recorders, at no moment was a verification of the setting of the thrust levers thought of, nor was there any reference on the part of the pilots concerning the power being developed by the number 2 engine.

Relative to this aspect, in particular, it is necessary to say that the pilots end up getting used to the fact that the thrust levers do not move automatically when there are changes in the engine power regimen made by the "autothrust" function.

Since during most of the flight it is useless to look at the thrust levers in order to identify the power being developed by the engines, the idea of a visual verification of the setting of the levers may not pass through the pilots' minds.

According to the simulations carried out during the investigation, it can be said that if the pilots had set the thrust lever of the number 2 engine to the "IDLE" position within 7 seconds after the verification that the ground spoilers had not opened, the aircraft would have stopped on the runway.

It is worth reminding that the recession of that thrust lever to the "IDLE" position would result in the immediate deflection of the ground spoilers, increasing the braking efficiency at the speed the aircraft was moving, and drastically reducing the runway distance required to stop.

So, the lack of a device to alert the crew of any setting of the thrust levers that could jeopardize the operation – in this case, one lever at "REV" and the other at "CL" – favored the loss of situational awareness on the part of the pilots, thus contributing to the occurrence of the accident.

Relatively to this issue, in special, it is important to analyze the certification of the A-320 in Brazil, which was made based on the RBHA 25, which in turn applies the prescriptions of the American regulation, according to the original version in English.

Both the American [14CFR25 - §25.1309, (c)] – and the European [whether the JAR §25.1309, (c), or the CS §25.1309, (c)] regulations – prescribe that warning devices be available to the crew to alert them about unsafe conditions of operation, and help them take the proper corrective actions. Both regulations demand that the systems, the controls and the alerting and monitoring means must be designed so as to minimize the crew errors that could result in further dangers.

In addition, the European regulation currently in force [CS §25.1309, (c)] demands that a warning indication be provided whenever an immediate corrective action is necessary.

In the PR-MBK, there was no alerting system that could lead the pilots to an understanding of a possible inappropriate setting of the thrust levers.

The very Annex 8, in the item 4.1 of Part IIIA, also disposes that the specifications of the design and construction must be such that they can reasonably ensure that all the components of the aircraft operate in an effective manner and are dependable under all possible operational circumstances.

And the 14CFR25, JAR-25 and CS-25 also require that the equipment, systems and installations be designed so as to guarantee the execution of their functions under all the foreseeable operational conditions (§25.1309, (a)).

So, the A-320 manufacturer, at the time of the aircraft certification, had not perceived the possibility of an inadvertent setting of one of the thrust levers to the "REV" position, with the other to "CL", but the records of the latest occurrences have demonstrated that, nowadays, such condition is quite known and foreseeable.

Once more, it is worth mentioning that similar situations had already been found in, at least, two other accidents: Bacolod (1998) and Taipei (2004). In both of those occurrences, the A-320 aircraft were operating with the reverser of one of the engines deactivated and neither aircraft had an alerting device regarding a contingent setting of the thrust levers in conflict with the necessary conditions for a landing. Also, in both accidents, the pilots failed to comply with the procedure prescribed by the manufacturer for the landing

with an inoperative reverser, and left the thrust lever of the engine with the deactivated reverser in the "CL" position.

Consequently, and based on all the regulations already mentioned, the lack of an efficient alerting device regarding this condition of operation implies a non-conformity relative to the applicable certification requisites.

From the perspective of aeronautical accident prevention, it is essential to highlight that, since this possibility of an inadvertent setting of the thrust levers has been evidenced in the products of various manufacturers, not being restricted to the manufacturer of the accident aircraft, it is a problem that affects the whole industry.

However, the contribution of the aircraft design was not limited to the lack of an alert regarding the inadvertent setting of the thrust levers.

Despite its degree of sophistication, the need of segregation of the A-320 systems favored a situation of antagonism between the systems that governed the number 1 engine and those which governed the number 2.

The logic that determined this antagonist behavior needs to be revised, since it goes against the dispositions of the Annex 8 and the regulations concerning the certification, as already commented at length.

Conceived as a resource to diminish the workload and minimize the incidence of human errors in the face of the increasing complexity of the systems that compose the aircraft, automation has also been a concern of the aeronautical community on account of its side effects.

It is a fact that the introduction of automated systems favors the development of a state of complacency on the part of the pilots, as a result of the gradual change of the role they play onboard the aircraft, towards becoming more and more a supervisor of the tasks performed by the computer.

In view of the renowned efficiency of the computer, the confidence of the pilot on its infallibility makes him relax in the monitoring of the flight conditions, believing that everything is totally under control.

This false impression ends up reducing the situational awareness and jeopardizing the flight safety, especially in a non-routine situation.

In the specific case of the A-320, the pilot gets used to receiving from the aircraft the guidance and the procedures to be performed in every situation, strengthening the level of accommodation and dependence in the man-machine relationship.

For example, during the "flare" for the landing, the "RETARD" auto call-out reminds the pilots (who are flying the aircraft with the "autothrust" function activated) that both thrust levers must be set to "IDLE".

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 wrong decisions exactly at a critical moment for the flight safety.

Still in relation with the "RETARD" auto call-out, it is important to observe that during the JJ3054 flight the warning device did not perform the function to which it had been designed, since it stopped sounding when one of the thrust levers was at "REV" and the other was at "CL".

Besides, on other flights, it was confirmed that the auto call-out is activated even when the thrust levers are already at "IDLE" and the airplane crosses 20ft of radio altimeter on the approach for landing.

According to the § 25.1301 of the 14CFR25, JAR-25 and CS-25, each item of equipment installed in the aircraft must be of the type and design appropriate for the desired function and must operate accordingly when installed.

Resuming the sequence of the accident: just after the landing, the only thing done by the system was to inform the pilots about the non-deflection of the ground spoilers, without a corresponding procedure to allow the opportune braking of the aircraft, or even one that could establish a link between the setting of the thrust levers and the non-deflection of the ground spoilers.

The dynamic that is in the relationship between the pilot and the automation conditions him to wait for guidance in the situations which are out of the normality. At a critical moment, the guidance was not presented, and the pilots were not prepared to understand what was happening.

Another issue is the fact that the actuation of the autobrake in the A-320 depends on the deflection of the ground spoilers. At landings with an armed "auto brake", the pilot has the expectancy that the automatic system will allow to brake the aircraft.

At the landing, despite the "call out" of the ground spoilers condition after the aircraft touches down, there is not a memorized procedure associated to the instance of non-actuation of the ground spoilers, and the crew is only capable to perceive the lack of efficiency of the autobrakes after a few seconds, on account of the lack of deceleration of the aircraft.

The understanding of this situation can demand a critical time interval before a corrective action be taken by the crew to prevent a catastrophic situation. It is worth, at this point, referring to the Annex 8, Chapter 2, item 2.3.

Also, it is important to remind that the manuals of the aircraft are big and difficult to consult, mainly during the flight. Frequently, the search for information on a certain subject ends up demanding a further reference to other sections of the document through which the subject may be distributed.

Obviously, the system did not determine any procedures since it worked as it had been designed to. In other words, for the system there was no failure at all, and, thus, there was no procedure to be proposed.

However, there is some sort of inappropriateness in the very logic of perception and response of the aircraft automation. It allows the crew to put the aircraft in a critical

condition and does not offer sufficient and opportune information so that the crew can resume the situational awareness and recover from that condition.

This logic of the system, in view of the regulation already mentioned, exposed the occupants of the aircraft to a situation of danger, and needs to be revised.

2.4.2 Latent conditions present in the operator

As for the operator, although the aircraft maintenance services were considered appropriate, the maintenance control system was thought to be vulnerable to mistakes in the feeding and in the assessment of the risks resulting of the associations of minor failures.

Starting with the filling-out of the RTA forms, some of the writings were unreadable, incomplete and with erasures. In addition, there was a lack of standardization relative to the language to be used, with some forms containing parts written in Portuguese and other parts in English.

Considering that the records of the failures are inserted in the computerized control system from these forms, the lack of standardization and the carelessness with which they are filled may result in a misreading of the records. Thus, a wrong date, for example, may lead to a mistake regarding the deadline prescribed for the corrective maintenance. It can also lead to the replacement of a wrong component, as a result of a misreading of its "Part Number".

Although there was an internal instruction of the company regarding the correct filling of those forms, it was not sufficiently detailed to cover all the potential problems.

There was also, with the exception of the RTAs originated in Congonhas and in the Maintenance Center of São Carlos, a certain lack of control of the forms filled, and it was not possible to find copies of several RTAs, which were being carried in the accident aircraft and were destroyed by the fire.

This lack of control was aggravated by the fact that the routine records ("NIL") in which there was not any problem reported were not, necessarily, forwarded for insertion in the maintenance database.

Thus, although the sequential numbering of the RTAs was a supporting tool for the control, it was common that some of the numbers in the sequence of records were missing.

Besides, the maintenance control system of the company allowed the postponement of certain corrective measures until a more comprehensive inspection could be made.

So, each failure was individually analyzed in order to establish the urgency of the forecast corrective action. Thus, a number of small failures, on account of being analyzed individually, could have their respective corrective actions delayed until the next inspection, without a proper evaluation of the impact on safety due to the cumulative effects and the associations between these failures.

The process, therefore, lacked a system for the management of the risk related to these associations.

As an aggravating circumstance, there was not an efficient oversight of the application of the dispositions contained in the documentation governing the activity of the sector, as well as in the regulations in force.

The reporting of the recurrent failures and malfunctioning was not being made regularly, contrary to what is prescribed in the RBHA 121 and in the very MGM of the

company, ratifying the observation that the inspecting agency failed to perform its duties, also in relation to the company.

On the other hand, due to commercial reasons, there was also a clear concern on the part of the maintenance sector of the company to comply with the requirements set by international organizations.

This aspect in particular does not come to the point of jeopardizing the operation, since those international requirements are normally much more conservative in terms of safety, but it shows some level of inappropriateness in the priorities relative to the compliance with the regulations in force, and suggests that the minimums established fall short of what is necessary.

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 JJ3054.

By and large, this unbalance in the composition of the crews favored the creation of an inappropriate climate on board and, depending on the complexity of the operation, it strengthened the influence of factors such as authority conflict and complacency, making it difficult to manage the flight.

Besides, according to the investigations of accidents in recent years, there is evidence that the climate generated in the cockpit operated by two captains tends to be complacent and/or uncomfortable, something which generates obstacles for good teamwork, thus hindering the effectiveness of the crew.

Another point refers to the differences between the formal culture of the organization and the way it is perceived by a certain part of its crewmembers, something that denotes certain fragility in the managerial sphere, mainly in relation to the way the company transmits its values to the employees. The lack of a more effective response on the part of the "Safety" regarding the operational safety reports received, possibly on account of the small number of qualified professionals in the sector, reinforced those differences. The initiative of some pilots to perform procedures they deemed more correct, in detriment of the ones prescribed, is an example of the adverse effects produced by such differences.

2.4.3 Regulation and inspection of the civil aviation

On the part of the regulatory activity, the problems concerning the operation at Congonhas were already being monitored, on account of the relevance of that airport to the passenger air transportation in Brazil.

As it was verified, in the beginning of 2006, the ANAC held meetings to deal with the issue involving the operations at Congonhas, seeking to find mitigating measures to be adopted for the maintenance of the safety conditions in the operations on the main runway.

Thus, on 10 April 2006, as a result of one of the meetings, the Agency recognized the need of the operator to have, for the operation in Congonhas with a wet runway, **all the thrust reversers in operating conditions**. These actions are recorded in the meeting minutes.

However, it was only in December of that year that a draft Supplementary Instruction appeared, in which the Agency established the obligation to use the reversers for the operation in Congonhas with a wet runway condition.

Nevertheless, the draft, which was even placed on the official Internet page of the Agency in the beginning of 2007, would only have its content transformed in a norm on the 31 March 2008.

Although it is not possible to predict the consequences in case the landing had occurred at another airport (probably Guarulhos), it is possible to presume that this accident would not have happened if the requirement for operating reversers had been in force before the 17 July 2007, as the aircraft would not have been allowed to proceed for a landing in Congonhas.

Consequently, it is possible to realize that the regulation process by ANAC was not efficient, due to the long time taken to declare as mandatory a requirement that was already known.

Concerning the inspecting activity, it is important commenting the fact that the works of enlargement of the passenger terminal and apron of Congonhas were not previously approved by the competent organization.

Therefore, in the case of the apron works, the inspecting organization would have been deprived of the opportunity to study the project, in which it could have perceived a contingent risk in the alteration of the illumination system.

Also, it was verified that the modifications brought by those works had not been object of homologation, since, according to an understanding shared by the ANAC and the INFRAERO, the runway had not suffered alterations in its physical characteristics (defined in the 2nd paragraph, article 36 of the IAC 2328-0790). Consequently, the prescriptions of the Instruction would not be applicable.

In principle, such understanding seems questionable, as the instruction deals with changes in the resistance and type of the pavement. It is worth recalling that on that very runway a rugged pavement had been installed, which later was replaced with another one.

In fact, this investigation has not found any evidence that the works on the main runway of the airport received a formal previous authorization from the ANAC, as prescribed in the article 36 of that IAC.

Considering that the authorization for a work is granted after a study of the respective project, it is possible to presume that some important issues from the operational safety perspective – such as the measurement and divulgence of the friction and surface texture coefficients, the reopening of the runway for operations before the making of the grooving, and the establishment of inspections for the reopening of the runway – would have been evaluated in a study like that, together with the associated risks.

Anyway, even if one considers this understanding as technically correct, it seems to deviate from the spirit of the instruction, which clearly intends to deal with changes that have impact on the operation of the aircraft. This becomes apparent when one realizes that the characteristics of the operation result, among other aspects, from the quality of the friction, rubber build-up, and drainage of the pavement installed.

On the other hand, the norm is not sufficiently clear and needs to be revised, since it allowed an interpretation that ultimately inhibited the identification of the conditions of danger and restricted the management of the risks resulting from the works.

At this point, in particular, the conduction of an airport inspection during the works on the runway, as determined by the IAC 162-1001A, would have allowed the identification and management of the risks associated to those issues. However, the special airport inspection during the runway renovation work was not made by the ANAC.

Thus, within the hypothesis number 2, this aspect gains relevance since it denotes a certain 'distance' between the inspecting agency and the accomplishment of its tasks before the airport administration, contributing to the climate of lack of safety perceived by the crews relative to the operations in Congonhas.

This inspection became still more important because the intention was to reopen the runway for operation without the making of the grooving. In other words, the runway started being used before the conclusion of the project of renovation that had been contracted.

So, the lack of a formal investigation of all the necessary technical requirements regarding the safe operation of the main runway and the lack of a formal procedure for its reopening contributed to the mistrust relative to its real safety conditions.

Conversely, the operation of the runway was resumed through the mere expiration of the NOTAM, which had been issued on account of the renovation works. There was not publication by the INFRAERO of the new friction and surface texture coefficients concerning the recovered runway, which was required by the RSV 13 / A / 06, issued by the CENIPA in April 2006 (after all, there were no guarantees that the problems had been solved, and the recommendation mentioned had not been cancelled).

Besides, the special post-accident airport inspection, prescribed by the IAC 162-1001A, was not made by the ANAC, and the aerodrome resumed operation on the following day, using only the secondary runway.

During the investigation, it was observed that the process of communication of recurrent failures and malfunctioning by the operator – prescribed in the RBHA 21 – was not efficient, and there was even lack of this type of communication. This fact was not detected by the ANAC.

Generally speaking, the efficiency of the ANAC in its operational activities could have been improved, if its SIPAER-Link had followed the normative directives issued by the central organization of the SIPAER (CENIPA).

Despite the fact that it is not possible to estimate the influence that the monitoring of the processes of regulation and inspection exercised by the ANAC's SIPAER-Link (its main task in the opinion of CENIPA) would have on the operational safety of the civil aviation, its contribution in terms of an increase of the ANAC's efficiency would have been perceptible, contributing to its own success in the accomplishment of the safety related objectives established by the Agency.

2.4.4 Airport administration

Up to the occasion of the accident, the Congonhas Airport did not have an Operational Certificate, in the terms of the RBHA 139, although operating international flights and regular domestic air transport, utilizing aircraft with more than 60 (sixty) passenger seats. Consequently, the airport did not have a MOA approved by the inspecting agency either.

It is worth reminding that an approved MOA would necessarily contain the various procedures concerning the operational safety measures for the execution of the works and, among them, the procedures for the inspection upon the completion of the works.

The airport did not have a runway end safety area (RESA) either, in discordance with what is prescribed by the Annex 14. Although it is not possible to affirm that the establishment of the RESA in Congonhas before the occurrence would have been able to

prevent the accident, it is possible to presume that the anxiety caused to the pilots by the runway conditions could have been mitigated.

The works executed for the expansion of the operational capacity of Congonhas were not previously submitted to the inspecting authority for approval.

In relation to the works of renovation of the runways, the airport administration did not timely demand the confirmation of the compliance with the requisites concerning the paint used for the markings of the runway.

The demonstration of conformity with the prescribed specifications of the work project was established by means of a technical opinion elaborated by the company that made the markings, dated from 30 July 2007 (thus, after the opening of the runway for operations). This goes against the prescription of item 3.3.4.3 of the managing company document (code SÃO/GRL/900 ET-247/R2, sheet 210), which requires the technical opinion to be presented before the application of paint:

“The application shall not be initiated before the presentation of the paint award, issued by a reputable organization, considering the approved lot, in accordance with the item 3.3.5.1.”

On the rainy days preceding the accident, the same procedures established through operational agreements were utilized for the determination of the runway conditions. However, as the procedures were established for a context in which the runway favored the accumulation of water for being uneven, their efficiency in the determination of the runway conditions after the renovation of the pavement was poor. With the renovation of the pavement, the irregularities of the pavement were removed.

In view of the discrepancies between the measurement of the surface texture made by the DIRENG after the accident and those made by the IPT, it is possible to suppose that the deficiency of the water drainage was due to the early accumulation of rubber on the tarmac. This would explain the differences in the measurements of the surface texture, as well as the similarities in the friction coefficients obtained by both organizations.

The accumulation of the rubber released by the aircraft tires mainly during the landing operations causes the clogging of the grooves that allow the draining of the water from the pavement.

In a certain way, with the beginning of the operations on the newly paved runway, the natural rubber accumulation resulting from the contact of the aircraft tires with the runway surface may have been more intense, so that the interval between the maintenance services (rubber removal) may have become longer than the necessary for the new pavement.

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3. CONCLUSION

3.1. Facts

- a. Both pilots held valid Medical Certificates (CCF);
- b. Both pilots held valid Technical Qualification Certificates (CHT) and IFR ratings;
- c. Both pilots were qualified and, according to the legislation then in force, had the necessary experience to conduct the flight;
- d. The aircraft had valid Registration and Airworthiness Certificates;
- e. The maintenance services were considered periodic and appropriate;
- f. Starting with the departure from Porto Alegre up to the landing at Congonhas, the aircraft had been within the limits of weight and balance established for the operation;
- g. The aircraft had the number 2 engine reverser deactivated, in accordance with the procedures established in the MEL;
- h. The parameters with which the aircraft was dispatched were within the operational envelope of the aircraft;
- i. The growth of the operator accentuated the effects of the lack of coordination among its diverse sectors, hindering the oversight at all management levels;
- j. The preventative tools were not well utilized by the operator;
- k. The operator's maintenance control system allowed postponing corrective actions without an appropriate evaluation of the risk relative to the association of failures;
- l. The operator was not able to retrieve all the copies of the maintenance records destroyed in the accident;
- m. The communication of recurrent failures and malfunctioning was not being done regularly to the Civil Aviation Authority;
- n. The prevailing meteorological conditions along the route and at the destination were known to the crew;
- o. The FWC of the PR-MBK did not possess the improvement introduced by the H2F3 standard;
- p. The FDR did not record any movement of the thrust lever of the engine nº 2, from the moment it was positioned at "CL" up to the collision of the aircraft;
- q. The landing occurred with one of the thrust levers at the "IDLE" position and the other one was registered by the FDR as being at the "CL" position;
- r. The positioning of the nº 2 engine thrust lever in "CL", while the nº 1 engine thrust lever was in "IDLE", determined the variation of the parameters of the first engine in trying to maintain the speed previously selected;
- s. After the landing, there was neither deflection of the ground spoilers, nor activation of the auto-brake;
- t. Approximately six seconds after the touch-down of the main gear, the first activation of the brakes through the pedals occurred, and reached maximum deflection five seconds later;

- u. For the conditions of operation with an inoperative reverser, wet runway, positioning of a thrust lever in "REV" and the other in "CL", a distance of more than 2,000 meters would be necessary for a complete stop of the aircraft, without considering the thrust provided by the nº 2 engine;
- v. The thrust reverser of the A-320 can only be activated when: the aircraft is on the ground with both the right and the left landing gear dampers compressed; a channel of the FADEC (Full Authority Digital Engine Control) is operating according to the reverse signal of the corresponding thrust lever; and a signal of the TLA (Thrust Lever Angle) is being validated by, at least, one SEC (Spoiler Elevator Computer);
- w. The A-320 power control system, even with the airplane on the ground (WOW), with the nº 1 engine thrust lever in the "REV" position, with the ground spoilers armed, with the auto brake selected and with application of maximum braking pressure on the pedals, gave priority to the thrust lever in the "CL" position;
- x. There were no errors in the FDR data recording process;
- y. There were no failures in the FADEC;
- z. There were no failures in the TCU (Thrust Control Unit);
- aa. There was no failure in the activating rod which connects the AFU (Artificial Feel Unit) to the TCU, or its connection;
- bb. It was not possible to discard a mechanical failure of the activating rod which connects the thrust lever to the AFU, or a failure of the AFU itself;
- cc. The PIC knew the prescribed procedure for a landing with an inoperative thrust reverser;
- dd. The PIC, during the descent, complained that he had a headache;
- ee. The SIC's experience as a co-pilot was limited to the "Right Seat Certification" training;
- ff. In the PR-MBK, there was no alerting system to warn the pilots of an inappropriate setting of the thrust levers;
- gg. The "RETARD" auto call-out, during the flight JJ3054, did not comply with the function to which it was designed, since it stopped sounding when one of the thrust levers was at the "REV" position and the other one was at "CL";
- hh. There are various records of occurrences in which the airplane had an inoperative thrust reverser, and the crew inadvertently placed a thrust lever in the "REV" position with the other one in the "CL" position;
- ii. The A-320 manuals have lots of pages and are hard to consult, mainly during the flight;
- jj. Congonhas Airport was not certified at the time of the accident, in discordance with the RBHA 139;
- kk. The works in the passenger terminal and on the parking ramp completed in 2007 were not homologated;
- ll. No special airport inspection was made during the works conducted at Congonhas Airport and completed in 2007;
- mm. No special post-accident airport inspection was made;
- nn. Up to the date of the accident, the main runway of Congonhas did not have a RESA;
- oo. The main runway of Congonhas presented, during a long time, a low coefficient of friction and irregularities on its surface which favored the accumulation of water;

pp. On 10 April 2006, the ANAC recognized the need of the operator to have all the thrust reversers in good working order for the operation in Congonhas with a wet runway condition.

qq. The inspecting organization did not detect the lack of communication of recurrent failures and malfunctioning prescribed in the RBHA 21 on the part of the operator;

rr. On 29 June 2007, the operations on the main runway of Congonhas were resumed, after the completion of the pavement repair work, but before the grooving was made;

ss. There was no rain precipitation during the operations in Congonhas between 29 June and 14 July 2007;

tt. Congonhas airport operated under rain on the days 15, 16 and 17 July 2007;

uu. On 16 July, a regular transport aircraft had an accident after aquaplaning on the main runway of Congonhas while landing;

vv. At the moment of the accident with the JJ3054, the volume of precipitation recorded at Congonhas was 0.6 mm;

ww. On the day of accident, the PR-MBK airplane itself had landed twice on the main runway of Congonhas, the first time at 11:11 am (JJ3701), when the recorded volume of precipitation was 1.5 mm;

xx. The works carried out in the passenger terminal and on the parking ramp did not formally receive the previous authorization established in the IAC 2328-0790;

yy. In April 2008, a norm was issued by the ANAC prohibiting the operation at Congonhas with a wet runway if any of the reversers was not available.

zz. The aircraft was completely destroyed.

3.2 Contributing factors

According to the SIPAER regulations, a contributing factor is a condition (act or fact, or a combination of the two) which, together with other ones, in sequence or as a consequence, leads to or allows the occurrence of an aeronautical accident, incident or ground occurrence, or which contributes to the aggravation of its consequences.

The contributing factors are classified in accordance with the approach utilized by the operational safety, namely Human Factors or Material Factors.

Below, a list is presented with all the factors whose contribution was effectively established, regardless of the degree at which such contribution has occurred. Also, the factors whose contribution, however possible, has not had a confirmation established along the investigation, in which case they were labeled as undetermined.

The SIPAER regulation establishes, in addition, that each one of the identified factors (contributing or undetermined) be subject to at least one safety recommendation. Thus, any factor that has, either effectively or potentially, contributed to the consummation of the accident will be the object of a preventative and/or corrective action.

The classification of the factors as either contributing or undetermined just reflects one's capability to confirm, with a reasonable degree of certainty, the presence of such factors among the actions and/or conditions which preceded the accident, and do not imply the assignment of values or degrees of importance to any of them.

3.2.1 Human factors

The Human Factors constitute the operational safety approach of the biological complex of the human being, and deals with the Medical, Psychological and Operational Aspects.

3.2.1.1 Medical aspect

The Medical Aspect corresponds to the area of the Human Factors in which there is the involvement of medical and physiological knowledge that is researched in order to define the presence of variables of this nature and the form of its participation in the events.

a. Pain - Undetermined

This factor is represented by a state of physical suffering resulting from illness and/or injury.

At a certain moment, during the approach, the PIC reported having a mild headache. Although it was not possible to verify which type of headache it was, or even to evaluate its intensity, 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.

This factor was considered undetermined due to the impossibility of confirming its contribution in factual terms.

3.2.1.2 Operational aspect

The Operational Aspect corresponds to the area of Human Factors relative to the performance of the human being in the activities directly associated with the flight.

a. Training – A contributor

This factor refers to the participation, from an operational perspective, of the training process previously received by the one(s) involved in the occurrence, on account of a quantitative and/or qualitative deficiency, in that they have not succeeded in obtaining full knowledge and other technical conditions necessary for the exercise of the activity.

The theoretical qualification of their pilots was founded on the exclusive use of computer interactive courses (CBT), which allowed a massive training, but did not ensure the quality of the training received.

In addition, the formation of the SIC was restricted to the “Right Seat Certification”, something that proved insufficient for him to deal with the critical situation experienced after the landing.

Lastly, there was a perception among the crews interviewed that the training through the years and on account of the high demand resulting from the company's growth was being abbreviated.

b. Application of the commands – Undetermined

This factor is related to the inappropriateness in the use of the aircraft flight controls on the part of the pilot(s).

One of the hypotheses considered in this investigation was that the pilot may have attempted to perform a procedure no longer in force at the time of the accident for the landing with a pinned reverser. This procedure consisted in the receding of both levers to the "IDLE" position during the flare at about a 10-foot altitude, and, after touching down, in activating the only reverser available, maintaining the thrust lever of the other engine in the "IDLE" position.

This procedure, though being more efficient from a braking perspective, could induce the crew to making mistakes, as there were several reports of occurrences in which there was a wrong setting of the levers, motivating the manufacturer to establish a new procedure, months before the accident.

Thus, there is a high probability that the PIC inadvertently left one of the thrust levers in the "CL" position, placing the other one first in "IDLE" and later in the "REV" position.

This factor was considered undetermined due to the impossibility of confirming its contribution in factual terms.

c. Cockpit coordination – A contributor

This factor deals with the inefficiency in the use of the human resources available for the operation of the aircraft on account of: inappropriate management of the tasks assigned to each crewmember, failure or confusion in communication or interpersonal relationship, or inobservance of operation rules.

Independently of the hypothesis considered, the monitoring of the flight at the landing was not appropriate, since the crew did not have perception of what was happening in the moments that preceded the impact. This loss of situational awareness hindered the adoption of an efficient and timely corrective action.

d. Forgetfulness by the pilot - Undetermined

This factor refers to the involuntary omission of a procedure, or part of it, by the pilot, as a result of a failure in the process of evocation of mnemonic contents.

It is possible that the pilot has inadvertently left one of the levers at the "CL" position, while trying to perform a procedure no longer in force for the operation with a pinned reverser.

This factor was considered undetermined due to the impossibility of confirming its contribution in factual terms.

e. Flight indiscipline – Undetermined

This factor deals with the (intentional) violation of operational norms, regulations or air traffic rules by the pilot, including the clearances issued by the ATC unit, without a justifiable reason.

The procedure prescribed for the operation with a pinned reverser had been modified by the manufacturer and, according to the FDR recordings, the procedure in force was known to the crew and executed by them on the leg that preceded the accident. However, as this procedure imposed an increase of up to 55 meters in the calculations of runway distance required for landing, it is possible that the PIC deliberately tried to perform

a procedure no longer in force in order to obtain a shorter landing distance. The deliberate adoption of a procedure no longer in force would characterize flight indiscipline.

This factor was considered undetermined due to the impossibility of confirming its contribution in factual terms.

f. Influence from the environment – Undetermined

This factor deals with the interference of the physical environment (cockpit or external) on the individual performance, except the one originating from weather phenomena.

The operating conditions of the Congonhas runway, may have affected the crew's performance from a psychological perspective, considering the state of anxiety that was present in the cockpit.

In addition, the lack of luminosity resulting from the operation at night time, associated with the size and color of the thrust levers may have hindered the verification of a contingent inappropriate positioning of those controls during the landing.

This factor was considered undetermined due to the impossibility of confirming, in factual terms, the psychological influence of the runway operating conditions and/or lack of luminosity on the performance of the crew.

g. Judgment of pilotage – Undetermined

This factor refers to the inappropriate evaluation on the part of the pilot(s) of certain aspects related to the aircraft operation, when they are qualified for the operation.

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 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 – there is a high probability that the PIC deliberately tried to perform the procedure no longer in force for the operation with a pinned reverser, in order to increase the braking efficiency, inadvertently leaving the number 2 engine thrust lever in the "CL" position. Considering this hypothesis, the diversion to an alternate airport would be desirable, instead of trying to perform a procedure that was not prescribed.

This factor was considered undetermined due to the impossibility of confirming its contribution in factual terms.

h. Management planning – A contributor

This factor refers to the inappropriateness of the planning made by the organization at a management level, mainly in relation to the allotment of human and material resources for the conduction of operational activities.

At the time of the accident, the operator had a disproportional number of captains in comparison with the number of co-pilots, a fact that obliged the scheduling sector to form crews with 2 captains. Thus, although complying with the minimum requirements of the regulation in force, such a practice may have contributed to the creation of a climate of complacency in the cockpit of the JJ3054.

Besides, the long experience of the SIC as a captain was not a guarantee of his competence in the co-pilot function – for which he had done only the “Right Seat Certification” training – and, added to his little experience in that aircraft, it contributed to the loss of situational awareness in the most critical moments of the flight.

i. Flight planning – Undetermined

This factor refers to the inappropriateness of the work done by the pilot for the preparation of the flight or part of it.

Thus, considering the hypothesis that the PIC deliberately tried to perform the old procedure for a landing with a pinned reverser to increase the braking efficiency, it is possible that the use of that procedure was not appropriately prepared, something that could have favored the wrong positioning of the levers (according to the hypothesis mentioned above, it is possible that the PIC inadvertently left the n°2 engine thrust lever in the “CL” position.).

The lack of a briefing for the descent in the CVR recording hindered the confirmation of a possible intention of applying the old procedure, no longer in force at the time.

This factor was considered undetermined due to the impossibility of confirming its contribution in factual terms.

j. Little experience of the pilot – A contributor

This factor refers to a condition presented by the pilot, resulting from little experience in the air activity, in the aircraft or, specifically, in the type or circumstances of the operation.

Despite his long experience in commercial jets, the SIC possessed only about 200 flight hours in aircraft of the A-320 type. Besides, his experience in the function of co-pilot was restricted to the “Right Seat Certification” training, which proved insufficient to deal with the emergency situation.

k. Management oversight – A contributor

This factor refers to inappropriate oversight by the management sphere of the organization (excluding the crew), regarding the planning and/or execution activities in the administrative, technical and/or operational areas.

The operator allowed the crew to be composed of two captains, with the occupant of the right-hand seat having done only the “Right Seat Certification” training.

Besides, the lack of coordination between the several sectors of the company, especially between the sectors of operation and training, determined the lack of an appropriate monitoring of the processes and of the quality of the pilots’ professional formation.

3.2.1.3 Psychological aspect

In the psychological aspect, one considers the participation of individual, psychosocial or organizational psychological variables in the performance of the person involved.

a. Anxiety - Undetermined

This factor refers to the sensation or feeling resulting from an excessive neural stimulation, following the interpretation of a dangerous situation.

The CVR recording allows to perceive that the PIC was showing anxiety in relation to the runway conditions for landing, and on two different occasions he asked the SIC to request from the TWR-SP the rain and runway conditions, and on one of them specifically, whether the runway was slippery. It is possible that the state of anxiety present in the PIC may have influenced the performance of the crew to some extent.

This factor was considered undetermined due to the impossibility to confirm that this anxiety has effectively influenced the performance of the crew.

b. Perception error – A contributor

The contribution of this factor takes place when one gets aware of a stimulus, failing, however, to interpret it correctly.

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.

c. Stress - Undetermined

This factor refers to the coordinate chemical mobilization of the whole human body, perceived as balance disturbing.

The stress has effect on the cognitive level (diminution of the concentration, diminution of the response speed, degradation of the memory, etc.), emotional level (alteration of the characteristics of personality, weakening of the emotional control, lowering of the self-esteem, etc.), behavioral level (alterations of the sleep pattern, diminution of interests, verbal articulation problems, etc.), and physiological level (sudoresis, tachycardia, sleep pattern alterations, gastric and dermatologic symptoms, etc.).

The presence of stress triggering stimuli was perceived, such as the state of anxiety on the part of the pilots, especially regarding the runway conditions, the cephalalgia of the PIC, the issues concerning the operation in Congonhas with a wet runway, the crowded aircraft and the inoperative reverser. However, it was not possible to determine whether those stimuli effectively led any of the two pilots to a high level of stress.

This factor was considered undetermined due to the impossibility to confirm its contribution in factual terms.

d. Lack of perception – A contributor

The contribution of this factor happens when someone fails to become aware of a stimulus. The reason may vary from lack of attention to lack of clarity of the stimulus.

Considering the hypothesis of a failure in the thrust control system, the contingent stimulus generated from the loss of resistance to the movement of the thrust levers may not have been perceived by the pilot(s), according to the CVR recordings

On the other hand, if one considers the hypothesis that the nº 2 engine thrust lever was inadvertently left in the “CL” position, while the pilots were trying to perform a procedure no longer in force, the characteristics of the autothrust system, which keep the levers motionless during the variations of thrust, in addition to the size and color of those control levers, hard to be observed on a night flight, were not sufficiently evident to be perceived by the pilots. This situation was aggravated by the lack of a warning device relative to the conflicting positioning of the thrust levers.

e. Loss of situational awareness – A contributor

This factor corresponds to the loss of a precise perception of the factors and conditions which affect the aircraft and its crew during the execution of a task. In other words, the loss of the situational awareness means the failure to perceive what is going on around, failing to keep conscious of the several variables pertinent to the operation or the flight, something that hinders the taking of a quick and correct decision.

Thus, no matter which hypothesis is considered, the loss of the situational awareness emerged as a result of the very lack of perception on the part of the pilots. In this sense, the automation of the aircraft, however complex, was not capable of providing the pilots with sufficiently clear and accurate stimuli, to the point of favoring their understanding of what was happening in the moments just after the landing in Congonhas.

f. Organizational climate - Undetermined

This factor is characterized by the contribution of a set of perceptions, feelings, attitudes, states of mood, which exists among the members of an organization, in the relationships between the individuals (of the same group or different groups) and between groups, on account of the rules and norms established.

In relation to the crews of the company, the investigation identified the perception that there was a pressure on the part of the management against diversions, on account of the inconvenience they could arise for the passengers and for the company itself.

If the pilots of the JJ3054 shared that perception, it is possible that this factor could have some influence on the pilot's decision to proceed for the landing in Congonhas, in spite of his concern with the runway operating conditions.

This factor was considered undetermined due to the impossibility to confirm its contribution in factual terms.

g. Regulation – A contributor

This factor refers to the influence of the inappropriateness or absence of legal, regulatory or normative precepts.

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.

h. Training - Undetermined

In the psychological aspect field, this factor covers the educational process through which the human resources of an organization develop efficiency in their present and future work, refining habits of thought and action, skills, knowledge and attitudes which allow them

to perform their activities in that operational context, considering: the content relative to the emergency situations, safety and prevention of accidents/incidents in theoretical and practical terms; the instructor – student relationship; the method used for the evaluation of the training and learning; the training frequency; and the compatibleness between the duties performed and the technical qualification.

In relation to the training, the investigation identified in the crews a perception that the company seemed to have reduced the contact hours applied to it, although in formal terms those contact hours had remained unaltered.

In relation to crew professional formation, the investigation identified a tendency on the part of the company to reduce the number of hours assigned to training, which remained unaltered in formal terms.

Moreover, the FDR recordings showed that, during the period in which the aircraft operated with the pinned reverser, 5 different types of landing procedures were performed by the various crews who operated it.

Este fator foi considerado indeterminado devido à impossibilidade de se comprovar factualmente que a percepção dos tripulantes entrevistados correspondia à realidade dos processos de treinamento empregados pelo operador e/ou que estas tenham efetivamente influenciado o desempenho da tripulação, contribuindo para o acidente.

This factor was considered undetermined due to the impossibility to confirm, in factual terms, that the crews' perception of a shortening in the training processes being applied was consistent with reality and/or whether such alleged shortening effectively influenced the performance of the crew, contributing to the accident.

3.2.2 Material factors

The Material Factors represent an approach regarding the operational safety of the aircraft, including its components, as well as items of equipment and information technology systems used in the airspace control, in their aspects of design, manufacturing, handling of material, and failures not associated with the maintenance services.

a. Design – A contributor

It deals with the participation of the aircraft or component design, on account of inappropriateness of the material established; of the controls, lights or instruments, on account of their shape, size, installation or positioning; or of the inappropriate setting of operation and/or preventative maintenance parameters.

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.

4. SAFETY RECOMMENDATIONS

A Safety Recommendation is a measure whose nature is either preventative or corrective and is determined by the Aeronautical Authority or SIPAER-Link within its respective area of responsibility, aiming at eliminating or mitigating the risk generated by a latent condition or active failure.

4.1 To the National Civil Aviation Agency - ANAC

It is recommended:

RSV (A) 45/ A / 07 – CENIPA

Issued on 21/July/2007

To immediately restrict the operation on the 17R/35L runway (main runway) of Congonhas Airport (SBSP) to the condition of “dry runway”.

RSV (A) 46 / A / 07 – CENIPA

Issued on 17/Sept/2007

To consider the 17R/35L (main) and the 17L/35R (auxiliary) runways of the Congonhas Airport (SBSP) as **PRACTICABLE**, only when their surface characteristics meet the skid-resistance requirements prescribed in the Civil Aviation Instruction – IAC 4302, dated 28 MAY 2001, taking into account the Safety Recommendation - RSV (A) 45 / A / 07 – CENIPA, issued on 21/July/2007.

RSV (A) 47 / A / 07 – CENIPA

Issued on 17/Sept/2007

To evaluate the condition of PRACTICABILITY of the 17R/35L (main) and 17L/35R (auxiliary) runways of the Congonhas Airport (SBSP), based on the results of the friction and surface texture measurement tests of their pavements, executed and forwarded by the Airport Administration after the construction, re-covering, maintenance or periodic inspection of the runways, in accordance with the IAC 4302, dated 28 MAY 2001.

RSV (A) 48 / A / 07 – CENIPA

Issued on 17/Sept/2007

To maintain an effective control of the execution by the Airport Administration of the friction and surface texture measurement tests concerning the pavements of the 17R/35L (main) and 17L/35R (auxiliary) runways of the Congonhas Airport (SBSP) after the construction, re-covering, maintenance or periodic inspection of the runways, in accordance with the IAC 4302, dated 28 MAY 2001.

RSV (A) 49 / A / 07 – CENIPA

Issued on 17/Sept/2007

To establish parameters and procedures so as to guarantee the safety of air operations on the 17L/35R (auxiliary) runway of Congonhas Airport (SBSP), in case of rain.

RSV (A) 50 / A / 07 – CENIPA

Issued on 17/Sept/2007

To make provisions for the evaluation of the performance of large size jet aircraft (more than 60,000 pounds), which operate or are expected to operate at the Congonhas Airport (SBSP) runway system, based on demonstrations of real operations with special landing techniques

on wet runways, according to the method prescribed in the IAC 3502-121 0888, establishing the operational flight parameters and procedures, as well as the infrastructure, to guarantee the safety of the landing and take-off operations at the airport.

RSV (A) 51 / A / 07 – CENIPA**Issued on 17/Sept/2007**

To inform the various companies operating at Congonhas (SBSP) that, for purposes of planning the air operations on the 17R/35L (main) and 17L/35R (auxiliary) runways, their respective Operation Managements, based on information published by the INFRAERO, by means of NOTAM, concerning the friction and surface texture requisites, in accordance with the IAC 4302, dated 28 MAY 2001, must do the runway analysis for their different types of equipment, in order to adjust to the existing conditions of the runways afore mentioned.

RSV (A) 52 / A / 07 – CENIPA**Issued on 17/Sept/2007**

To follow the actions concerning the monitoring of the evolution of the friction and surface macro-texture parameters of the Congonhas Airport main runway (SBSP), to be executed by the airport administration, so as to have technical data and information elements capable of facilitating and expediting the evaluation of the special maintenance plan to be proposed by the airport administration.

RSV (A) 53 / A / 07 – CENIPA**Issued on 17/Sept/2007**

To determine the establishment of the Runway End Safety Area (RESA), in accordance with the technical standards set by the ICAO Annex 14, as one of the infrastructure priority parameters to be established for the Congonhas Airport (SBSP), adjusting the other components of the runway system to the operational safety requisites of the runways, thus guaranteeing the safety of the landing and takeoff operations as recommended in the RSV(A) 50, even though it may imply the shortening of the current length of the main and auxiliary runways.

RSV (A) 144 / A / 07 – CENIPA**Issued on 21/Nov./2007**

To set procedures for the RBHA 121 operators to insert in the briefing of descent an analysis of the runway length necessary for landing and the actions to be taken in case of non-functioning of the ground spoilers and/or brakes. Such analysis has the objective of defining the immediate start of a pull-up (go-around), if necessary.

RSV (A) 145 / A / 07 – CENIPA**Issued on 21/Nov./2007**

To study the viability of setting norms for the RBHA 121 operators to insert, in the procedure after the touchdown, the confirmation of the functioning of the ground spoilers before the activation of the thrust reverser. This sequence has the objective of allowing a touch-and-go landing, in case of non-functioning of the ground spoilers.

RSV (A) 146 / A / 07 – CENIPA**Issued on 21/Nov./2007**

To establish procedures for the RBHA 121 operators to do training in flight simulators of touch-and-go landings after the non-functioning of ground spoilers and/or brakes, with the objective of demonstrating the characteristics of the aircraft performance under those conditions.

RSV (A) 147 / A / 07 – CENIPA**Issued on 21/Nov./2007**

To update the pertinent documentation so as to officially the procedures recommended in the RSVs 144, 145 and 146.

RSV (A) 148 / A / 07 – CENIPA**Issued on 21/Nov./2007**

To evaluate the convenience of establishing deactivated thrust-reverser landing training for the RBHA 121 operators, with the objective of implementing the training under such condition.

RSV (A) 149 / A / 07 – CENIPA**Issued on 21/Nov./2007**

To study the need of establishing parameters for the performing of tankering by the RBHA 121 operators, when proceeding to land in limit conditions of the landing envelope.

RSV (A) 169 / A / 07 – CENIPA**Issued on 28/Dec./2007**

To study, in coordination with the certification organizations of other countries and aircraft manufacturers, the need to establish procedures for the aircraft certified under the Brazilian Aeronautical Homologation Regulation - RBHA 25, regarding the landing phase, defining a corrective action when the ground spoilers do not deflect after the touchdown.

RSV (A) 171 / A / 07 – CENIPA**Issued on 28/Dec./2007**

To monitor and evaluate, in coordination with the EASA, in terms of safety requisites and time for its implementation, the proposal of modification of the RETARD auto call-out system of the A-320 aircraft, so that it performs only the function for which it was designed, namely, to advise the crew to place the thrust levers in the "IDLE" position.

RSV (A) 172 / A / 07 – CENIPA**Issued on 28/Dec./2007**

To issue, in the short term, an Airworthiness Directive so that the Type design of the A-320 aircraft includes a warning system to allow the crew to identify a wrong setting of the thrust levers and take the necessary corrective actions to maintain the safety of the operation.

RSV (A) 173 / A / 07 – CENIPA**Issued on 28/Dec./2007**

To establish certification criteria **under the Brazilian Aeronautical Homologation Regulation - RBHA 25** to require that the aircraft designs already certified and the aircraft designs in process of certification have their power control systems and their warning systems optimized, so as to allow the identification of the conditions in which the thrust levers are incorrectly positioned during critical phases of flight.

RSV (A) 175 / A / 07 – CENIPA**Issued on 28/Dec./2007**

To monitor and evaluate, in coordination with the EASA, in terms of safety requirements and time for its implementation, the proposal for the modification of the logic of actuation of the

systems responsible for the deceleration of the A-320 aircraft, so that it considers the clear intention of the crew to make a landing and guarantees the effectiveness of the deceleration, even if the thrust levers are incorrectly positioned.

RSV (A) 177 / A / 07 – CENIPA**Issued on 28/Dec./2007**

To evaluate, for the aircraft certified under the RBHA 25, the advantages and disadvantages of utilizing the thrust reverser before verifying the deflection of the ground spoilers, and to study the need of establishing the most proper procedure from the perspective of Flight Safety.

RSV (A) 10 / A / 07 – CENIPA**Issued on 18 / Apr. / 2008**

To ensure the real effectiveness of the theoretical training, considering: the feasibility of the adoption of training systems that utilize the computer as a basic tool for learning (CBT); and the need to establish mechanisms for a better monitoring and evaluation of the teaching method applied during this phase.

RSV (B) 11 / A / 07 – CENIPA**Issued on 18 / Apr. / 2008**

To re-evaluate the requirements established for the professional formation and knowledge updating of the technical crewmembers of the aviation segment under the RBHA 121, notably in relation to the syllabus and training hours, aiming at adjusting them to the real needs observed before the operators.

RSV (A) 95 / A / 08 – CENIPA**Issued on 2 / June/2008**

To study the need to establish a contingency plan for the monitoring of the technical-operational and maintenance routine of the TAM *Linhas Aéreas S/A*, so as to ensure that the practices adopted by the company guarantee the operation with safety and meet all the requisites established in the legislation in force.

RSO (A) 176 / 09 – CENIPA**Issued on 27/Oct./2009**

To refine the inspecting mechanisms, so as to ensure that the operators effectively inform the cases of recurrent failures and of failures, malfunctioning and defects, in accordance with the RBHA 21.

RSO (A) 177 / 09 – CENIPA**Issued on 27/Oct./2009**

To revise the acceptance process of the TAM AIRLINES' General Maintenance Manual, considering the impact that the grouping of failures monitored by the quality system for correction during the execution of more comprehensive checks may have on flight safety.

RSO (A) 178 / 09 – CENIPA**Issued on 27/Oct./2009**

To refine the inspecting mechanisms, so that the operators keep the traceability of the events by means of proper recording and backup mechanisms.

RSO (A) 179 / 09 – CENIPA**Issued on 27/Oct./2009**

To implement inspecting actions regarding the start and/or completion of the processes of certification of all the airports whose certification is mandatory in accordance with the regulations in force.

RSO (A) 180 / 09 – CENIPA**Issued on 27/Oct./2009**

To evaluate the creation of runway end safety areas (RESA) as prescribed in the RBAC 154/2009 at aerodromes included in the criteria established by the RBAC 139, informing the ICAO about the contingent differences found in Brazil relative to the Standards and Recommended Practices of the Annex 14 to the Convention on International Civil Aviation.

RSO (A) 181 / 09 – CENIPA**Issued on 27/Oct./2009**

To revise the dispositions of the IAC 2328-0790, in order to include in the pertinent regulation a requirement for the obtainment of previous approval from the ANAC regarding any project that results in alteration of the runway pavement (no matter what the designation of the object is: renovation, recapping, recovering, etc.) which may cause alteration in the coefficients of friction, macrotexture, or any other characteristic capable of affecting the performance of the aircraft during landing and takeoff operations.

RSO (A) 182 / 09 – CENIPA**Issued on 27/Oct./2009**

To revise the regulation in force, in coordination with the Airspace Control Department, observing the standards and recommended practices issued by the International Civil Aviation Organization, in order to establish procedures, assignments and responsibilities relative to the suspension and reestablishment of landing and takeoff operations at airports on account of temporary impracticability or changing of the physical and/or operational characteristics of the runways.

RSO (A) 183 / 09 – CENIPA**Issued on 27/Oct./2009**

To refine the regulation processes to allow the immediate adoption of preventative measures regarding well known situations, so that the slowness of such processes does not diminish the efficiency of prevention.

RSO (A) 184 / 09 – CENIPA**Issued on 27/Oct./2009**

To promote a widespread dissemination of this report, mainly to its internal public, as well as the airline companies ruled by the RBHA 121 and the airport administrations.

4.2 To the Brazilian Airport Infrastructure Enterprise - INFRAERO

It is recommended:

RSV (A) 153 / A / 07 – CENIPA**Issued on 18/Dec./2007**

To make provisions for the repositioning and/or calibration of the level of illumination of the parking ramp reflectors of the Congonhas Airport (SBSP) new passenger terminal, so as to prevent the dazzling of pilots during the landing and takeoff operations at the main runway (17R / 35L).

RSV (A) 154 / A / 07 – CENIPA**Issued on 18/Dec./2007**

To reformulate the procedures utilized in the processing of the Prevention Reports - RELPREV, so as to prioritize their quick reception by the Local Airport Administrations (AAL) and their immediate analysis, deliberation and execution of pertinent preventative actions.

RSV (A) 155 / A / 07 – CENIPA**Issued on 18/Dec./2007**

To implement procedures which establish the active participation of the AAL in the oversight of the works executed in their respective airports, aiming at guaranteeing full knowledge of the physical modifications made and the compatibility of the operational practices.

RSO (A) 185 / 09 – CENIPA**Issued on 27/Oct./2009**

To adopt appropriate provisions in order to allow the start of the certification processes of airports under its administration that are not still certified and whose certification is mandatory in accordance with the regulations in force.

RSO (A) 186 / 09 – CENIPA**Issued on 27/Oct./2009**

To intensify, in the Complete Aeronautical Emergency Exercises (EXEAC), the need of coordination between the public security/ civil defense agencies and the COMAER organizations, in order to ensure that the SIPAER investigators can work in the accident site the earliest possible, without compromising safety.

RSO (A) 187 / 09 – CENIPA**Issued on 27/Oct./2009**

To refine the educational activities prescribed in the Enterprise's Aeronautical Accidents Prevention Program, so as to guarantee the understanding by the personnel of the purpose and ways of utilization of each one of the SIPAER voluntary reporting tools, stressing the responsibilities of the Enterprise's SIPAER-Link relatively to the treatment of the information received.

RSO (A) 188 / 09 – CENIPA**Issued on 27/Oct./2009**

To refine the supervision processes relative to the execution of works in the movement area of the airports under its administration, or in other areas that may impact on the airport operations, so as to ensure the compliance with all the requirements of the respective approved project.

RSO (A) 189 / 09 – CENIPA**Issued on 27/Oct./2009**

To submit to the previous approval by the ANAC any project which may implies alteration or renovation of the landing and takeoff runway pavement (independently of the denomination of its object, such as: renovation, recapping, recovery, etc.) and that may cause alteration in the coefficients of friction, macrotexture, or any other characteristic capable of affecting the performance of the aircraft in landing and takeoff operations.

4.3 To the local airport administration of Congonhas - INFRAERO AAL-SBSP

It is recommended:

RSV (A) 54 / A / 07 – CENIPA**Issued on 17/ Sept /2007**

To monitor the surface characteristics of the 17R/35L (main) and 17L/35R (auxiliary) runways of Congonhas Airport (SBSP), in accordance with the IAC 4302, dated 28 MAY 2001, readily implementing the appropriate corrective actions for the recuperation of the required safety standards, whenever the levels of maintenance of the friction or surface texture coefficient are below the prescribed minimums, immediately informing the airmen, by means of NOTAM, on the conditions of the runways aforementioned.

RSV (A) 55 / A / 07 – CENIPA**Issued on 17/ Sept /2007**

To forward to the National Civil Aviation Agency (ANAC) the results of the measurement of friction and surface texture tests relative to the pavements of the 17R/35L (main) and 17L/35R (auxiliary) runways of Congonhas Airport (SBSP) after any construction, re-covering, maintenance or periodic inspection, as established by the IAC 4302, dated 28 MAY 2001.

RSV (A) 56 / A / 07 – CENIPA**Issued on 17/ Sept /2007**

To take measurements of the friction coefficient and surface macrotexture of the 17R/35L (main) runway of Congonhas Airport (SBSP), considering the cutting of grooving, and forward the results to the National Civil Aviation Agency, as prescribed in the IAC 4302, dated 28 May 2001.

RSV (A) 57 / A / 07 – CENIPA**Issued on 17/ Sept /2007**

To take measurements of the friction coefficient and surface macrotexture of the 17R/35L (main) runway of Congonhas Airport (SBSP), every fortnight at the least, so as to evaluate the evolution of those parameters, as a result of the rubber build-up caused by the landing and takeoff operations on the 17R/35L (main) runway.

RSV (A) 58 / A / 07 – CENIPA**Issued on 17/ Sept /2007**

To submit, for the approval by the National Civil Aviation Agency, a special plan of maintenance of the 17R/35L (main) runway of Congonhas Airport (SBSP), based on results obtained through the procedure determined in the Safety Recommendation - RSV (A) 57 / A / 07 – CENIPA.

4.4 To the companies operating under the RBHA 121

It is recommended:

RSV (A) 143 / A / 07 – CENIPA**Issued on 02/Oct./2007**

To study the convenience of adjusting the operation of their aircraft at airports defined by them as “airports operation under special condition”, while considering the possibility of not making landings and takeoffs in situations with pinned thrust reversers.

4.5 To the airline companies operating at Congonhas Airport (SBSP)

It is recommended:

RSV (A) 59 / A / 07 – CENIPA

Issued on 17/ Sept /2007

To adjust the performance of their aircraft for the operations at the Congonhas Airport (SBSP), considering the possibility of using the 17L/35R (auxiliary) runway for landings and takeoffs in rainy weather.

4.6 To TAM Linhas Aéreas

It is recommended:

RSV (A) 60 / A / 07 – CENIPA

Issued on 17/ Sept /2007

To emphasize the strict adherence of the technical crews to the MEL of the A319, A320 and A321 equipment, relative to the item 78-30 – OPERATIONAL PROCEDURES – EXHAUST – THRUST REVERSER, which deals with the operation of the aircraft with a pinned thrust reverser.

RSV (B) 12 / A / 08 – CENIPA

Issued on 18 / Apr. / 2008

To carry out an internal audit of all the operation, training and maintenance processes conducted within the company, aiming at the gathering of non-conformities in relation to the regulation in force, as well as measuring the effectiveness of those processes.

RSV (B) 13 / A / 08 – CENIPA

Issued on 18 / Apr. / 2008

To re-evaluate the Training Program, aiming at adjusting it to the real needs of the operation, and considering: the need of a better monitoring of the crew technical-operational conditions; the adequacy of the contact hours currently adopted; and the efficacy of the methodology applied to the theoretical training.

RSV (B) 14 / A / 08 – CENIPA

Issued on 18 / Apr. / 2008

To refine the processes of performance monitoring of the crews along their operational life in the company, from the very beginning of the training, so as to allow for the timely correction of operational deviations.

RSV (B) 15 / A / 08 – CENIPA

Issued on 18 / Apr. / 2008

To establish distinct training processes for the professional formation and updating of the pilots, based on the crew performance monitoring mentioned in the Safety recommendation RSV (A) 14 / A / 08 – CENIPA.

RSV (B) 16 / A / 08 – CENIPA

Issued on 18 / Apr. / 2008

To unify the management of the practical and theoretical training of the crews, with the purpose of obtaining a better control of the quality of the professional formation and knowledge updating.

RSV (B) 17 / A / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To establish mechanisms to ensure the standardization of the Flight Instructors, in order to improve the trainings, better the adherence to the prescribed operational procedures and provide familiarization and experience to the instructor in the operation on the right-hand seat of the airplane.

RSV (B) 18 / A / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To create incentive mechanisms to motivate the flight instructors, besides acknowledging the importance of their role.

RSV (B) 19 / A / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To establish criteria so that the occupation of the right-hand seat of the aircraft cockpit be limited to: co-pilots; instructors; or captains taking up instructor formation courses.

RSV (B) 20 / A / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To re-structure the CRM training, with the purpose of increasing the perception of the organizational culture influence on the crewmember performance, while making it a permanently favorable element for the safety of operations.

RSV (B) 21 / A / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To establish systematized processes for the oversight of training, technical-operational and maintenance activities, throughout the various management levels, seeking to obtain a coordinated action from the various sectors of the company for the benefit of the safety in the operations.

RSV (B) 22 / A / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To re-structure the prevention activities conducted by the Safety sector, considering the possibility of having SIPAER accredited elements in the other sectors of the company, so as to increase the capillarity of the Safety Sector, consequently improving the safety mentality in the company, and increasing the effectiveness of prevention.

RSV (B) 23 / A / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To create programs for the dissemination of the teachings gathered in the operational safety investigations (from accidents, high risk incidents, prevention reports, etc.) which adopt practices not restricted to the utilization of the electronic mail, favoring the personal involvement of the flight safety sector workers, along with the other employees.

RSV (B) 24 / A / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To establish systematized processes to allow the company prevention sector (SAFETY) to adequately manage the risks associated with the operational activities, including the impacts

resulting from the administrative decisions, in accordance with the precepts disseminated by the ICAO regarding the SMS (Safety Management System).

RSV (B) 25 / A / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To refine the criteria and practices concerning the announcement of changes in operational procedures, aiming at guaranteeing the updating of all the crews, encouraging their commitment, and allowing for a better interaction between the crews and the operations sector.

RSV (B) 26 / A / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To re-affirm, before the crewmembers, the policy of the company relative to the adoption of the go-around maneuver as a preventative tool, so as to make it clearer and explicit, thus preventing possible deviations which compromise the operational safety.

RSO (A) 190 / 09 – CENIPA**Issued on 27/Oct./2009**

To revise the control processes of the maintenance records with the objective of ensuring the necessary traceability of the events.

RSO (A) 191 / 09 – CENIPA**Issued on 27/Oct./2009**

To revise the control processes of the maintenance records with the objective of ensuring the adequate management of the risk associated with the combinations of grouped failures to be monitored by the quality system, in the cases mentioned in the item 4.3.1 do MGM.

RSO (A) 192 / 09 – CENIPA**Issued on 27/Oct./2009**

To revise the procedures and controls established for the records entered in the RTA (Aircraft Technical Records) sheets, with the objective of preventing misinterpretation and/or misunderstanding resulting from unreadability, erasures, lack of standardization in the language used, and lack of data.

RSO (A) 193 / 09 – CENIPA**Issued on 27/Oct./2009**

To establish mechanisms to ensure the effective communication of failures, malfunctioning and defects to the ANAC, as prescribed in the RBHA 121.

RSO (A) 194 / 09 – CENIPA**Issued on 27/Oct./2009**

To refine the voluntary reporting tool through the company's corporate computer net, so that the identification of the report writer be no longer obligatory, thus preventing the inhibition of the participation of the employees in the processes of accident prevention.

RSO (A) 195 / 09 – CENIPA**Issued on 27/Oct./2009**

To refine the educational activities prescribed in the company's Aeronautical Accidents Prevention Program, so as to guarantee the understanding by the personnel of the purpose

and ways of utilization of each one of the SIPAER voluntary reporting tools, stressing the responsibilities of the Enterprise's SIPAER-Link relatively to the treatment of the information received.

RSO (A) 196 / 09 – CENIPA**Issued on 27/Oct./2009**

To reiterate, before the pilots, the importance of the compliance with the prescribed phraseology for the communications with air traffic control units, mainly in what refers to the provision of accurate information on the number of persons on board, endurance and alternate aerodrome.

RSO (A) 197 / 09 – CENIPA**Issued on 27/Oct./2009**

To reiterate the importance of the utilization of flight data monitoring for the detection and treatment of deviation from the standards, ensuring the implementation of the necessary preventative actions (such as, additional training, revision of procedures, etc.), as well as the provision of appropriate feedback to the crews.

4.7 To the Airbus France S. A. S.

It is recommended:

RSV (A) 168 / A / 07 – CENIPA**Issued on 28/Dec./2007**

To establish a procedure for the A-320 aircraft model, regarding the landing phase, defining a corrective action to be taken by the crew when the ground spoilers do not deflect after the touchdown.

RSV (A) 170 / A / 07 – CENIPA**Issued on 28/Dec./2007**

To optimize the RETARD auto call-out system of the A-320 aircraft, so that it executes only the function to which it was designed, that is, advise the crew to set the thrust levers in the "IDLE" position.

RSV (A) 174 / A / 07 – CENIPA**Issued on 28/Dec./2007**

To enhance the logic of functioning of the systems responsible for the deceleration of the A-320 aircraft, so that it considers the clear intention of the crew to land and ensures the effectiveness of the deceleration, even if there is an incorrect positioning of the thrust levers.

RSV (A) 176 / A / 07 – CENIPA**Issued on 28/Dec./2007**

To evaluate the advantages and disadvantages of utilizing the thrust reverser before verifying the deflection of the ground spoilers in the A-320 aircraft, and to establish a more proper procedure from the perspective of Flight Safety.

RSV (B) 27 / C / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To evaluate the need to restructure the sequence of the texts contained in the manuals of the A-320 aircraft, so as to facilitate and expedite their handling, mainly during the flight.

4.8 To the International Civil Aviation Organization

It is recommended:

RSO (A) 198 / 09 – CENIPA**Issued on 27/Oct./2009**

To study the convenience of issuing a specific guidance as for the comprehensiveness of the applicability of the ICAO Annex 8 standards and recommended practices referring to Human Factors in the context of design certification and continuing airworthiness.

4.9 To the Aeronautical Accident Investigation and Prevention Center - CENIPA

It is recommended:

RSV (A) 61 / A / 07 – CENIPA**Issued on 17/ Sept. /2007**

To publish to the Brazilian aeronautical community, by means of the DIVOP (Operational Publication) and other existing means of communication, the content of these Safety Recommendations (RSV), in order to maintain a high level of perception and situational awareness.

RSV (A) 62 / A / 07 – CENIPA**Issued on 17/ Sept. /2007**

To carry out a Special Flight-Safety Inspection in the TAM LINHAS AÉREAS S/A company, in accordance with the NSCA 3-3, item 6.2.2.

RSV (A) 63 / A / 07 – CENIPA**Issued on 17/ Sept. /2007**

To carry out a Special Flight-Safety Inspection in the INFRAERO AAL-SBSP, in accordance with the NSCA 3-3, item 6.2.2.

RSV (A) 156 / A / 07 – CENIPA**Issued on 18/Dec./2007**

To publish to the Brazilian aeronautical community, by means of the DIVOP (Operational Publication) and other existing means of communication, the content of these Safety Recommendations (RSV), in order to maintain a high level of perception and situational awareness.

RSV (B) 28 / C / 08 – CENIPA**Issued on 18 / Apr. / 2008**

To refine the monitoring mechanisms, favoring a better proactivity in the identification of the hazards and in the management of the risks associated to aspects intervenient in the operation of the companies ruled by the RBHA 121.

DISSEMINATION

- - AIRBUS FRANCE S. A. S.
- - AIRLINE COMPANIES
- - ANAC
- - BEA
- - DECEA
- - ICAO
- - INFRAERO
- - NTSB
- - SRPV SP

On 27/Oct./2009.

Chief of the CENIPA

I HEREBY APPROVE THIS FINAL REPORT:

Commander of the Aeronautics

FSAC

ANNEX A – COMMENTS BY THE STATES PARTICIPATING IN THE INVESTIGATION

In compliance with the provisions of the Chapter 6, item 6.3, of the Annex 13 to the Convention on International Civil Aviation, the States participating in this investigation had the opportunity to make their comments concerning the content of this final report.

By means of the National Transportation Safety Board, the United States of America manifested its total agreement with the facts, conclusions, and findings of this report.

By means of the Bureau d'Enquêtes et d'Analyses pour La sécurité de l'aviation civile, France forwarded the document n° 000887/BEA, containing comments on the content of the final report.

All the comments deemed pertinent influenced the final version of the report. As for the other ones, with which the Commission does not agree, they are presented below.

“BEA Comments on the Draft Final Report on the Accident to the Airbus A320 registered PR-MBK”

PART 1

1. General Points

1.1 Regulatory References

1.1.1 Reference to ICAO Annex 8

The BEA does not agree with the interpretation of ICAO Annex 8 that is made in the report. The A 320 was certified in 1988 in accordance with the JAR 25 *change 11* criteria and not CS 25. These criteria were based on ICAO recommended standards and practices (Annex 8, SARPs). They guarantee flight safety as long as the aircraft is operated in accordance with the published limitations and procedures.

To this end, the certification authorities checked that all events that could lead to disastrous situations have been foreseen by the manufacturer. In principle, however, the authorities distinguish between system and engine failures and basic piloting errors, excluding events such as forgetting to reduce thrust at the moment of landing.

Furthermore, the BEA thinks that the Congonhas event was not foreseeable.

At the time of certification, a landing procedure was foreseen where a thrust reverser was deactivated. This procedure specified:

- placing the two thrust levers on IDLE,
- positioning in the REV detent only the thrust reverser that corresponds to the engine whose thrust reverser was active.

In 1998 and 2004, two accidents occurred at Bacolod and Taipei on A 320's flying with this configuration. The pilots had forgotten to place in the IDLE detent the thrust reverser corresponding to the engine whose thrust reverser was inoperative. This situation, which had not been foreseen during certification, thus became foreseeable. In this case, two corrective actions were taken by Airbus:

- the development of the FWC (H2F3) standard to ensure triggering of a specific warning with an ECAM « ENG X THR LEVER ABV IDLE » message,
- an operational change requiring that crews position the two thrust levers in the REV detent. This procedure prevents any inappropriate action on the thrust levers.

However it is clear that the Congonhas scenario was different:

- the airplane was not in accordance with the H2F3 standard as the airline TAM had rejected the modification proposed by the manufacturer,
- the crew, voluntarily or not, did not follow the new procedure.

This specific situation had not been foreseen by the certification authorities. The BEA thus believes that, in this case, no non-conformity can be determined.

Since the accident, the manufacturer has been studying new corrective actions to take into account this scenario, which is now known.

1.1.2 Reference to the CS 25.1309 (c)

The European and North American certification authorities only apply the provisions of this paragraph in case of a system failure. The incorrect positioning of the thrust levers cannot be considered as a failure since it results from an action by the crew.

In this context, the BEA believes that this paragraph cannot be quoted in order to affirm non-conformity of the airplane.

1.2 Classification of Contributing Factors.

The report proposes two hypotheses. The first relates to a mechanical failure whose probability of occurrence is one in 400 billion hours of flight. The second is based on the fact that human error is an expected phenomenon and is frequent in aviation. The BEA thus believes that the first hypothesis should be rejected as totally improbable.

In addition, the report shows that the «material» factors are systematically considered as “contributing” while human factors, though clearly brought to light throughout the report, appear in 13 cases out of 21 as “undetermined”. This formulation is ambiguous in that it gives the impression that the design of the airplane is the major cause of the accident, thus impeding the most effective identification of all the preventive measures.

The BEA thus believes that the «probable» nature of these human factors should be reiterated in the conclusions of the report (paragraph 3.2.1.2) in accordance with ICAO DOC 9756 (see part 2).

2. Specific Comments

2.1 Comments on Airplane Ergonomics

The report indicates on pages 66 and 67 that the complexity of the A320's automation is such that pilots do not always know how systems work. This automation could thus have led indirectly to the accident (page 81).

The BEA does not share this point of view for the following reasons:

- automation is an inevitable evolution that allows improvements in safety by reducing the crew's workload, which is corroborated by in service experience,
- this evolution was the subject of tests and certification worldwide. It has been followed by all of the major manufacturers (Boeing, Embraer etc.) and is not a characteristic specific to the A320. Any possible recommendations in this area would thus concern the whole of the aviation industry,
- the extension of the ground spoilers is dependant on the positioning of the thrust levers on IDLE in order to avoid any such maneuvers in flight. This robust logic is that used on the majority of modern transport airplanes. It is simple and cannot be unknown to pilots,

- the report clearly indicates the stressful state that the two pilots found themselves in. It thus appears that their inability to understand the non-deceleration of the airplane was due to their anxiety on the state of the runway and not to an excess of automation on the A320,
- the link between the error in the positioning of the thrust levers and the «non moving throttle levers» design remains doubtful since comparable events have occurred in the world on airplanes equipped with «moving throttle levers».

2.2 Comments on the A320 Documentation

The BEA does not share CENIPA concern in relation to the complexity of the A320 documentation for the following reasons:

- this complexity is comparable to that of airplanes of the same generation
- the flight manuals are not intended to be « studied » in flight, especially during critical phases for which « memory items » are designated. Their use is generally explained to crews during appropriate instruction or training sessions,
- nothing indicates that the crew had any difficulties on this subject during the flight,
- the operator can adapt the manufacturer's documentation if he finds it unusable. This was not apparently the option chosen by TAM.

2.3 Comments on the Recommendations

2.3.1 Comment on recommendations 145/A/07, and 176/A/07

The thrust reversers must be selected without delay after landing in order to take full advantage of the maximum efficiency (square of the airplane's speed). Delaying their use while waiting for the *ground spoilers* to extend would systematically increase landing distances and thus the risk of a runway excursion.

Consequently, the BEA does not support this recommendation.

2.3.2 Comment on recommendation 146/A/07

The BEA considers that recommendation 146/A/07 might introduce « negative training », which we know, from experience, can have disastrous consequences.

In fact:

- Training in procedures that are not in accordance with the SOPs can lead crews to reproduce these procedures during operations.
- Using a simulator that is not in accordance with the definition of the airplane can lead to an incorrect understanding of the airplane's functions by crews,
- The simulator does not allow all real situations to be reproduced. For example, the simulated response of the engines is always symmetric and does not take into account the effect of aging that may result in thrust asymmetry."

PART 2 Classification of Contributing Factors

Contributing factors	Draft Report Classification	BEA Suggestion	Justification
Application of commands	Undetermined	Probable	<ul style="list-style-type: none"> - To be consistent with 2.3.2 page 79 stating that “the second [hypothesis] appears more likely.” - Since this scenario is more likely than the mechanical failure, this factor has to be probable, and even contributing.
Influence from the environment	Undetermined	Contributing	<ul style="list-style-type: none"> - To be consistent with page 76 stating that the wet and slippery runway implied anxiety for the PIC, - To be consistent with the sentence on page 76 : “The operation in Congonhas represented an enormous concern for the pilots, in psychological terms” - “The PIC showed anxiety in relation to the conditions on the runway...”
Piloting judgment	Undetermined	Probable	<ul style="list-style-type: none"> - To be consistent with the explanation provided in this same paragraph (g) - It could be argued that relying on a 55-meter penalty to ensure the safe landing is an indication of a questionable piloting judgment. On this basis the classification could be <i>contributing</i>.
Anxiety	Undetermined	Contributing	- Several paragraphs throughout the Draft Report describe a high level of anxiety for the PIC.
Stress	Undetermined	Probable	- Several paragraphs throughout the Draft Report describe a high level of stress for the PIC.
Training	Undetermined	Probable	- DFDR has shown that 5 different landing procedures with one reverser INOP were recorded. This shows a lack of standardization of procedures among the operators’ flight crew

PART 3

Technical Comments

Paragraph	Comment	Justification / Suggested wording
1.18.1	BEA does not support the following statement: “The thrust reverser system is considered by its manufacturer as an additional decelerating system.”	Thrust Reversers systems are required by certification authorities not to be taken into account for calculating braking distance during the certification process. Therefore, it is not up to the manufacturer to decide whether or not it is a mandatory system.
paragraph s	“approximately 6 seconds...” is written. This is inconsistent with pages 64-65 stating “about seven seconds... Two seconds later”, i.e. 9 seconds instead of 6.	
paragraph v	“The A320 power control system, [...], gave priority to the thrust lever in the CL position”. This wording suggests that the Aircraft’s system logic overrode the pilot’s decision-making, which is incorrect since the pilot may decide at any time to override any system. Moreover, the system worked as per the design philosophy ensuring that ground spoiler deployment does not occur when one thrust lever is above IDLE.	This philosophy is shared among aircraft manufacturers with the intent of preventing any in-flight deployment, which has potential catastrophic consequences.