# COMANDO DA AERONÁUTICA

## CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

# FINAL REPORT
# IG - 556/CENIPA/2018

| | |
|---|---|
| **OCCURRENCE:** | **SERIOUS INCIDENT** |
| **AIRCRAFT:** | **CS-TOD** |
| **MODEL:** | **A340-312** |
| **DATE:** | **08DEC2011** |

# 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 triggering 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 Appendix 2, Annex 13 to 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.**

## SYNOPSIS

This is the Final Report of the 8 December 2011 serious incident involving the model A340-312 aircraft, registration CS-TOD. The incident was classified as “[CTOL] Collision with obstacle(s), during take-off or landing”.

During the takeoff run in SBGL, the aircraft went beyond the limits of the departure end of the runway and collided with obstacles. The pilots did not notice the situation, and proceeded with their flight destined for Lisbon (LPPT).

The aircraft passengers and crewmembers were not injured in the occurrence.

The aircraft sustained light damage to the right main landing gear.

An accredited representative of the French BEA (*Bureau d’Enquêtes e d’Analyses pour la sécurité de l’Aviation Civile*), State where the aircraft was manufactured, and an accredited representative of the Portuguese GPIAA (*Gabinete de Prevenção e Investigação de Acidentes com Aeronaves*), State of the operator, were designated for participation in the investigation.

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## GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

| | |
|---|---|
| ADC | Aerodrome Chart |
| ALS | Approach Lighting System |
| ANAC | Brazil's National Civil Aviation Agency |
| ATIS | Automatic Terminal Information Service |
| BEA | *Bureau d'Enquêtes e d'Analyses pour la sécurité de l'Aviation Civile* - France |
| CENIPA | Aeronautical Accident Investigation and Prevention Center |
| CGNA | Air Navigation Management Center |
| CVR | Cockpit Voice Recorder |
| DECEA | Airspace Control Department |
| DTCEA-GL | Galeão Airspace Control Departament |
| FDR | Flight Data Recorder |
| FMGEC | Flight Management Guidance Envelope Computer |
| GPIAA | (Portugal's) Aircraft Accidents Prevention and Investigation Cabinet |
| ICA | Command of Aeronautics' Instruction |
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| INFRAERO | Brazilian Airports Infrastructure Enterprise |
| METAR | Meteorological Routine Aerodrome Report |
| NOTAM | Notice to Airmen |
| PF | Pilot Flying |
| PM | Pilot Monitoring |
| RSV | Flight Safety Recommendation |
| SBGL | ICAO location designator – Antônio Carlos Jobim International Airport |
| TOGA | Take-Off Go Around |
| UTC | Universal Time Coordinated |
| VRF | Visual Flight Rules |

## 1. FACTUAL INFORMATION.

| | | |
|---|---|---|
| **Aircraft** | **Model:** A340-312<br>**Registration:** CS-TOD<br>**Manufacturer:** Airbus Industrie | **Operator:**<br>TAP Portugal |
| **Occurrence** | **Date/time:** 08DEC2011/22:37 (UTC)<br>**Location:** Tom Jobim Intl. Airport (SBGL)<br>**Lat.** 22°48'36"S **Long.** 043°15'02"W<br>**Municipality – State:** Rio de Janeiro - RJ | **Type(s):**<br>[CTOL] Collision with obstacle(s), during take-off or landing<br>**Subtype(s):**<br>Nil. |

### 1.1 History of the flight.

The aircraft departed from Antônio Carlos Jobim International Airport, RJ (SBGL) destined for Lisbon, Portugal (LPPT), at 22h37min (UTC), operating as Flight TP074, in order to transport passengers and cargo, with eleven crew members and 255 passengers on board.

During the takeoff run from runway 10, whose first 1,270 meters were interdicted due to work in progress, the aircraft had an overrun on departure, and its landing gear collided with obstacles.

The crew did not notice the situation, and proceeded with their flight destined for Lisbon (LPPT), where the aircraft landed uneventfully.

In 09DEC2011, at 17h55min (UTC), the Aerodrome Operator Inspection Service was requested to go to the runway 28 threshold, where they confirmed that the aircraft had an overrun during the takeoff and collided with lights of the *Approach Light System* (ALS) and antennae of the *Instrument Landing System* (ILS), at the end of the runway.

At 21h30min (UTC), the Aerodrome Operator's Ramp and Runway Inspector received information from the SBGL TAP Air Portugal Maintenance Supervisor, reporting that an ALS lamp had been found stuck to the right main landing gear structure of the CS-TOD after landing at LPPT.

The aircraft sustained light damage.

No injuries were registered in all occupants.

### 1.2 Injuries to persons.

| Injuries | Crew | Passengers | Others |
|---|---|---|---|
| Fatal | - | - | - |
| Serious | - | - | - |
| Minor | - | - | - |
| None | 11 | 255 | - |

### 1.3 Damage to the aircraft.

The CS-TOD sustained light damage to the right main landing gear. There was damage to the wheels no. 3, 7 and 8, and some of the components of the right main landing gear had detached from the assembly due to the collision.

During a post-flight inspection, the Air Portugal maintenance team found parts of the runway lighting system stuck between the right main gear and wheel no. 8.

### 1.4 Other damage.

There was damage to several lights of the ALS, as well as to three ILS antennas of the SBGL runway 28.

### 1.5 Personnel information.

#### 1.5.1 Crew's flight experience.

| Hours Flown | | |
|---|---|---|
| | Pilot | Copilot |
| Total | 14,000:00 | 6,000:00 |
| Total in the last 30 days | 64:00 | 46:00 |
| Total in the last 24 hours | 00:00 | 00:00 |
| In this type of aircraft | 700:00 | 900:00 |
| In this type in the last 30 days | 36:00 | 22:00 |
| In this type in the last 24 hours | 00:00 | 00:00 |

**N.B.:** data provided by the airline company.

#### 1.5.2 Personnel training.

The aircraft captain did his Pilots' General Course at TAP Portugal in 1985.

The copilot did the Company Integration Course at TAP Portugal in 2002.

#### 1.5.3 Category of licenses and validity of certificates.

The aircraft captain had an Airline Transport Pilot license, and his technical qualifications were valid.

The copilot had an Airline Transport Pilot license, and his technical qualifications were valid.

#### 1.5.4 Qualification and flight experience.

The crew was qualified and had enough experience for the type of flight.

#### 1.5.5 Validity of medical certificate.

The crew had valid medical certificates.

### 1.6 Aircraft information.

The aircraft serial number 91 was manufactured by Airbus Industrie in 1995. Its airworthiness certificate was valid. The aircraft maintenance records were up-to-date.

The last inspection of the aircraft (type A1.20) was done in 21NOV2011, by the workshop of *TAP Manutenção e Engenharia – Lisboa*. After this inspection, the aircraft flew 201 hours and 30 minutes.

The last overhaul (type C6.2) was done in 11FEB2011, by the workshop of *TAP Manutenção e Engenharia – Brasil* on 11 February 2011. After this overhaul, the aircraft flew 4,033 hours and 41 minutes.

Both workshops had certification for the type of service provided.

### 1.7 Meteorological information.

There was meteorological information available to the crew, who used it to plan the flight. The SBGL weather report as of 22:00 UTC was the following:

SBGL 082200Z 05005KT 9999 –RA SCT010 BKN025 BKN080 25/22 Q1011.

According to the SBGL *Automatic Terminal Information Service* (ATIS), information *Uniform* 21h51min (UTC), the wind was 100 degrees at 4kt, visibility 7km, temperature 24 degrees Celsius, altimeter setting 1010hpa.

### 1.8 Aids to navigation.

Nil.

## 1.9 Communications.

The investigation team analyzed the SBGL ATIS recordings at the time of the initial call of the aircraft for flight clearance.

The ATIS (information U) warned of a restriction relative to the length of runway 10, and reproduced the contents of the NOTAM D2382/2011.

## 1.10 Aerodrome information.

SBGL was a public aerodrome under the administration of INFRAERO. It operates VFR and IFR during day- and night-time. The runway was made of asphalt, thresholds 10/28, dimensions 4,000m x 45m and 28ft field elevation.

The *Airdrome Chart* (ADC) shows that, in order to take off from the displaced threshold of runway 10 and utilize the available 2,730 meters, the crew should use the distance between taxiways AA and BB on departure (Figure 1).

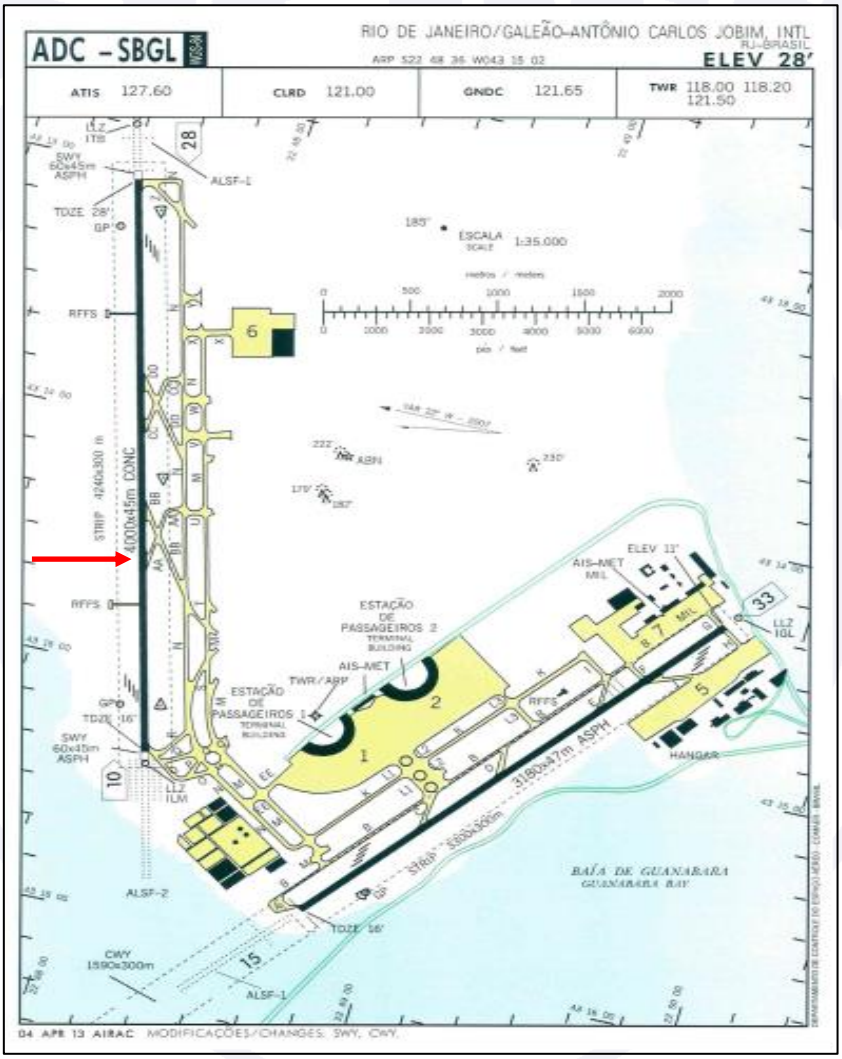


Figure 1 - SBGL Aerodrome Chart (ADC).

Starting the takeoff run after having joined runway 10 via taxiway BB would result in a reduction of 600 meters in the available runway length.

According to the ADC, taxiways AA and BB intersect each other at an angle of approximately 135 degrees.

The NOTAM D2382/2011, valid from 31OCT2011 to 12JAN2012, had information about the runway partial interdiction, and read as RWY 10 FST 1270M CLSD WIP.

The NOTAM D2383/2011, valid from 31OCT2011 to 12JAN2012, informed that the available takeoff distance on runway 10 was 2,730 meters.

On the day of the incident, the runway in use was RWY 10 and its first 1,270m was interdicted due to work in progress. There was clear and visible runway signage available to the crew, indicating where the beginning of the displaced threshold was located.

**1.11 Flight recorders.**

It was not possible to read out the aircraft main flight recorders due to the delay with which the occurrence was notified to the Brazilian Investigation Authority (CENIPA).

The Cockpit Voice Recorder (CVR) and the Flight Data Recorder (FDR) recorded the flight parameters and the conversation/radio talk in the flight deck. The crew did not notice the collision, and continued flying up to the final destination (LPPT), where TAP Portugal performed the prescribed maintenance procedures, and released the aircraft for flight.

With every new flight of the CS-TOD, new information were recorded on top of the old ones on CVR and FDR, making it impossible to retrieve information related to the incident. Thus, when the CENIPA received the notification, the relevant information was no longer available.

The aircraft also had a Quick Access Recorder (QAR) device. The QAR data was retrieved after flight by the maintenance team, and were forwarded to the CENIPA.

Based on the quick-access data recording parameters, the investigation team asked AIRBUS to calculate the takeoff performance parameters, and these data were compared with the ones used by the crew at the moment of takeoff. The results of this analysis are described in item 1.16 of this report (Tests and Research).

**1.12 Wreckage and impact information.**

After being notified of the occurrence by the TAP Portugal maintenance staff, the Aerodrome Operator sent technicians to verify the situation on runway 28.

According to the Occurrence Report written by the Aerodrome Operator (INFRAERO), there were tire marks up to 200m beyond the end of the runway 28 stopway. The last obstacle hit by the aircraft during takeoff was a set of antennas of the Localizer at a distance of 300 meters from the end of the stopway.

The runway 28 threshold stopway measures 60m x 45m. Thus, the distance between the end of runway 10 and the last obstacle hit by the incident aircraft was 360 meters, in the same direction of the runway axis.

**1.13 Medical and pathological information.**

**1.13.1 Medical aspects.**

Nil.

**1.13.2 Ergonomic information.**

Nil.

**1.13.3 Psychological aspects.**

Not investigated.

**1.14 Fire.**

There was no fire.

**1.15 Survival aspects.**

Nil.

## 1.16 Tests and research.

As for the tests performed by TAP Portugal Maintenance in the CS-TOD, it is worth presenting the results described in the Technical Report TP125/201.

After the aircraft landed in Lisbon, TAP Maintenance started an investigation to verify the particulars of the occurrence. Several tests were performed in the aircraft systems, mainly in relation to the landing gear and brake system.

According to the report, there is no evidence of a technical failure of the aircraft that could have contributed to the occurrence. The damage caused by the impact was corrected, and the aircraft was released for flight.

During the investigation, Airbus was asked to perform takeoff calculations based on the aircraft flight parameters obtained from the quick-access data recordings for the prevailing weather conditions at the moment of takeoff and for the same runway conditions.

The A340-312 was fitted with two Flight Management Guidance Envelope Computers (FMGEC), in charge of managing the whole flight.

The aircraft also had a takeoff configuration check system which would provide crew warning alerts if the configuration of the aircraft was different that the FMGEC settings.

When a runway is partially interdicted, as was the case of SBGL runway 10, the crew is expected to insert the proper displacement in the FMGEC. According to the Airbus analysis, the pilots had inserted a forward displacement of approximately 1,270 meters, corresponding to the junction between taxiway AA and runway 10, that is, the takeoff position corresponding to the end of the work in progress area and the beginning of the available runway.

At the start of the takeoff run, when the throttles are moved to the takeoff position, the FMGEC registers the aircraft position in terms of latitude and longitude. According to the Airbus analysis, when the throttles were moved to the takeoff position, the aircraft was at a distance of approximately 1,900m from the runway 10 threshold.

The first conclusion of the Airbus report indicates that the aircraft started the takeoff run from a point at a distance of approximately 600m ahead of the displaced threshold. From this point, the available runway length was about 2,095m.

The second conclusion refers to the power required for takeoff. The quick-access data recorder did not record the power that was utilized at takeoff, but according to the pilots, a Flex Take-Off of 34º C was used.

For A340-312 aircraft, a takeoff may be made either with maximum power (TOGA) or reduced power (Flex Take-Off). Reduced power is used for preserving the engines at takeoff (lower temperature of operation), under certain parameters of aircraft weight and runway length.

Two calculations of the power and distance required for takeoff were made by Airbus: the first one from the point at which the takeoff run effectively started (throttles in takeoff position), and another one, with simulation of a takeoff from the beginning of the displaced threshold (runway length available according to the NOTAM).

a) Takeoff calculation, considering the distance available when the throttles were moved to the takeoff position (2,095m);

b) Takeoff calculation, considering the distance available according to the NOTAM (2,730 meters). The information on table below (2,717m) refers to the minimum required distance for a Flex Take-Off with 34°C.

The table below shows the results obtained in both calculations:

| Case | Available length | Flex Max OAT W = 236.4T | V1 bal Kt IAS | VR Kt IAS | V2 Kt IAS |
|---|---|---|---|---|---|
| A | 2095 m | N/A | N/A | N/A | N/A |
| B | 2717 m | **34°C** | 130.5 | 144.4 | 153.8 |

Figure 2 - Takeoff distance calculations.

According to Figure 2, the Airbus conclusion was that a takeoff from a runway with 2,095 meters available would not be possible even if maximum thrust (TOGA) had been applied. However, if the takeoff run started from the position indicated in the NOTAM (with an available runway length of 2,717m or more) a takeoff with reduced power (Flex Take-Off of 34º C) would be feasible.

**1.17 Organizational and management information.**

The investigation team studied the activities performed by a number of organizations in the phase of preparation for the works to be done at SBGL. Among the organizations, were the INFRAERO, the Galeão Airspace Control Departament (DTCEA-GL), and the company contracted to do the construction work (*AMC Engenharia*).

On 23AUG2011, a meeting was held at INFRAERO Operations Management facilities in SBGL to discuss the works that had to be done to the airport, and the writing of an operational agreement encompassing the description of standard routes and the preparation of a specific NOTAM for each phase.

On 06SEP2011, another meeting was held with representatives of INFRAERO, DTCEA-GL and *AMC Engenharia*, aiming at coordinating the actions taken by each of these organizations.

The decision made by them was that: the Aerodrome Operator (INFRAERO) would be responsible for requesting NOTAMs, the DTCEA-GL would include runway interdictions in the ATIS broadcast, and *AMC Engenharia* would be responsible for signaling any runway/taxiway interdictions. In this meeting, a draft operational agreement between the INFRAERO and DTCEA-GL was presented.

On 14SEP2011, an Operational Agreement Letter for the execution of the SBGL Airport works was signed. This Letter contained the operational procedures to be performed by *Galeão* Control Tower (DTCEA-GL), Galeão Operational Management (INFRAERO) and *Galeão* Engineering Management (INFRAERO).

Included in the established procedures were standardized taxi routes for aircraft wishing to take off from the runway 10 displaced threshold (first 1,270 meters interdicted). The final portion of the taxi route would follow the profile for taxiways N, BB and AA. There was also an alternative taxi route for wide-body planes not capable of making a left turn onto taxiway BB. These aircraft would taxi via taxiways N and AA.

**1.18 Operational information.**

In relation to the crew procedures, the aircraft captain and the copilot were interviewed so that the conditions prior to takeoff and details of flight preparation could be

verified. According to the pilots, the rest periods were complied with, and they had taken no medicine.

In preparation for the flight, the copilot did the takeoff calculations based on the NOTAM information, and he used an Airport Analysis table of TAP Portugal that had been prepared for a threshold displacement of 1,270 meters and an available takeoff distance of 2,730 meters. The calculated takeoff thrust was Flex Take-Off with 34ºC. The captain checked the copilot calculations, and inserted them in the aircraft FMGEC.

For purposes of division of tasks in the cockpit for the flight route between SBGL – LPPT, the aircraft captain would be flying as PM (Pilot Monitoring), whereas the copilot would be flying as the PF (Pilot Flying). As prescribed in the TAP Manual, all the taxi up to the line-up for takeoff was done by the captain, who then handed over the controls to the copilot for takeoff.

The aircraft was cleared to taxi via taxiways EE, M, T and BB. The captain reported that, upon crossing taxiway AA, he sighted an "X" marking, and considered that it was closed. According to the pilots' accounts in the interviews, they understood that a takeoff from position BB would correspond to the reference dimensions, something that, in their opinion, was confirmed when the Control Tower cleared them to take off.

They entered the runway at the intersection with taxiway BB and immediately commenced the takeoff run with normal acceleration to take advantage of the aircraft speed. Both pilots noticed a slight vibration at the end of the runway for about 3 to 4 seconds but, with the aircraft on a pitch-up attitude, they attributed the vibration to an uneven pavement.

After takeoff, the crew observed a temperature alert coming from the right main landing gear. Thus, they let it remain in the down position a bit further for cooling. The remainder of the flight up to Lisbon was uneventful.

### 1.19 Additional information.

The DTCEA-GL held a meeting with the Control Tower Supervisors to discuss mitigating measures related to the works on runway 10. The minutes of the meeting proceedings were written (*Ata de Reunião* no. 008/SOGL).

Several issues were discussed during the meeting, and a traffic controller said that in the early times of the runway interdiction, all aircraft were monitored more closely. However, as time went by, this was no longer the case, since the crews became familiar with the changes. He said that the runway restrictions were always informed to the pilots, and when a longer runway was necessary, controllers would suggest runway 15 for takeoff.

As for the material made available to the TAP crews by the company, it is worth highlighting that the tables for takeoff calculation did not bring information about the position of the displaced threshold. Nor were other visual or graphic aids provided for identification of the route to be followed by the aircraft while taxiing towards the displaced threshold.

### 1.20 Useful or effective investigation techniques.

Nil.

## 2. ANALYSIS.

The flight was a airline passengers transport operation between SBGL and LPPT.

On the day of the occurrence, the first 1,270 meters of SBGL runway 10 were interdicted due to work in progress. There was a NOTAM with information about this situation, and *Galeão* ATIS was broadcasting the runway restrictions.

Based on this information, the investigation team initially considered three hypotheses for the occurrence involving the CS-TOD: the crew was not knowledgeable of the reduction in the available runway length; the crew made a mistake in the takeoff calculation; the crew made a takeoff in discordance with the prescribed configuration or acceleration parameters.

The first hypothesis was raised, because a lack of knowledge regarding the reduction of the runway length available for takeoff would have led the crew to calculate the takeoff parameters for a more comfortable situation: a longer runway. This would affect the takeoff calculation, since the crew could make use of less power or a different flap configuration, making the aircraft move along a greater distance on the runway and, therefore, overrun its limits.

The initial evidence led the investigators to withdraw the first hypothesis, since both pilots declared to be aware of the runway 10 conditions. The crew received the relevant information before the flight, utilizing them in the preparation of the flight, and this could be verified by means of the takeoff calculations that were made.

The TAP Portugal Airport Analysis table utilized by the copilot had been prepared for a runway 10 displacement of 1,270 meters and for an available takeoff distance of 2,730 meters. The displacement of the runway threshold was inserted in the FMGEC and remained recorded in the aircraft equipment.

Thus, the copilot was aware of the restriction, and utilized a table appropriate for the situation. The aircraft captain, in the exercise of his duties, confirmed the takeoff calculation made by the copilot, and learned about the runway restrictions.

Since the crew was aware of the runway restrictions and utilized a correct table, the second hypothesis was considered, in order to verify whether an error had been committed in the takeoff calculation. This hypothesis was tested by comparing the data provided by the crew (and inserted in the FMGEC) with the independent calculations made by aircraft manufacturer (Airbus).

The result obtained by the crew was that takeoff would be possible with a reduced thrust (Flex Take-Off) at 34ºC. Takeoff with reduced power is a normal procedure prescribed by the manufacturer to extend the service life of the engines.

The recorded takeoff parameters were sent to the aircraft manufacturer, and a team of Airbus engineers was asked to simulate the same data provided by the crew. The engineers obtained the same results previously obtained by the CS-TOD crew, refuting the hypothesis of an error in the takeoff calculations.

The third hypothesis relates to a takeoff in discordance with the prescribed configuration or acceleration parameters. After verifying that the takeoff calculations were accurate and had been inserted in the FMGEC, it was necessary to confirm whether the aircraft had been configured in accordance to the prescriptions and whether the takeoff had been normal.

The investigation verified that the aircraft has a system of detection and alert in case the takeoff configuration is not completed. The crew did not report any abnormalities at takeoff, and affirmed that the aircraft acceleration was normal.

Moreover, none of the parameters recorded by the aircraft indicated any type of irregularity during the takeoff run. This was evidence that this hypothesis was rather unlikely to have happened.

In addition, the pilots affirmed that they entered the runway, lined up, and, without stopping, proceeded for a direct takeoff. Such procedure allows a quicker acceleration, reducing the distance necessary for takeoff.

Another aspect that was investigated: the pilots noticed a slight vibration at the end of the runway and thought that it was due to undulations on the pavement. After an analysis of the aircraft trajectory, it was possible to identify that such “undulations” coincided with the end of the runway, since the marks made to the ground by the aircraft were rather distinct.

The pilots did not realize that they had surpassed the runway limits on account of the rotation attitude of the aircraft (nose up), no allowing them to see the end-of-runway lights.

Therefore, none of the three aforementioned hypotheses was able to clarify the occurrence.

After the analysis of the communications between the ATC units and the aircraft, another hypothesis was considered: the crew commenced the takeoff run from a position located 600 meters ahead of the displaced runway.

According to this hypothesis, instead of making use of the whole available distance of 2,730 meters, the aircraft had started the takeoff run at a distance of 2,095 meters from the departure end of the runway. For a better understanding of the sequence of events that culminated in the occurrence, it was necessary to analyze in detail all the aspects involved, from the preparation of the works up to the aircraft departure.

The Aerodrome Operator (INFRAERO) and *Galeão* Ground Control (DTCEA-GL) were aware of the various changes caused by the work in progress in the aerodrome, and, on 14SEP2011, signed an Operational Agreement Letter prior to the execution of the works at SBGL.

The Operational Agreement Letter listed the standard taxi routes to be followed by aircraft wishing to take off from runway 10 (with a displaced threshold). The final portion of the route was to be made via taxiways N, BB and AA. There was also an alternative route for wide-body planes which might not be able to turn left on taxiway BB in order to enter the departure runway. The alternative route in this case was via taxiways N and AA.

Despite the prescription of a specific taxi procedure for wide-body planes, in the occurrence involving the CS-TOD, the procedure was not complied for a lot of reasons. One of the factors that may have had an influence was that the prescribed taxi procedure was excessively generic. Instead of defining which aircraft had to perform the procedure, the Letter only mentioned “wide-body planes”.

As already explained, the interdiction of the initial portion of SBGL runway 10 (first 1,270 meters) meant that the pilots had to take off from a displaced threshold.

For performing the taxi maneuver, there were two possibilities: the first one was to enter the runway via taxiway AA, at the position of the displaced threshold. The other possibility was to enter the runway via taxiway BB and, in this case, it would be necessary to backtrack the runway towards the displaced threshold location, which was abeam taxiway AA.

The distance from the intersection between the runway and taxiway BB to the displaced threshold location was 600 meters. An aircraft could start the takeoff run from this position, but it would have only 2,095 meters of runway length available. Nevertheless, in order to understand such changes, it would be necessary for the pilots to get familiarized with them, utilizing the aerodrome charts.

It is worth highlighting that taxiways AA and BB cross each other at a highly accentuated angle (approximately 135 degrees). Such angle and the width of the taxiway

make it not viable for a large size airplane like the A340-312, while taxiing on taxiway BB, to turn left in order to enter taxiway AA.

The characteristics of the layout of taxiways AA and BB may have influenced the pilots to believe that, if they taxied via taxiway BB, they would get to the correct location of the displaced threshold.

However, in order to start a takeoff run from the displaced threshold, the pilots would have to enter the runway via taxiway AA, and should have requested an amendment to the clearance from ATC, since the taxi had been approved via taxiway BB.

A clear instruction to aircraft like the A340-312 (requiring them to taxi via taxiway N and, then, via taxiway AA) could have prevented the incident.

Besides, some of the controllers reported that in the early times of the runway interdiction, all aircraft were instructed about the runway restrictions, and about the procedures they had to follow. If a longer runway was necessary for takeoff, the controllers would recommend runway 15.

However, as time passed by, these instructions were reduced, since the crews became familiar with the changes. Although the guidance provided by Ground Control was not an obligation, since the restrictions were publicized by means of NOTAM and ATIS, they would probably have helped to prevent this incident by strengthening the crews' situational awareness.

Another aspect that may have influenced the pilots' situational awareness was related to their preparation for the flight. The crews normally use aerodrome charts to become familiar with a location, especially in complex systems, as was the case with SBGL. Such procedure was even more important when there was work in progress at an aerodrome.

In this incident, the lack of familiarization became evident with the pilots' accounts, as both of them were in doubt whether to enter the runway via taxiway AA or taxiway BB. These aspects indicated that their preparation for the flight was not adequate (study of the aerodrome, identification of taxiways, and location of the displaced threshold).

An aspect worth noting is the information made available to the pilots by means of the NOTAM (RWY 10 FST 1270M CLSD WIP). Although the text of the NOTAM makes it clear that the initial portion of the runway was interdicted, there were no further instructions as to which taxiway had to be used in order to access the displaced threshold (in this case, taxiway AA).

A more complete and elaborate text could have strengthened the crew's situational awareness, making them alert for a correct identification of the taxiways to be utilized.

By the same token, the material provided by the TAP Portugal company for calculation of the takeoff and preparation of the flight did not favor the crew's situational awareness. The table for calculating the takeoff performance with a forward displacement of 1,270 meters was not clear as to where to start the takeoff run.

After the occurrence of the incident, TAP Portugal began to provide their crew with a *croquis* showing the route to be followed to join the runway. Such visual aid could have fostered understanding on the part of the crew and prevented this incident, if it had been made available before the incident flight.

According to the transcript of the recordings, after starting the engines, TAP Flight 074 received clearance from Ground Control to taxi via taxiways EE, M, T, and BB. There were neither further instructions concerning the restrictions imposed by the work in progress nor observation of the standardized taxi route prescriptions contained in the Operational Agreement Letter in force since 14SEP2011.

Furthermore, there was not any type of questioning by the crew in relation to the clearance received, considering that it is the crew's responsibility to tell ATC when they are not able to comply with a given instruction. This shows that the crew was not aware of the fact that the taxi clearance received would take them to a position 600 meters ahead of the displaced threshold location.

The crew reported taxiway BB, and were cleared to take off. The pilots did not question the Control Tower about the location of the displaced threshold, and proceeded with the takeoff, inferring that they were in the planned position.

Further analyses of the FMGEC showed that the aircraft entered the runway at the intersection with taxiway BB, in accordance with the clearance issued by the Control Tower. The takeoff run started at this position, in consonance with the data of the aircraft recorders.

In A340-312 aircraft, the FMGEC records the aircraft position in terms of latitude and longitude when the throttles are moved to the takeoff setting. According to the Airbus analysis, from the data recorded in the FMGEC, at the moment of starting the takeoff run, the aircraft was at approximately 600 meters ahead of the displaced threshold location, and had 2.095 meters of takeoff distance available.

Thus, one may conclude that the crew prepared the takeoff considering an available distance of 2,730 meters, but started the takeoff run at approximately 600 meters ahead of the position informed in the NOTAM, close to taxiway BB, thus having less distance available for the takeoff.

At this point of the investigation, the Airbus team of engineers was asked to make a new takeoff calculation, taking into consideration the same parameters used for the first calculation, but reducing the takeoff distance available to 2,095 meters.

The results obtained in this second calculation showed that there was no possibility of success with the thrust regime that was selected by the crew (Flex Take-Off at 34ºC). Even if they had utilized maximum thrust of the engines (TOGA), the available runway length was not enough for the takeoff. Thus, their incorrect positioning on the runway was decisive for the occurrence of the incident.

The details of the damage reported by the Aerodrome Operator, with marks on the ground as far as 200 meters beyond the stopway, and the last obstacle hit (antenna of the localizer) at 360 meters, indicate that the takeoff would have been uneventful if it had started 600 meters before, that is, from the displaced threshold location.

All the aspects described in this report show that one should not make judgments on the severity of an event based only on its consequences. The small amount of damage caused to the aircraft and to the aeronautical infrastructure is not a good reference for the urgency of mitigating the factors that contributed to this incident, if one aims preventing the occurrence of a serious accident.

## 3. CONCLUSIONS.

### 3.1 Facts.

a) the pilot had valid A340 type ratings;

b) the pilots had valid medical certificates;

c) the pilots were qualified and had the necessary experience for the flight;

d) the aircraft had a valid airworthiness certificate;

e) the maintenance services were considered periodical and appropriate;

f) the CS-TOD, of the TAP Portugal fleet, operating as TP 074, departed from SBGL at 22h37min (UTC), destined for LPPT, with 266 people on board;

g) on the day of the accident, the first 1,270 meters of runway 10 were interdicted due to work in progress on the runway;

h) the NOTAM D2382/2011 and the SBGL ATIS had information concerning the interdiction of runway 10;

i) the pilots performed the calculation for departure from the displaced threshold, considering an available runway length of approximately 2,730 meters;

j) the aircraft was prepared for takeoff from the displaced threshold, including insertion of data in the FMGEC;

k) the taxi clearance received by the crew was via taxiway BB in the final segment;

l) no taxi-clearance amendment was requested for utilizing the AA taxiway;

m) the aircraft joined the runway via BB taxiway, approximately 600 meters ahead of the displaced threshold location;

n) the start of the takeoff run recorded in the FMGEC occurred when the aircraft had 2,095 meters of runway available;

o) the aircraft performance was not enough for taking off with 2,095 meters of runway available, even with maximum thrust (TOGA);

p) the takeoff run was normal without any kind of problem in the aircraft;

q) the distance between the departure end of runway 10 and the last obstacle hit by the departing incident aircraft was approximately 360 meters;

r) some of the ALS lights, as well as antennae of the localizer were damaged; and

s) the aircraft sustained light damage to the right main landing gear; and

t) no injuries were registered in all occupants.

**3.2 Contributing factors.**

- **Airport infrastructure – a contributor.**

The work in progress in the aerodrome resulted in a displacement of the runway 10 threshold, reducing the takeoff distance available to 2,730 meters. The existing alerts concerning this situation (by means of NOTAM and ATIS) were not enough to prevent the incident, since they did not offer guidance as to which taxiway had to be used by wide-body planes.

The high angle formed between taxiways AA and BB do not allow wide-body planes taxiing on taxiway BB to turn onto taxiway AA, which provides direct access to the displaced threshold location.

- **Flight planning – a contributor.**

Despite of the availability of taxi information in the ADC, there was inadequate familiarization with the precise location of the displaced threshold, taxiways and location of the work in progress, leading the crew to accept the taxi clearance without questioning or requesting a clearance change. In addition, the crew did not recognize their incorrect position when they were cleared to line up and take off.

- **Management planning – a contributor.**

The material provided by TAP Portugal to the crew for takeoff calculation and flight preparation, did not favor the crew's situational awareness, as it did not contain precise information on the location of the displaced threshold.

- **Managerial oversight – undetermined.**

The Operational Agreement Letter for the execution of works at SBGL, signed by the Aerodrome Operator (INFRAERO) and by the ATC unit (DTCEA-GL), contained the standard taxi routes to be used by the aircraft to get to the displaced threshold location. The agreement contemplated a preferential route and an alternative one (this latter to be used by "wide-body planes" in general).

The lack of a more specific criterion, establishing which types of aircraft had to use the alternative route, may have led the controllers to authorize an airplane for a route that was not adequate for its size.

- **Use of phraseology by ATS – undetermined.**

Although information on the displaced threshold was provided to the pilots by means of NOTAM/ATIS, and the fact that responsibility for getting familiarized with the aerodrome belonged to the crew, the lack of a phraseology with clear guidance relative to the location of the displaced threshold and the best way to get to it, may have induced the pilots to their wrong positioning for takeoff.

## 4. SAFETY RECOMMENDATION.

***A proposal of an accident investigation authority based on information derived from an investigation, made with the intention of preventing accidents or incidents and which in no case has the purpose of creating a presumption of blame or liability for an accident or incident. In addition to safety recommendations arising from accident and incident investigations, safety recommendations may result from diverse sources, including safety studies.***

***In consonance with the Law n°7565/1986, recommendations are made solely for the benefit of the air activity operational safety, and shall be treated as established in the NSCA 3-13 "Protocols for the Investigation of Civil Aviation Aeronautical Occurrences conducted by the Brazilian State".***

**Recommendations issued at the publication of this report:**

**To the Brazil's National Civil Aviation Agency (ANAC):**

**IG-556/CENIPA/2018 - 01** **Issued on 09/04/2018**

Require from Aerodrome Operators that, in the case of work in progress at airports, they strive to write requests of NOTAMs containing clear, simple, concise and ambiguity-free information, so that NOTAMS are understood without consultation of other documents, in accordance with the prescriptions of the ICA 53-1/2012.

**IG-556/CENIPA/2018 - 02** **Issued on 09/04/2018**

Require from Aerodrome Operators that, during the planning of works at aerodromes, they provide the crews with written explanatory material containing information on the works, with widespread publicity to the operators that make use of the airport.

**IG-556/CENIPA/2018 - 03** **Issued on 09/04/2018**

Require from Aerodrome Operators (and monitor accordingly) that, during the planning of works at aerodromes, they simulate aeronautical occurrences in all the phases of the works, with the objective of eliminating the hazards and mitigating the risks involved.

**IG-556/CENIPA/2018 - 04 Issued on 09/04/2018**

Require from the airline companies operating in Brazil and regulated by RBAC 129 that they inform the Brazilian Aeronautical Investigation Authority (CENIPA) of any aeronautical occurrence involving their aircraft within the Brazilian territory, taking into account the prescriptions of the pertinent legislation in force.

**To the Brazil's Airspace Control Department (DECEA):**

**IG-556/CENIPA/2018 - 05 Issued on 09/04/2018**

Require from ATC units that they establish and maintain, during the time the operational agreements are in force, an appropriate and standardized radiotelephony communication, taking into consideration the wingspan, length and weight of aircraft.

**IG-556/CENIPA/2018 - 06 Issued on 09/04/2018**

Require from ATC units, during the time in which operational agreements due to work in progress at the aerodrome are in force, to refrain from using generic terms, and to establish specific aircraft taxi routes, taking into account the type of aircraft to which the clearance is being delivered.

## 5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

The DTCEA-GL held a meeting with *Galeão* Tower Control supervisors to discuss mitigating measures concerning the work in progress at SBGL runway 10. These measures were listed in the meeting minutes no. 008/SOGL.

The DTCEA-GL prepared the Operational Notice 149/DGL 3.3/11, in effect from 22DEC2011, for supervisors and controllers of the Control Tower. It dealt with the taxi of wide-body planes toward runway 10, and determined that large size aircraft, such as the A340-312, had to taxi via taxiways M, U and AA, or taxiways M, T, N and AA, with the objective of preventing the need to make accentuated turns.

TAP Portugal made a *croquis* of SBGL, showing the locations of the work in progress and of the displaced threshold to be handed in to their pilots, so that they could quickly identify those locations. In addition, an internal notice was issued to reinforce the operational safety policy of the company, together with an informative *croquis* to be distributed to the crews for the case of work in progress at airports in which the company were operating.

On September 4th, 2018.