COMMAND OF AERONAUTICS

AERONAUTICAL ACCIDENT INVESTIGATION AND PREVENTION CENTER

FINAL REPORT
IG - 014/CENIPA/2013

OCCURRENCE: SERIOUS INCIDENT

AIRCRAFT: PR-GUL

MODEL: B737-800

DATE: 16 OCTOBER 2011

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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 does not focus 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.

Thus, it is worth highlighting the importance of protecting the persons who provide information regarding an aeronautical accident. The utilization of this report for punitive purposes maculates the principle of "non-self-incrimination" derived from the "right to remain silent" sheltered by the Federal Constitution.

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

N.B.: This English version of the report has been written and published by the CENIPA with the intention of making it easier to be read by English speaking people. Taking into account the nuances of a foreign language, no matter how accurate this translation may be, readers are advised that the original Portuguese version is the work of reference.

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SYNOPSIS

This is the Final Report of the 16 October 2011 serious incident involving the B737-800 aircraft, registration PR-GUL. The serious incident was classified as "OTHER".

During takeoff, an *Airspeed Unreliable* condition occurred, and the crew, after stabilizing the aircraft, was directed to divert to an alternate aerodrome.

Neither the passengers nor crew were injured.

There was no damage to the aircraft.

An accredited representative from the NTSB (National Transportation Safety Board, USA) was designated for participation in the investigation.

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ABEAR	Brazilian Airline Companies Association
ADIRU	Air Data Inertial Reference Unit
ADM	Air Data Module
AGL	Above Ground Level
ANAC	Brazil's National Civil Aviation Agency
A/P	Autopilot
APP-SP	São Paulo Approach Control
AOA	Angle of Attack
A/T	Autothrottle
ATC	Air Traffic Control
CCF	Medical Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CHT	Technical Qualification Certificate
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
EEC	Electronic Engine Control
GS	Ground Speed
IAS	Indicated Airspeed
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
Lat	Latitude
Long	Longitude
MCP	Mode Control Panel
METAR	Meteorological Aerodrome Report
NTSB	National Transportation Safety Board
N 1	Low Pressure Rotor Speed
PCM	Commercial Pilot - Airplane
PF	Pilot Flying
PFD	Primary Flight Display
PLA	Airline Transport Pilot – Airplane
PLI	Pitch Limit Indicator
PM	Pilot Monitoring
PPR	Private Pilot – Airplane
RSV	Flight Safety Recommendation

RWY	Runway
SBGL	ICAO location designator – Galeão Aerodrome
SBKP	ICAO location designator – Campinas Aerodrome
SBRJ	ICAO location designator – Santos Dumont Aerodrome
SBSP	ICAO location designator – Congonhas Aerodrome
SID	Standard Instrument Departure
SIPAER	Aeronautical Accident Investigation and Prevention System
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VMC	Visual Meteorological Condition

AIRCRAFT	**Model:** B-737-800 **Registration:** PR-GUL **Manufacturer:** BOEING	**Operator:** *GOL LINHAS AÉREAS*
OCCURRENCE	**Date/time:** 16OUT2011 / 19:22 UTC **Location:** SBSP - Congonhas ADRM **Lat.** 23°37'34"S – **Long.** 046°39'23"W **Municipality – State:** São Paulo – SP	**Type:** Other

1 FACTUAL INFORMATION

1.1 History of the occurrence

During the takeoff roll in SBSP, the *Engine* warning light illuminated on the Master Caution panel before the aircraft had reached the *rotate* speed. Both *EEC's* (*Electronic Engine Control*) shifted to the Alternate mode, and the *IAS Disagree* sign was displayed.

Immediately after landing-gear retraction, there was indication of *Altitude Disagree (ALT DISAGREE).* Speed and altitude indications began to show significant differences on the various displays, accompanied with a *Stick Shaker* warning, characteristic of a stall condition.

The crew controlled the aircraft and declared an emergency condition to ATC, being subsequently vectored by APP-SP for an uneventful landing in SBKP.

1.2 Injuries to persons

Injuries	Crew	Passengers	Third parties
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
Uninjured	06	95	-

1.3 Damage to the aircraft

Nil.

1.4 Other damage

Nil.

1.5 Information on the persons involved

1.5.1 Information on the crew

HOURS FLOWN		
	PILOT	EXAMINER
Total	7,500:00	12,000:00
Total in the last 30 days	56:45	70:40
Total in the last 24 hours	05:30	04:45
In this type of aircraft	5,510:10	5,129:30
In this type in the last 30 days	56:45	70:40
In this type in the last 24 hours	05:30	04:45

NB: the data relative to the *hours flown* were provided by the operator.

1.5.1.1 Professional training

The captain (Pilot Flying – PF) earned his wings as a private pilot (airplane category) in 1999; as a commercial pilot (airplane category), in 2001; and as an Airline Transport Pilot (airplane category), in 2011, when he was already flying for the operator.

The other captain (Pilot Monitoring – PM) had earned his private pilot wings in 1974, his Commercial Pilot wings in 1976, and his ATP pilot wings in 1992, all of them in the airplane category.

1.5.1.2 Validity and category of licenses and certificates

Both pilots had valid ATP licenses and B737-800 Technical Qualification certificates.

1.5.1.3 Qualification and flight experience

The pilots had enough experience for the flight proposed by the operator.

The Pilot Flying was doing a check flight in order to qualify as an air shuttle service captain.

The Pilot Monitoring was qualified as a captain, instructor and examiner in the company, and accredited by the ANAC.

1.5.1.4 Validity of the medical certificate

The pilots had valid medical certificates.

1.6 Aircraft information

The B737-800 PR-GUL (SN 35845) was manufactured in 2011, and had an Airworthiness Certificate valid up to 6 October 2026.

It was one of the newest aircraft in the operator's fleet, and had recently been incorporated into the company's operating specification.

As it was a new aircraft, it had not been subjected to any inspection or overhaul. It had a total of 24 hours and 15 minutes of flight, with 14 operation cycles.

1.7 Meteorological information

At the time of the incident, the SBSP aerodrome routine weather report (METAR) showed sky overcast, base of clouds at 700ft, wind 130 degrees at 5kt, horizontal visibility without restrictions, temperature 16 degrees, dew point 15 degrees, QNH 1011 millibars.

Previous weather reports indicated sky overcast during the period, with light rain and restricted visibility.

1.8 Navigational aids

Nil.

1.9 Communications

The communications established with the ATC units were appropriate.

The crew called ATC (APP-SP), and declared emergency. The APP-SP assisted the aircraft right away by authorizing it to continue climb without restrictions, and giving it vectors to divert to SBKP for landing.

1.10 Aerodrome information

The serious incident occurred outside of aerodrome area.

1.11 Flight recorders

The aircraft was equipped with a *Digital Flight Data Recorder* (DFDR) and a *Cockpit Voice Recorder* (CVR).

After landing in SBKP, the aircraft remained energized for the deplaning of passengers and crew, as well as for a later research of the failure, and this resulted in loss of the recorded CVR audio data.

The information contained in the DFDR was recovered and analyzed. The data collected revealed the following information:

17:44:40: commencement of takeoff roll.

17:44:48: 80kt *Callout*, *Ground Speed* (GS) 75kt, IAS on the PFD of the PF was 45kt.

Since the DFDR only receives speed data from the PFD of the Pilot Flying (left-hand-side seat), it was not possible to confirm, in the analysis of the data, the speed information contained in the PFD of the Pilot Monitoring (right-hand-side seat).

And, since the speed information with the aircraft parked on the ground, or with the hose disconnected is 45kt (default), it is not possible to guarantee that this was the information contained in the PFD of the PF.

Without the CVR data, it was not possible to verify whether the PM made the 80kt call-out to the PF, and whether the latter noticed that there was a difference of 30kt between the numbers showed by the two ASI's.

According to the B*737 NG Flight Crew Training Manual,* at the takeoff the pilots have to comply with the following procedures:

The PM should monitor engine instruments and airspeed indications during the takeoff roll and announce any abnormalities.

The PM should announce passing 80 knots and the PF should verify that his airspeed indicator is in agreement.

A pitot system blocked by protective covers or foreign objects can result in no airspeed indication, or airspeed indications that vary between instruments. It is important that aircrews ensure airspeed indicators are functioning and reasonable at the 80 knot callout. If the accuracy of either primary airspeed indication is in question, reference the standby airspeed indicator.

Another source of speed information is the ground speed indication. Early recognition of a malfunction is important in making a sound go/stop decision. Refer to the Airspeed Unreliable section in chapter 8 for an expanded discussion of this subject.

17:44:52: *Master Caution* illuminates. At the moment, the IAS on the PFD of the PF was 48kt and the GS was 92kt.

17:45:00: the aircraft starts rotating. The *Master Caution* light remained *ON,* the IAS indicated on the PFD of the PF was 47kt, and the GS was 138kt.

17:45:04: aircraft gets airborne. At the moment, the IAS was 69kt, the GS was 153kt, and the *pitch* was 10.55°;

It can be observed that the 'rotate' event occurred normally, even within the expected time of 3 to 4 seconds.

17:45:20: the A/P was indicated as engaged in the PFD of the PF, IAS 140kt, GS 168kt, pitch 16.17° and altitude 925ft AGL.

17:45:32: pitch 26.02°, IAS 188kt, GS 150kt, altitude 1,793ft AGL, rate of climb 4,811ft/min and N1 101%.

The GS started decreasing, the altitude was not compatible with the aircraft performance (pitch 26.2°) and the rate of climb was coherent with the aircraft altitude.

17:45:48: height 2,931ft, *pitch* 22.5°, IAS 213kt, GS 133kt, rate of **climb** 71ft/min. (emphasis added).

17:45:52: height 3,107ft, *pitch* 16º**,** IAS 199kt, GS 133kt, rate of **descent** 1,077 ft/min, *SPD WRN R* warning light illuminates, A/P disengaged, flaps retracted, N1 75.5% (emphasis added).

In this situation, the IAS was higher than the GS, and the aircraft was descending at a rate of approximately 1,000ft/min, with reduced thrust, flaps retracted and a pitch-up attitude of 16º.

Despite the pitch-up attitude, the aircraft was not climbing, since it had practically no lift.

17:46:08: The rate of descent increased to 3,069ftt/min, the altitude diminished to 2,049ft, with the aircraft losing more than 500ft, with 196kt IAS, 160kt GS, 9.49º pitch, and 102.9% N1.

17:46:16: rate of climb 854ft/minute, IAS 201kt, GS 184kt, *pitch* 7.3°, height 2,172ft, N1 102.9%.

The aircraft stopped descending in practical terms, and started climbing at a rate of 854ft/min, with the GS getting higher.

17:46:20: height 2,168ft, *pitch* 11.43°, IAS 205kt, GS 215kt, rate of climb 839 ft/minute, and N1 102.9%.

The aircraft maintained altitude, the GS increased to 215kt, and the rate of climb remained stabilized at 839ft/min.

17:46:36: height 3.184ft, *pitch* 17,58°, IAS 236kt, GS 223kt, rate of climb 3,967 ft/minute, and N1 102.9%.

The aircraft regained normal flight conditions. In this situation, it is possible to see that the GS and IAS were quite close to each other.

The manufacturer's manual states that altitude and thrust have to be maintained, pointing out that the pilots have to be familiar with these parameters in the various situations of flight.

17:51:58: level flight, height 7,721ft, GS 267kt, IAS 341kt.

18:04:16: commencement of descent for the approach to SBKP, height 7,335ft, GS 260kt, IAS 340kt, rate of descent 758 ft/min.

18:05:00: descent, height 6,286ft, *Master Caution* activated, GS 275kt, IAS 323kt, rate of descent 1,200 ft/min.

18:05:12: descent, height 6,142ft, *Master Caution* off, GS 277kt, IAS 319kt, rate of descent 1,200 ft/min.

18:09:32: approach, height 3.278ft, GS 218kt, IAS 236kt, rate of descent 993 ft/min.

18:11:04: final, height 1,882ft, GS 168kt, IAS 181kt, rate of descent 972 ft/min., flaps 25.

18:13:20: final, height 516ft, GS 144kt, IAS 89kt, rate of descent 535 ft/min., flaps 40.

18:13:56: final, height 302ft, GS 147kt, IAS 59kt, rate of descent 381ft/min., flaps 40.

18:14:00: final, height 326ft, GS 148kt, IAS 54kt, rate of descent 402 ft/min., flaps 40, STK SKR1 Activated.

18:14:20: landing, GS 148kt, IAS 45kt.

18:14:28: reversers, GS 138kt, IAS 45kt.

1.12 Wreckage and impact information

Nil.

1.13 Medical and pathological information

1.13.1 Medical aspects

Not investigated.

1.13.2 Ergonomic information

Nil.

1.13.3 Psychological aspects

1.13.3.1 Individual information

Since the CVR data were lost after the maintenance action provided by the company in SBKP, and also with the purpose of clarifying what had happened in the cockpit, the technical crew was interviewed. The following information was obtained:

1.13.3.1.1 Pilot being checked:

The PF did not feel motivated to remain operating in the airshuttle service.

The preparatory actions regarding the incident flight were normal, with routine checks, checklist procedures and briefings being performed as prescribed.

There was an extra crewmember in the aircraft. He did not want to occupy the jumpseat in the cockpit at first, but changed his mind after the captain (PM and examiner) insisted.

The PF said that his rest period on the night before had been normal.

Still during the takeoff roll on the runway, he noticed that the A/T disconnected, with illumination of the respective warning light, and also with indication of *IAS DISAGREE*.

When the aircraft got airborne, the A/T was rearmed and the *ALT DISAGREE* message appeared.

According to the pilot interviewed, the *Speed Trend* indication had a high value (tending to 250kt). Since the flaps were still at 10º, he reduced power, manually.

He said that the *Stick Shaker* was activated, but was not sure whether the flaps were already retracted (he thought they were in the extended position).

At that moment, the examiner told him to keep calm, since the plane was flying, but the extra crewmember of the jumpseat intervened: "It is not flying at all! It needs power!" The PF reacted to this latter remark right away.

He reported that during the flight there was no warning to characterize loss of lift. The speed indication values gradually diminished during the approach to SBKP (only on the left side), reaching a value close to 45kt, reason why the landing was made with *Stick Shaker* warning.

Back to the moment of the event: he was asked whether the PM had crosschecked the speed indications. His answer was that the examiner reduced the intensity of the lights of the instruments on the left and said: "don't trust them!"

As for the aircraft attitude, he said that, as far as he could remember, it was above the PLI (Pitch Limit Indicator).

He also said that *IAS DISAGREE* and *ALT DISAGREE* flags had appeared in the navigation instruments.

After verifying with ATC, the crew decided to proceed to SBKP, which was operating within VFR minima.

1.13.3.1.2 Examiner

The examiner said that just after takeoff he heard a 'click', which probably resulted from the A/T being disconnected. The PF reengaged the A/T right away.

The entire event lasted approximately fifty seconds, after which a condition of emergency was reported to ATC (Mayday).

He said that, at that moment, he got worried about what kind of failure that one might be. There was a doubt: if it was only speed, would they fly with a pitch of 15º or 20º?

After the aircraft control was regained, the possibilities were: continue to SBGL, return to SBSP, divert to either SBGR or SBKP.

He said that the assistance provided by the São Paulo Approach Control was of primary importance to them, since they received SBKP weather information (operating at VFR minima, but VFR all the same).

The PM said that, during the emergency, he touched the PF's hand and told him to continue flying the aircraft. He then lowered the intensity of the other pilot's displays because he considered them not trustworthy.

There was acceleration of the engines, but he could not say whether it was due to an action by him or by the PF. They retracted the flaps, and kept the pitch between 15º and 20º, flying in the direction of the sea, where they would feel more comfortable.

His perception was that the *Stick Shaker* remained activated during all the flight, disturbing them considerably.

The *Airspeed Unreliable* checklist was read, and the pilot who was on the jumpseat had the table in this hands. He did the readings of the *pitch versus thrust*, and made all the communications with the company.

During the flight, the speed and altitude indications were different, but within 'reasonable' values.

1.13.3.1.3 Extra pilot on the jumpseat

He does not remember much about the takeoff roll, since he was reading something else at that time.

But he remembers the time when the engine master caution light illuminated, due to EEC Alternate. After the aircraft got airborne and the landing gear was retracted, he recalls having heard a 'click', probably from the A/T.

Then he observed that the panel on the left had a lot of variations in the speed indication. At the same time, he heard the stall alert and felt the aircraft vibration.

According to him, the reaction of the examiner was to transmit a Mayday message to the APP-SP, "while personally assuming a high workload. He requested the aircraft heading to be maintained, and the PF just flew the aircraft; the controller's attitude was impeccable".

In the interview, he said that he gave some help to the other crewmembers, by making contacts with ATC, while the examiner communicated with the company, or by using the PAS to talk to the passengers. Later, he asked to assume the communication with the company.

In relation to the flags indicating malfunction, he mentioned *IAS DISAGREE* and *ALT DISAGREE*, as well as EEC in alternate mode.

He also had the impression that at the takeoff there were differences in the speed indications at the time of the 80kt crosscheck.

He recalled having noticed a rate of descent of about 2,800ft/min at the moment of the *Stick Shaker* warning, when he made the remark that "the plane is not flying at all", after which thrust was applied and the aircraft regained flight condition.

In relation to the behavior and attitude of the pilots after the stall alert, he said that the PF was rather silent and the examiner a little tense, "assuming responsibility for everything, except the controls". Nonetheless, both the final approach and landing in SBKP were made by the examiner.

1.13.3.2 Psychosocial information

Nil.

1.13.3.3 Organizational information

The company had experienced a period of rapid growth, with the incorporation of two airline companies and a fleet of approximately one hundred and forty aircraft.

In consequence, there was an increase of the workload for the maintenance sectors, since there had not been an equivalent increase in the number of required maintenance professionals (mechanics, inspectors, engineers, etc.).

Thus, the company's maintenance sectors felt a strong pressure to meet the deadlines of inspections, maintenance services, overhauls and respective aircraft releases on account of the extensive flight schedule (more than 700 daily flights).

It was verified that part of the mechanics and inspectors had difficulty understanding the manufacturer's manuals and technical orders in English.

Several internal maintenance processes require the preparation of reports in English. According to the professionals, the company did not provide them with training in this respect. Sometimes, they would resort to internet translation tools so that they could understand information and do appropriate maintenance work.

Moreover, given the complexity of the administrative and managerial structure shared by Congonhas and Confins, there was some difficulty in the communication, coordination and management of the various tasks to be performed by the company's maintenance sectors.

Some of the engineering sectors had representatives in Confins (State of Minas Gerais), but the managers' office was in Congonhas (State of São Paulo).

If the mechanics of the hangar in Confins needed either to solve certain demands or to program in advance the monitoring of a specific service by an engineer, they had to request engineering support from São Paulo.

This situation, sometimes, generated a negative impact on the maintenance deadlines and procedures, even with services being provided based only on the knowledge accumulated by the mechanics, without the aid of engineers.

It was also observed that the senior mechanic was the one in charge of tutoring the junior professionals. These latter ones reported that they accompanied the experienced mechanics in the performance of maintenance services, but, since there was occasionally work overload, they had to do the work without assistance.

As for the maintenance inspection service, it was identified that it was performed by the most experienced mechanic since there weren't enough inspectors. There were moments at which the inspector would also work in the maintenance, resulting in a general inspection instead of an inspection related to a certain process.

The company had three maintenance work-shifts. In the hangar of Confins, the supervisors of each line would meet at the beginning of the shift for purposes of information exchange, alignment of the activities necessary for the day, and dealing with the contingent difficulties. During the night-shift (small hours) there was not a supervisor *in loco,* and he would be on call at home, instead.

There were not meetings of the supervisors with the teams of maintenance lines for an evaluation of the demands. There was only a reading of the pieces of information entered by mechanics into the protocol after the tasks (completed/pending/finalized) were performed. It is worth highlighting that the pieces of information entered in the protocol aforementioned were written in English.

It was also detected that, on account of the demand, services were provided on some bases at levels for which there was not qualification.

In relation to the incident in question, the maintenance professional reported that they were unaware of what had really happened. Some of them said that they learned about it just informally, while others said they did not know anything at all about the subject.

When questioned about the aircraft radar (to which the service had been provided), they said that there was a new procedure for accessing the radar component, and that in the company there was only one aircraft other than this one featuring the same radar model.

All the other aircraft had a different procedure. They said that, in the manual of the aircraft, such change was not explicit, but the procedure was implicit. It is worth pointing out that the aircraft was new and that it had been sent to the hangar just once for the installation of customized products.

As for the training of the pilots, the program prescribed an *Airspeed Unreliable* emergency training, as part of the aircraft initial course and in the recurrent flight simulator training sessions.

However, according to information gathered during the investigation, the aircraft failure evolved in a way that was different and more complex than the training in the flight simulator.

According to the training program approved by the ANAC, the annual recurrent training after the initial course consisted of three four-hour sessions in the flight simulator dealing with several emergency situations, aircraft and system failures.

The number of existing emergencies that can be trained is very high, and the three simulator sessions were not sufficient to cover all the possibilities. When a failure was not subject to training in a given year, it would possibly be trained in the next year.

1.14 Fire

There was no fire.

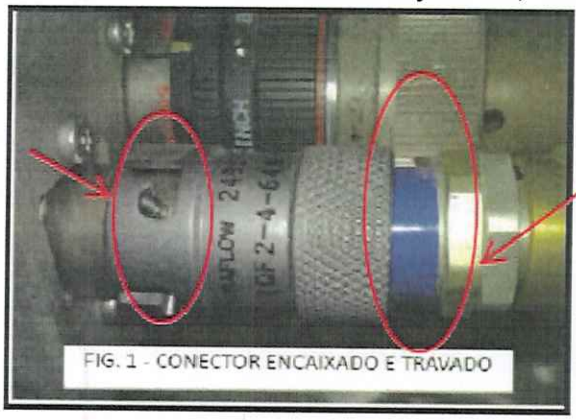
1.15 Survival aspects

Nil.

1.16 Tests and research

After the incident, the operator subjected the aircraft to several functional tests, as prescribed in the Boeing maintenance manuals, in order to identify the reason of the failure.

In one of the prescribed tests, it was possible to see that the left *HOSE ASSY - P/N B394DDB0106D* of the ADM (*Air Data Module) was not connected, thus allowing the release of the air coming from the left hand side pitot tube, which the feeds the captain's instruments and other aircraft systems, as seen in figures 1 and 2.*



Figures 1 and 2 – the blue color detail indicates a correct locking.

After a correct hose connection was made, the *Air System Data Test* was carried out, and no abnormalities were identified.

On account of the criticality of the item, notwithstanding that the failure had already been fixed, the company maintenance decided to take the following actions:

1- Replace the left static ADM;

2- Replace the right static ADM with the same component of another aircraft;

3- Replace the left AOA (*Angle of Attack*) *sensor*;

4- Replace the right AOA *sensor* with the same component from another aircraft.

Then, a new Air System Data test of both systems was carried out, and no failures were found.

Later, simulations were made in the equipment, with the insertion of a number of speeds (50, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280 and 300kt) and altitudes (5,560 and 9,000ft). The hose was kept unlocked, as it was on the day of the incident.

In a few instances, there was no significant difference between the speeds indicated in the captain's and copilot's PFDs. In other ones, however, there was a significant speed discrepancy, in the exact same way it had occurred during the flight in question.

From these tests, it is possible to affirm that the *IAS DISAGREE and ALT DISAGREE* messages resulted from the incorrect connection of the aforementioned hose, and not from its locking.

1.17 Organizational and management information

The airline company's operations headquarters (main management staff and administrative structures) is located at Congonhas Airport in São Paulo. At the same airport, the company has an aircraft maintenance base.

Recently, the company had built a large aircraft maintenance center in the airport of Confins, near Belo Horizonte, where the operator's fleet of Boeing 737-700/800 aircraft are provided with major maintenance services, inspections and overhauls of the maintenance program approved by the ANAC.

1.18 Operational aspects

The new aircraft had only made the ferry flight from the aerodrome of Seattle in the USA to the aerodrome of Confins (SBCF) in Brazil. In SBCF, it underwent an incoming inspection and a few procedures of customization to the operational standards of the airline company.

In the inspection mentioned above, the software CDS DEU OPC (PN 3116-BCG-018-Y2), which was programmed to be installed in another aircraft, was mistakenly installed in the PR-GUL.

Later, the aircraft flew from SBCF to SBSP. During this flight, the aircraft had a problem with its radar.

In São Paulo, a new maintenance service was performed in the aircraft to fix the radar failure, and the technicians found out about the incorrect installation of the radar software in the aircraft. In both maintenance interventions, the aircraft radar maintenance service involved the access to the component via the EE compartment, which is located ahead of the nose landing gear. In the new aircraft, this access is made via the radome.

In earlier models, in order to have access to the radar, it was necessary to remove some of the components, and this included the unlocking and disconnecting of the pneumatic hoses (from the left Pitot tube), which are connected to the left Air Data Module (ADM), on the same side of the captain.

After provision of the maintenance service, the aircraft departed for a flight between SBSP and SBRJ, during which this serious incident occurred.

During this flight, the left seat pilot (PF), who was already qualified as captain of B737-800 aircraft, would be checked in view of his prospective qualification as an Airshuttle-Service Captain.

For that purpose, another pilot, qualified as captain and examiner in the company, was assigned to occupy the right-hand-side seat and work as PM.

There was still another captain of the company (in the jumpseat), without function on board, who was traveling to Rio de Janeiro.

All the prescribed procedures were performed normally up to the beginning of the takeoff roll. Then, at a speed of about 90kt, the *Engine* light in the *Master Caution* panel illuminated, and both EEC units changed to the *Alternate* mode, together with the indication of *IAS DISAGREE.*

Immediately after retraction of the landing gear, there was indication of *ALT DISAGREE.*

At that moment, the crew observed that the speed and altitude indications displayed in the two main AIS and Altimeter units (pilot and copilot) had discrepancies between them, and the crew could not identify which of the instruments had reliable information.

After takeoff, the PF engaged the A/P and the A/T, in compliance with the operator's standards. At the same time, the aircraft entered a layer of clouds, and began to fly in IMC conditions. The speed selected in the MCP was 190kt.

The aircraft, then, assumed a very high pitch-up attitude of about 26º. The PM started retracting the flaps, also in compliance with the company's operational standards.

After the flaps were retracted, the aircraft stall warning (Stick Shaker) was activated.

Up to that moment, the pilots had not been able to perceive the pre-stall condition. Later, the aircraft started descending at a high rate and with a high pitch-up attitude, resulting in a high sink rate at low altitude (approximately 5,000ft altitude, or a height of about 2,500ft).

Then, the pilot who was sitting on the jumpseat identified the stall condition of the aircraft, and told the other crewmembers that the aircraft was not flying, asking them to accelerate the engines, which they promptly did, together with the disengagement of the A/P and A/T.

With the increase in power, the aircraft reduced the angle of attack quickly and recovered from the stall condition, resuming its climbing trajectory.

After declaring emergency and requesting assistance from APP-SP, the pilots managed to identify that the wrong speed and altitude information was in the PF panel (left side).

Thus, they performed the procedures prescribed in the QRH for *Airspeed Unreliable.*

Upon contacting the airline during the emergency, the crew passed the information that they had chosen to divert to SBKP on account of its proximity, runway length and more favorable weather conditions.

However, the company questioned whether it would not be better to divert to Rio de Janeiro instead, in order to minimize the inconvenience for the company and the passengers.

The PM, seated on the right seat, took over the controls and made an emergency landing in SBKP.

In Figure 3, it is possible to see the prescribed procedures for the *Airspeed Unreliable* condition, in accordance with the 737 Flight Crew Operations Manual.

BOEING 10.1
737 Flight Crew Operations Manual

Airspeed Unreliable

Condition: The pitch attitude is not consistent with the phase of flight, altitude, thrust and weight, or noise or low frequency buffeting is experienced.

Objective: To establish the normal pitch attitude and thrust setting for the phase of flight.

1 Adjust the airplane attitude and thrust. Maintain airplane control.

2 PROBE HEAT switches . . . . Check ON

3 Cross check the MACH/AIRSPEED indicators.

4 Cross check the IRS and FMC ground speed and winds to determine airspeed accuracy if indicated airspeed is questionable.

Note: Erroneous or unreliable airspeed indications may be caused by blocked or frozen pitot-static system(s), or a severely damaged or missing radome.

5 Attitude and thrust information is located in the Performance Inflight section.

■ ■ ■ ■

Additional Information

The flight path vector is based on inertial sources and may be used as a reference in maintaining proper path control.

Figure 3 – Procedures prescribed for the *Airspeed Unreliable* condition.

1.19 Additional information

Nil.

1.20 Utilization of other investigation techniques

Nil.

2 ANALYSIS

The aircraft was a model recently released by the manufacturer, and incorporated into the company's operating specification, with approximately 25 flight hours, after having made the ferry flight from the United States to SBCF in Brazil, where the airline company has a large maintenance center.

In this maintenance center, the aircraft was subjected to an incoming inspection, in addition to customization to the standards adopted by the airline, as well as installation of some items, to be later released for routine operation.

After completion of the incoming inspection, the aircraft made a flight transporting passengers between SBCF and SBSP. During this flight, the aircraft sustained a radar failure.

In SBSP, it was verified that the radar failure aforementioned was due to the installation of software that was inappropriate for the aircraft radar type.

In both cases, the access to the radar component for the provision of the maintenance service was made via the EE compartment, located ahead of the nose gear.

However, in new aircraft, as was the case of this one, the access for the provision of this type of service is made via the radome.

In earlier models, it was necessary to remove a few components for access to the radar, and this included the unlocking and disconnecting of the pneumatic hoses of the left-hand-side Pitot tube. These hoses are connected to the left Air Data Module (ADM), on the same side of the aircraft captain's seat.

Upon completion of the radar maintenance service, the components have to be placed back in their original position, and the ADM hoses must be reconnected and locked.

The ADM transforms the analogic data of the air captured by the left Pitot tube into digital information for the left ADIRU (*Air Data Inertial Reference Unit*), which feeds several aircraft systems.

It turns out that, in this more modern version of the aircraft, access to radar has been simplified, and the removal of nearby components is no longer necessary for accessing the system.

Since the mechanics were not familiar with the new maintenance routine yet, they ended up performing the old procedure related to radar maintenance.

However, it was observed that, upon completion of the procedure, the left ADM pneumatic hose was fitted but not locked correctly, allowing it to disconnect and release air, generating wrong information for the ADM and, consequently, for the PF instruments (altimeter and ASI).

Since the radar maintenance services were provided on two different occasions (one at Confins, and the other at Congonhas), it was not possible to determine in which of the two the ADM hose was installed incorrectly.

However, the most likely hypothesis is that the misconnection took place in Congonhas, since otherwise the failure in question would have occurred in Confins.

The pilots were sufficiently experienced in the aircraft, in the route flown and in the aerodromes involved in the operation, in addition to having all valid licenses, certificates and qualifications.

Although without function on board, there was another pilot of the company in the cockpit (on the jumpseat). He was on his way to Rio de Janeiro, and had experience both in the aircraft and on the route.

The takeoff was normal, but it was not possible to determine the reason why the PF did not abort it at the 80kt call-out.

At that moment, based on the readout of the DFDR data, it is possible to suppose that the IAS in the PFD of the PF was 45kt, and the GS was 75kt, probably identical to the IAS in the PFD of the PM.

The PM, in turn, did not notice the discrepancy, or if he noticed it, he allowed the PF continue with the takeoff, despite the significant difference of the speed indications.

The procedures prescribed in the *737 NG Flight Crew Training Manual* are clear and objective in relation to abnormalities in the indication of speed at the 80kt call-out.

The correct procedure would be to abort takeoff. Despite the runway contamination with water and the particular operation characteristics of SBSP, the condition was still favorable for the aircraft to stop safely within the limits of the runway.

In the sequence, the *Engine* light in the *Master Caution* panel illuminated, and both units of the *Electronic Engine Control* (EEC) changed to the *Alternate* mode.

At that moment, the IAS in the PFD of the PF was 48kt, and the GS was 92kt.

Taking into account the operation in SBSP with a wet runway, the decision to abort takeoff at a speed of 92kt may be considered as more critical.

Since the CVR data were not preserved, it was not possible to determine the reason why the crew continued with takeoff.

Immediately after retraction of the landing gear, the *IAS DISAGREE* and *ALT DISAG*REE flags illuminated in both PFDs.

The crew observed that the speed and altitude indications appearing in the two main altimeters and ASIs of the PF and PM had discrepancies between them, and they could not identify which of the indications was dependable at the time.

Prevailing weather conditions were IMC, which the crew had encountered just after takeoff at about 600ft AGL.

Normally, the flight crew has a high workload during the takeoff phase.

The departure from São Paulo is still more critical, as the SID has a series of restrictions concerning speed and altitude, in addition to heavy air traffic in the São Paulo Terminal Area (TMA-SP).

After takeoff, complying with a standard of the operator, the PF engaged the A/P, as well as the A/T (which had disconnected during the takeoff run).

Since the speed selected in the MCP was 190kt in order to comply with the SID parameters, the A/P and the A/T started working to reach and maintain the selected speed.

However, due to the fact that the speed shown in the PFD of the PF at the moment was erroneously too high, the aircraft assumed an excessively pitched-up attitude, close to 30°, in order to reach the speed selected by the PF in the MCP (190kt).

Concomitantly, the PM started retracting the flaps, also in compliance with the operational standards of the company.

The retraction of the flaps, together with the high pitch-up angle of the aircraft, resulted in a high angle of attack and low real aerodynamic speed, triggering the airplane stall warning (*Stick Shaker*).

In this phase of flight, shortly after takeoff, with a rather high workload, the pilots were still performing the routine operational procedures, and had not managed to identify the failure that had occurred at the beginning of the takeoff roll and which, with the aircraft airborne, had become more critical, aggravated as it was by the IMC conditions.

From the information collected in the interviews with the pilots, it was possible to see that the tasks in the cockpit were not appropriately managed and distributed during the emergency, since there was not a clear division of the tasks between who had to fly the plane, keeping it under control, and who had to deal with the emergency and communicate with ATC.

The pilot on the right-hand-side seat ended up overloaded with work for having accumulated several concomitant tasks, and the pilot on the jumpseat had to help him.

From the visualization of the flight parameters recorded in the FDR, it was observed that these events occurred in a very short stretch of time, not allowing the pilots to identify neither the pre-stall condition nor, later, the stall condition, when the aircraft started descending at a high rate and with a pronounced pitch-up attitude, resulting in a high sink rate at low altitude.

That was the moment at which the pilot on the jumpseat identified the aircraft stall condition, and informed the other pilots that the aircraft was not flying, telling them to accelerate the engines, which they promptly did, together with disconnecting the A/P and the A/T.

With the increase in power, the aircraft quickly accelerated, the pilot reduced the angle of attack, and the aircraft began to fly again, having recovered from the stall at an altitude of approximately 2,000ft AGL.

Later, the crew called APP-SP, declared emergency, and received prompt assistance from the ATCO.

Upon comparing the ground speed information received from ATC with the information shown by the cockpit instruments, the crew concluded that the affected panel was the left one.

Thus, the pilot on the right-hand-side seat took over the controls, and made the landing in SBKP.

Modern aircraft, equipped with highly automated systems, lead the crews to excessively rely and utilize such automated resources (FMS, A/P and A/T), generating dependence on these resources, something that, in turn, made degrade their psychomotor ability to fly the aircraft manually.

Studies of the subject, as well as investigation of accidents involving modern aircraft, confirm that the ability of human beings to manage complex systems is limited.

Moreover, since the systems and computers have a high level of dependability and, most of the time, perform accurately the tasks for which they were programmed, there is a natural tendency on the part of people to be complacent, since they expect that the machine is going to manage everything by itself.

The problem then occurs exactly when the equipment fails, and the pilot has to identify the problem and take action to fix the aircraft discrepancies, keeping it flying with safety.

Normally, in emergency situations such as these, the crews have to deal with events which they had few opportunities to practice in simulator training.

In such context, in the analysis of the training program of the airline company pilots, it was observed that the *Airspeed Unreliable* emergency training was prescribed and done in the flight simulator, as part of the initial course.

However, according to information gathered, the failure that occurred with the aircraft was distinct and more complex than the training that was done in the simulator, and this is likely to have made it difficult for the crew to identify correctly the problem.

It is worth to point out, however, that the pilots do an annual recurrent training in the flight simulator after the initial course, in accordance with the training program approved by the ANAC.

This training consisted of three flight simulator sessions, each one with duration of 4 hours, for the practice of several emergency situations, as well as aircraft and system failures.

Since the number of emergencies to be trained was rather large, the three sessions in the simulator were not enough to cover all the possibilities.

Therefore, should a given emergency not be trained in a given year, it would be dealt with only in the next recurrent training, leading to an interval that was longer than the ideal one for the training of certain emergencies.

Consequently, the operator had to prioritize and adjust its training program in order to contemplate the main failures and emergencies, generating the possibility that the *Airspeed Unreliable* emergency might not be practiced every year.

After the event in question, the airline company training sector conducted studies in order to give more emphasis to the referred emergency, since it was observed that it could have catastrophic consequences.

In relation to maintenance issues, the investigation commission observed that the rapid growth of the operator's fleet (approximately 140%) had imposed a strong demand for mechanics, maintenance technicians, inspectors and engineers.

But, since duly qualified and experienced professionals are hard to find in the market, there was a significant work overload for the company's maintenance employees, as far as the compliance with the stipulated deadlines was concerned, in order to not harm the company's air route network. Therefore, the entire scenario became a latent condition.

It was verified that some of the maintenance tasks were performed without participation of the inspectors after the task was completed, due to a shortage of these professionals.

With the number of maintenance professionals falling short of what could be desired, the mechanics were constantly working under pressure, something that could generate failures with unwanted flight safety consequences.

Another important aspect observed was the lack of English language proficiency on the part of some mechanics, something that could jeopardize the correct interpretation of maintenance technical orders, manuals and documents written in English.

Finally, the existence of two maintenance centers of the company (in Confins and Congonhas) could generate a series of managerial hardships, on account of personnel shortage, administrative complexity, high demand for services, and a number of engineers falling short of the desirable for the management of all tasks.

The hardest challenge in the conclusion of this analysis is to try and explain the reason why three experienced aircraft pilots (qualified as captains), in a modern and automated aircraft cockpit, took so long to understand a relatively simple failure, which, according to the *checklist*, should have been managed by just maintaining the aircraft altitude and the required power.

The crew realized that something was wrong. The aircraft warning lights informed that there was discrepancy in the speed indications, and the *Stick Shaker* was activated.

In spite of perceiving the events, the crew did not quickly understand what they meant. They were not able to identify the seriousness of the problem related to the aircraft airworthiness in a swift manner, that is, there was a poor situational awareness.

Situational awareness is the perception of all the important elements in the environment.

In addition to perception, a perfect understanding of these elements (i.e., the warnings) is necessary. Then, it would be necessary to project their effects to the near future.

The lack of understanding on the part of the crew may be associated with the various aspects listed below:

1. Difficulty detecting the failure and managing it, probably on account of not feeling confident to solve the problem manually and utilize the very system;

2. The idea that the system was able to function by itself, generating complacency and poor situational awareness. The excessive confidence in the systems on the part of the PF, when he utilized the A/P and the A/T, after confirmation of the emergency;

3. Lack of motivation on the part of the PF, for not being happy to fly in the airshuttle service, may have generated a decline of attention and a degradation of the situational awareness;

4. Inappropriate training. The failure appeared in a manner that was different from the one trained in the simulator, making it more complex to perceive and understand.

5. Evidence of stress on the part of the pilot that was being checked, since the company had imposed to him an activity which he would rather not be doing.

Situational awareness governs performance in complex activities (such as the ones associated with aviation), and performance is dependent upon the decision-making process, which, in turn, depends upon situational awareness.

3 CONCLUSIONS

3.1 Facts

1) The crew had valid licenses, certificates and qualifications;

2) The pilots were qualified for the type of flight, and had enough experience both in the route and in the aircraft;

3) The aircraft had a valid airworthiness certificate;

4) The aircraft was new and had just recently arrived form the manufacturing plant;

5) The prevailing weather conditions were IMC;

6) At takeoff roll, the *Engine* light illuminated on the *Master Caution* panel, and both EEC's shifted to the Alternate mode;

7) The indications of *IAS DISAGREE* and *ALT DISAGREE* illuminated on both PFD's;

8) The indications of speed and altitude respectively in the two ASI's and in the two altimeters of the aircraft began to show significant discrepancies;

9) The crew did not manage to quickly identify which indications were valid;

10) The crew received stall warning information (*Stick Shaker*) several times before landing in SBKP;

11) The pilot who was on the jump-seat alerted the crew of the stall situation;

12) the crew declared emergency to ATC, and was vectored (by APP-SSP) for a landing in SBKP;

13) The pilot on the right-hand-side seat had the controls for landing in SBKP;

14) The passengers and crew got out uninjured; and

15) The aircraft sustained no damage.

3.2 Contributing factors

3.2.1 Human Factor

3.2.1.1 Medical aspect

Nil.

3.2.1.2 Psychological aspect

3.2.1.2.1 Individual information

a) Attitude – a contributor

There was complacency, as well as excessive confidence in the systems on the part of the PF and PM when they utilized the A/P and A/T after confirmation of the emergency;

b) Stress evidence – undetermined

The pilot being checked was performing an activity imposed by the airline company, not something that he personally would rather be doing (operate in the airshuttle service);

c) Memory – a contributor

The failure occurred differently from the way its respective training was performed in the simulator, making it more complex to notice and understand;

d) Motivation – undetermined

Since he did not feel motivated to remain operating in the airshuttle service, it is possible that a decline in the state of attention on the part of the PF may have degraded his situational awareness.

3.2.1.2.2 Psychosocial information

Not a contributor.

3.2.1.2.3 Organization information

a) Work organization – a contributor.

The complexity of the administrative and managerial structure of the company's management bases, shared by Congonhas and Confins, resulted in some difficulty in terms of communication, coordination and management of the various tasks that had to be performed by the company's maintenance sectors. Such situation evolved from a latent condition and became an active failure in this incident.

b) Training – a contributor.

A number of internal processes of maintenance required the writing of reports in English. According to the professionals, they did not receive training from the company in this respect, and would sometimes resort to internet translation tools to help understanding the information and performing the maintenance service.

3.2.2 Operational Factor

3.2.2.1 Concerning the operation of the aircraft

a) Application of the controls – a contributor

After takeoff, the PF engaged the A/P and A/T, which had disconnected during the takeoff roll, without considering the *AIS DISAGREE* and *ALT DISAGREE* indications, something that led the aircraft to a critical pitch altitude for that phase of the flight.

b) Adverse weather condition – undetermined

The prevailing weather conditions were IMC, which the crew encountered just after takeoff, at approximately 600ft AGL. If the weather conditions had been VMC, it is possible that the crew might have understood more quickly the situation the aircraft was in.

c) Cockpit coordination – a contributor

The cockpit tasks were not appropriately managed and distributed during the emergency, since it did not become clear who would be flying the airplane, keeping control over it, and who had to identify the failure, manage the emergency, and communicate with ATC.

The pilot on the right-hand-side seat ended up accumulating several concomitant tasks, becoming overwhelmed, to the point that the pilot on the jumpseat had to help him.

d) Training – undetermined

The *Airspeed Unreliable* emergency training was prescribed for and performed during the Initial Flight Simulator Course. However, the real failure which affected the aircraft occurred in a manner that was different and more complex than the one that was trained in the simulator. This is likely to have made it more difficult to be correctly identified by the crew.

e) Pilotage judgment – a contributor

After retraction of the landing gear, already with the *IAS DISAGREE* indication, and the onset of the *ALT DISAGREE* indication on both PFD's, one judged that it would be possible to maintain the normal procedures by engaging the A/P and the A/T.

f) Aircraft maintenance – a contributor

It was confirmed that the left ADM pneumatic hose was fitted but not correctly connected, allowing it to disconnect and later release air, resulting in incorrect information being passed to the ADM and consequently to the PF instruments (altimeter and IAS).

3.2.2.2 Concerning the ATS units

Not a contributor.

3.2.3 Material Factor

3.2.3.1 Concerning the aircraft

Not a contributor.

3.2.3.2 Concerning ATS equipment and technological systems

Not a contributor.

4 SAFETY RECOMMENDATION (RSV)

A safety recommendation is the establishment of an action which the Aeronautical Authority or SIPAER-Link issues to their respective area of responsibility, aiming at eliminating or mitigating the risk of a latent condition or the consequence of an active failure.

From a SIPAER perspective, a safety recommendation is essential for the safety of flight, refers to a specific hazard, and has to be complied with by a certain deadline.

Safety Recommendations made by the CENIPA

To the National Civil Aviation Agency (ANAC):

IG-014/CENIPA/2013 – RSV 001 Issued on: 16/12/2013

Determine that operators under RBAC 121 and 135 reevaluate their simulator training program so that more critical emergencies are trained more frequently.

IG-014/CENIPA/2013 – RSV 002 Issued on: 16/12/2013

Determine that operators regulated by RBAC 121 and 135 review their processes of receipt of new aircraft incorporated in their operating specifications, with the purpose of identifying needs and capacitating maintenance human resources for the technological innovations contained in new equipment contingently acquired by them.

IG-014/CENIPA/2013 – RSV 003 Issued on: 16/12/2013

Determine that the Operators regulated by RBAC 121 and 135 develop definitive procedures to guarantee the preservation of VCR data in case of aeronautical occurrences.

IG-014/CENIPA/2013 – RSV 004 Issued on: 16/12/2013

Determine that the Operators regulated by part 121 and 135 develop definitive procedures to guarantee the presence of professionals with training in SAFETY acting directly in the Maintenance Centers and maintain continuous contact with the Directorate of Operational Safety.

IG-014/CENIPA/2013 – RSV 005 Issued on: 16/12/2013

Disseminate the contents of this report at seminars, lectures and like activities dedicated to operators regulated by RBAC 121 and 135.

5 CORRECTIVE AND/OR PREVENTATIVE ACTION ALREADY TAKEN

The airline company adopted the following pertinent mitigating actions during the process of investigation, with the purpose of upgrading the operation levels of safety:

- Making of a specific Alert Bulletin for the maintenance professionals;

- Analysis and changes in the process of simulator training for the crews;

- Analysis and changes in the process of ground training for the crews;

- Changes in the operational procedures for the engagement of the A/P after takeoff; and

- Analysis and changes in the maintenance processes which were involved in some way in this aeronautical occurrence.

6 DISSEMINATION

– (Brazil's) National Civil Aviation Agency (ANAC)

– (Brazilian Air Force) Department of Airspace Control (DECEA)

– *National Transportation Safety Board (NTSB)*

– *GOL Linhas Aéreas*

– Brazilian Airline Companies Association (ABEAR)

7 APPENDICES

Nil.

On 16 / December / 2013

Brig Gen LUÍS ROBERTO DO CARMO LOURENÇO
Chief of the CENIPA

I HEREBY APPROVE THIS FINAL REPORT:

Lt Brig JUNITI SAITO
Commander of Aeronautics