

**COMANDO DA AERONÁUTICA**  
**CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE**  
**ACIDENTES AERONÁUTICOS**



**FINAL REPORT**  
**A - 526/CENIPA/2015**

<b>OCCURRENCE:</b>	<b>ACCIDENT</b>
<b>AIRCRAFT:</b>	<b>PT-MFW</b>
<b>MODEL:</b>	<b>PA-31T2</b>
<b>DATE:</b>	<b>06 NOV 2012</b>



## NOTICE

*According to the Law n° 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 item 3.1, Annex 13 to the 1944 Chicago Convention, which was incorporated in the Brazilian legal system by virtue of the Decree n° 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 6 November 2012 aeronautical accident with the PA-31T2 aircraft, registration PT-MFW. The occurrence was classified as fuel starvation/exhaustion.

On the final approach for landing on the runway 18 of SBBI, the aircraft crashed into the ground.

All aircraft occupants (2 passengers and 2 crewmembers) perished in the crash.

The aircraft sustained substantial damage.

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



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**GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS**

ANAC	Brazil's National Civil Aviation Agency
APP-CT	Curitiba Approach/Departure Control
ASV	Flight Safety Agent
CA	Airworthiness Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CHT	Technical Qualification Certificate
CMA	Aeronautical Medical Certificate
CTM	Aeronautical Maintenance Technical Control
DCTA	Department of Science and Airspace Technology
GSO	Operational Safety Manager
IAC	Civil Aviation Instruction
IFR	Instrument Flight Rules
METAR	Routine Aerodrome Weather Report
MGM	General Maintenance Manual
MGO	General Operating Manual
MGSO	Operational Safety Management Manual
NTSB	National Transportation Safety Board (USA)
PCM	Commercial Pilot – Airplane category
PLA	Airline Transport Pilot – Airplane category
PPR	Private Pilot – Airplane category
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
RELPREV	Prevention Report
SERIPA	Regional Aeronautical Accident Investigation and Prevention Service
SBBI	Location designator – Bacacheri aerodrome
SBCA	Location designator – Cascavel aerodrome
SBDO	Location designator – Dourados aerodrome
SSFE	Location designator – Estância Hércules aerodrome
SGSO	Operational Safety Management System
TWR-BI	Bacacheri Aerodrome Control Tower
VFR	Visual Flight Rules
UTC	Universal Time Coordinated

## 1. FACTUAL INFORMATION.

<b>Aircraft</b>	<b>Model:</b> PA-31T2	<b>Operator:</b> <i>Taxi Aéreo Hércules Ltda.</i>
	<b>Registration:</b> PT-MFW	
	<b>Manufacturer:</b> Piper Aircraft	
<b>Occurrence</b>	<b>Date/time:</b> 06NOV2012 / 20:25 UTC	<b>Type(s):</b> Fuel starvation/ Exhaustion.
	<b>Location:</b> Rural Area ( <i>Rodovia dos Minérios</i> )	
	<b>Lat.</b> 25°15'30"S <b>Long.</b> 049°19'41"W	
	<b>Municipality – State:</b> Almirante Tamandaré – Paraná.	

### 1.1 History of the flight.

At 19:49 UTC, the aircraft departed from SBDO, destined for SBBI, with two pilots and two passengers on board, on a valuables-transport flight.

At 20:22 UTC, the aircraft contacted Bacacheri Control Tower (TWR-BI) and was authorized to proceed to the final approach.

At 20:25 UTC, radio contact between TWR-BI and the aircraft was lost.

### 1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	2	2	-
Serious	-	-	-
Minor	-	-	-
None	-	-	-

### 1.3 Damage to the aircraft.

The aircraft was completely destroyed.

### 1.4 Other damage.

Nil.

### 1.5 Personnel information.

#### 1.5.1 Crew's flight experience.

	Hours Flown	
	Captain	Copilot
Total	11,088:35	771:10
Total in the last 30 days	19:20	06:40
Total in the last 24 hours	00:00	00:00
In this type of aircraft	618:35	16:10
In this type in the last 30 days	19:20	06:40
In this type in the last 24 hours	00:00	00:00

**N.B.:** Information provided by the operator.

#### 1.5.2 Professional formation.

The captain did his Private Pilot Course (Airplane category) at the *Aeroclube de Blumenau* in 1989

The copilot did his Private Pilot Course (Airplane category) at the *Aeroclube de Alagoas* in 2004.

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

The copilot held a Commercial Pilot License (Airplane category), as well as valid technical qualification certificates (CHT) for PA-31 (PAYE) type aircraft, AMEL, ASEL, and IFR rating.

The captain held an ATP License (Airplane category), a valid technical qualification certificate (CHT) for PA-31 (PAYE) type aircraft, and was IFR-rated.

### 1.5.4 Qualification and flight experience.

The pilots had qualification and enough experience for conducting the flight in question.

### 1.5.5 Validity of medical certificate.

The pilots' aeronautical medical certificates were valid.

### 1.6 Aircraft information.

The aircraft (SN 31T-8166067) was manufactured by Piper Aircraft in 1983.

Its airworthiness certificate was valid.

The airframe, engine, and propeller logbook records were up-to-date.

The last inspection of the aircraft ("200-hour" type) was conducted by the *Manutenção WAS Ltda.* workshop on 31 October 2012 (Municipality of Sorocaba, São Paulo State). After this inspection, the aircraft flew 3 hours and 44 minutes.

### 1.7 Meteorological information.

The prevailing weather conditions were VMC.

### 1.8 Aids to navigation.

Nil.

### 1.9 Communications.

All radio communications between the aircraft and ATC units were considered normal. The pilots did neither report any aircraft problems nor declared any type of emergency.

At 20:25:51 UTC, TWR-BI inquired the aircraft on the distance to SBBI, but never received an answer from the crew.

TWR-BI and APP-CT made several calls and attempts to contact the accident aircraft, even by means of relay messages from other air traffic flying at the moment, but no contact was established.

### 1.10 Aerodrome information.

The accident occurred outside of aerodrome area.

### 1.11 Flight recorders.

Neither required nor installed.

### 1.12 Wreckage and impact information.

The accident occurred in a rural area of the municipality of *Almirante Tamandaré*, *Paraná* State, at a distance of 18km from SBBI.

The first impact occurred when the left wing of the aircraft struck a Brazilian pine tree (*araucaria angustifolia*) approximately 30 meters tall.

In the sequence, the aircraft collided with another tree, rupturing the right wing tip tank.



The aircraft crashed into the ground in a pitch-down attitude of about 60 degrees, and rotated clockwise some 135 degrees before coming to a stop, which occurred at a distance of 150 meters from the point of first impact with the tree.

The propeller blades showed characteristics compatible with collision without deliverance of engine power.

The right wing broke at the root with the fuselage, following the impact of the right wing tip tank with the tree and the strong impact with the ground.

The landing gear was in the retracted position, and the vertical speed indicators were showing a descent rate of 1,500 ft/min (pilot's panel) and 800 ft/min (copilot's panel).

### **1.13 Medical and pathological information.**

#### **1.13.1 Medical aspects.**

There were no relevant medical records relative to the pilot. He had a deficient chromatic vision, but was able to identify primary colors.

The copilot was overweight and had already experienced a few problems with an upset stomach. His high blood pressure was under control, and his eyesight problems were corrected with glasses.

According to accounts made by workmates and family members, the workload in the company was demanding for the company pilots, but there was no concrete evidence of fatigue among them.

#### **1.13.2 Ergonomic information.**

Nil.

#### **1.13.3 Psychological aspects.**

The copilot, who was effectively flying the aircraft at the moment of the accident, was the younger crewmember. According to reports, he was very fond of flying, and due to a busy schedule, he did not have much time to rest. He had worked the past two years without vacation from work.

The aircraft captain, working as the copilot at the moment of the accident, lived in the vicinity of SBBI, and worked full time for the company. His mates described him as an extroverted and playful person, as well as a very good aviation professional.

He was one of the few pilots who flew Seneca aircraft in the company, and sometimes got overloaded operating this type of aircraft. Additionally, he was the instructor of all the other pilots hired by the company and that were beginning to fly that aircraft model.

The first officer even looked up to the captain, from whom he had received training for flying Cheyenne aircraft. They had made friends with each other.

The captain was also the Chief of Operations in the company, and was, therefore, responsible for delivering directives concerning operational standards. However, according to information, his supervision was not very effective. He displayed a friendly behavior towards his subordinates and sometimes represented the group in the attempt to solve contingent issues concerning operation, shift work, vacations, and salary.

He had been working for the company for two years. At the time he was hired, he had been experiencing a tough situation in professional terms because it was hard to get a job. Having had this opportunity, the captain became entirely devoted to his work, and would not go out on vacation or get some rest on holidays, as a way to show his gratefulness to the company.



The captain was considered by his peers as a great pilot, who had experience and mastered the aviation activity. In the family context, he was short-tempered and, sometimes, displayed a bad mood.

According to reports, he stayed awake on a few occasions and would arrive at the company at five o'clock in the morning. According to his colleagues, he used to eat just once a day.

The company flights normally had the objective of transporting valuables, and so security issues were always a concern, a factor that influenced protective actions and the time the aircraft stayed on the ground.

The pilots' shiftwork did not contemplate rest periods and, thus, the pilots were used to continuous duty periods. As dictated by the company demands, rest periods and vacations were postponed. Since the number of pilots was not sufficient for accommodating the number of operations, they would sometimes put off or give up the right to go on vacation.

It was common for training sessions to be delivered concomitantly with the operations of the company, with the objective of saving time, instructors and fuel. The CRM training for the pilots was delivered every two years at the very company by an instructor hired for that purpose.

The fleet aircraft were to be refueled at the company headquarters whenever possible, so that fuel price variations could be controlled. Even though the management staff did not oppose refueling outside of headquarters, a culture existed in which such attitude was not desirable.

The company did not hold meetings aimed at standardizing operational procedures. Each pilot was responsible for his own operational routine. There was neither exchange of information on flight safety, nor monitoring, evaluation and supervision of the air activity.

According to information collected, the company sought to hire good professionals, and then gave them independence for the planning and decision-making related to their flights.

On account of the company's busy flight routine, the pilots could not always meet each other. There was not anyone responsible for gathering the group and monitor the pilots, either.

#### **1.14 Fire.**

No signs of either in-flight or post-impact fire.

#### **1.15 Survival aspects.**

The Paraná State Military Police Fire Brigade arrived at the crash-site two hours after the occurrence, and informed that five vehicles of the Paraná State Military Police were already there, together with a representative of the Hercules Air-taxi company, and a few onlookers.

The pilots and one of the passengers (a security guard of Brinks *Segurança Transporte de Valores*) were killed in the crash.

The fourth casualty of the crash, also a Brinks' security guard, who had been taken to the *Hospital do Trabalhador* in a serious condition, underwent a surgery but ended up dying one day after the accident. According to the hospital staff, the *causa mortis* was polytrauma.

### 1.16 Tests and research.

In the crash-site field, no traces of fuel leak were found. There was neither fuel in the wing tanks, nor post-impact fire, nor marks on the fuselage that could indicate the presence of fuel.

According to information provided by the fire brigade and by the rescue team of the *Paraná State Civil Office*, there was no smell of fuel in the crash-site.

The PT6A-135 Pratt & Whitney engines were disassembled at the premises of the *TurbServ Engenharia de Manutenção Ltda.* in the municipality of Sorocaba, São Paulo State. The disassembly was performed by professionals of the aforementioned company, in the presence of representatives of the aircraft owner, SERIPA V, and DCTA.

They verified that the engines were operating, but not developing power when the aircraft crashed into the ground.

The main fuel pump of the engine had marks in the housing of gears and in the interior of the frame, an indication of lack of fuel, due to the fact that the gears sustain a quick temperature increase (approximately four seconds) in the absence of fuel, which cools them.

This could be justification for the lack of power in the engine at the moment of collision with the ground.

Overheating makes the gears expand and rub the pump frame, leaving the marks verified in the Figures 1 and 2. Another characteristic indication of lack of fuel was found in the teeth of the pump gears (Figures 3 through 5). They indicate the occurrence of cavitation in the fuel pump.



Figure 1 – View of the fuel pump frame, showing marks of rubbing in the housing of gears.

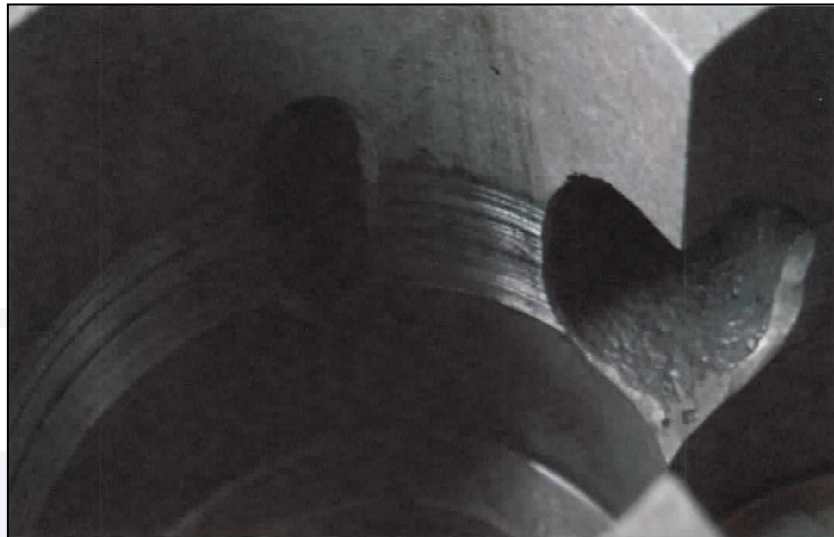


Figure 2 – Closer view of the fuel pump, with marks of rubbing in the housing of gears.

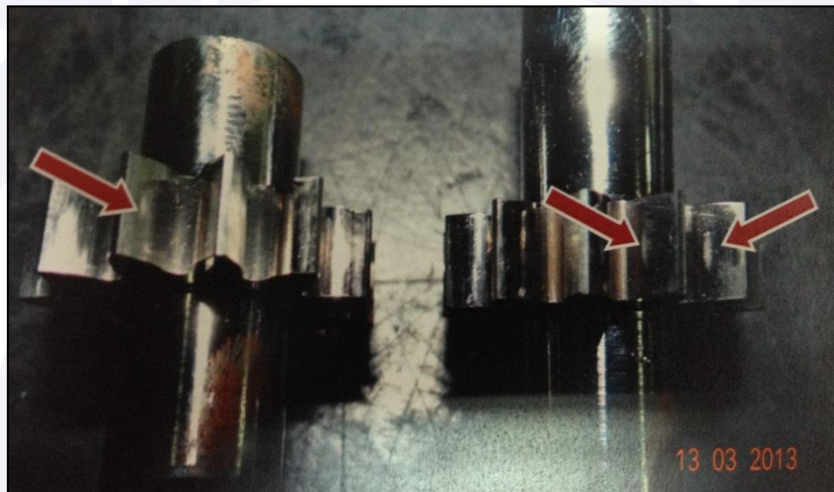


Figure 3 – General view of the fuel pump gears with signs of cavitation.

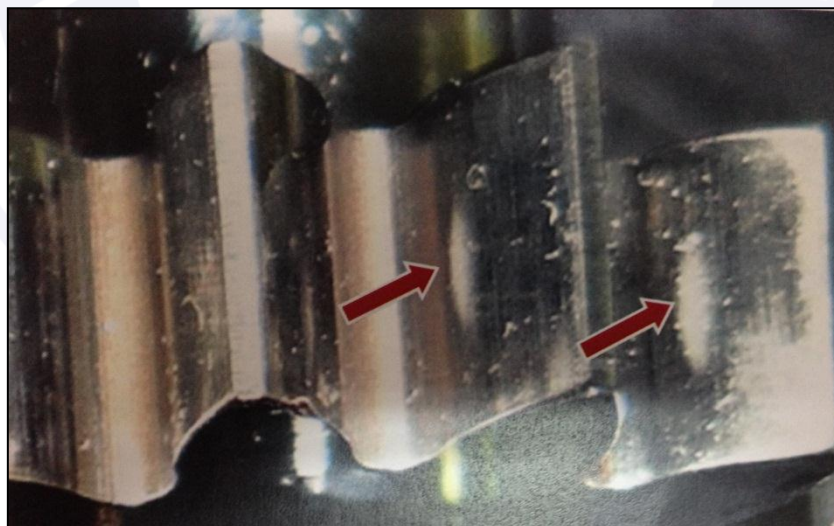


Figure 4 – View of the gear with signs of cavitation.



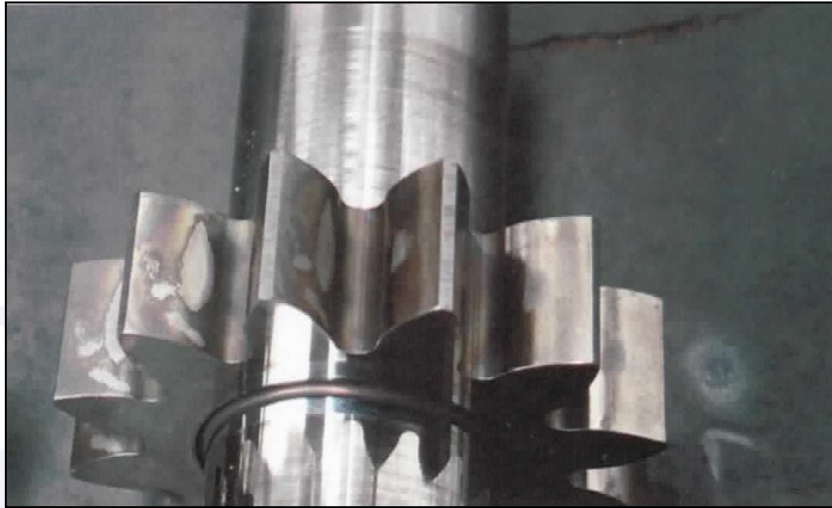


Figure 5 – Evidence of cavitation in the pump-gear teeth.

The propellers also showed evidence that the engines were not developing power. In figures 6 and 7, it is possible to observe that the blades had folded a characteristic of lack of power at the moment of the collision with the ground.



Figure 6 – Left-Engine propeller.



Figure 7 – Right-Engine propeller.

As there was strong evidence that the aircraft engines had stalled on account of lack of fuel, the investigators decided to verify the dependability of the fuel gauges in other aircraft. A test was performed on a Cheyenne PA-31T, an aircraft similar to the PT-MFW (PA-31T2).

Initially, the aircraft had approximately 1,200 lb. of fuel in the tanks, according to the fuel quantity indicators (Figure 8), that is, 600 lb. in each wing tank. In the sequence, the aircraft was refueled with 481 liters (858 lb.) of aviation kerosene (Jet A-1) (Figure 9). Therefore, the fuel gauges had to show an additional 429 liters of fuel in each wing tank, i.e., each tank had to show 1,029 lb., with a total of 2,058 lb. in the aircraft.



Figure 8 – Initial indication of the fuel gauge (1,200 lb.).



Figure 9 – Provision of 481 liters (858 lb.) of Jet A-1.

However, what the fuel quantity indicator really showed was 900 lb. of fuel in each wing tank, that is, a total of 1,800 lb. with a difference of 258 liters of fuel, considering that

the fuel quantity indicators in this type of aircraft did not have an acceptable level of dependability.



Figure 10 – Final indication in the fuel gauge (1,800lb).

### 1.17 Organizational and management information.

The company (*Táxi Aéreo Hércules Ltda.*) is homologated for non-regular public air transport of passengers, cargo, and sick passengers in the air-taxi category.

Its main operating base is located at Bacacheri airport (SBBI) in Curitiba, State of Paraná. The company also has a secondary base at the *Estância Hércules Aerodrome* (SSFE) in the municipality of *Foz do Iguaçu*, State of Paraná.

The company organigram is the following:

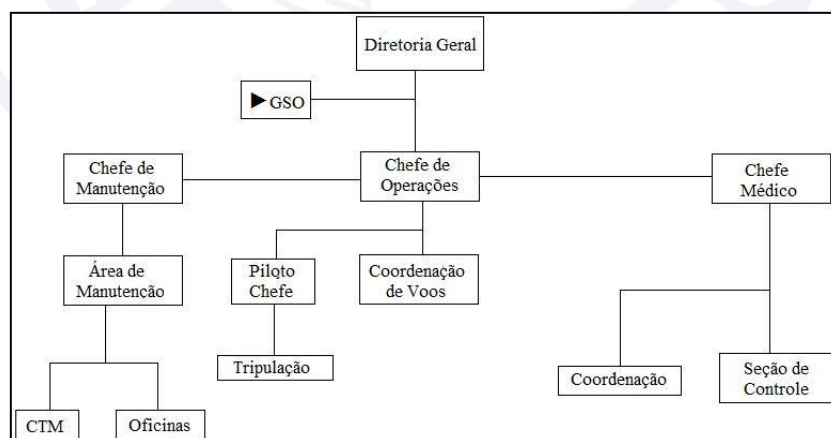


Figure 11 – Táxi Aéreo Hércules Ltda. organigram.

The aircraft captain, flying as copilot, was also the company Chief of Operations. The Operational-Safety manager (GSO) was shareholder of the company and accumulated the function of Accountable Manager.



The flight-safety activities were concurrently performed by the Chief of Operations and a Flight-Safety Agent of the company. The control and management of the Prevention Reports (RELPREV) were the sole responsibility of the Chief of Operations, but the investigation commission did not find filed RELPREVs or how the process of publication worked. This seemed to be in contradiction with the Brazilian Civil Aviation Regulation 119 (RBAC 119) and the Brazilian Civil Aviation Regulation 135 (RBAC 135), which prescribe that operational-safety activities are to be dealt with by the company's Operational-Safety Manager.

The Chief of Maintenance was stationed on the secondary base, although the Technical Maintenance Center (CTM) and the aircraft fleet were on the main base (*Bacacheri* airport). According to information provided by the company, the Chief of Maintenance monitored the maintenance processes *on line* in real time with assistance provided by the Technical Maintenance Center, which updated the aircraft records. When necessary, he would go to wherever the aircraft was.

At the time of the accident, the aircraft fleet was composed of eight aircraft [two EMB-810D's (Seneca III), two PA-31T2's (Cheyenne II XL), two PA-31T's (Cheyenne II), one PA-42-720 (Cheyenne IIIA), and one Cessna C-525 (Citation)].

### **1.18 Operational information.**

The aircraft was within the weight and center of gravity limits specified by the manufacturer.

On the day of the accident, the aircraft, with two pilots and two security guards on board, was programmed for two valuables-transport flights, taking off from and landing at SBBI. The first flight would be between SBBI and SBBCA, and the second would be between SBBI and SBDO.

For the first flight of the day (SBBI-SBCA-SBBI), the aircraft was refueled with 480 liters of Jet A-1, and took off at 12:00 UTC, landing in SBBCA at 13:05 UTC. It took off from SBBCA at 14:00 UTC, and landed in SBBI at 15:09 UTC.

For the flight on the second day (SBBI-SBDO-SBBI), the aircraft was refueled with 886 liters of Jet A-1 fuel. It took off from SBBI at 16:39 UTC, and landed in SBDO at 18:23 UTC. It took off from SBDO at 18:49 UTC, destined for SBBI.

According to the person who did the refueling in SBBI, in the second operation of the day (SBBI-SBDO-SBBI), the aircraft captain ordered the aircraft to be refueled to its full capacity, i.e., including the nacelle tanks and the wing tip tanks, corresponding to approximately 2,452 lb. The person also said that neither the crew nor any other company employees were present during the aircraft refueling operation in SBBI.

At 20:22 UTC, the aircraft made the first radio contact with SBBI control tower (TWR-BI). It received information that the airport was operating VFR, runway in use 18, altimeter setting 1016 hectopascals, and was cleared to proceed for the final approach.

At 20:23:03 UTC, the aircraft made its last contact with TWR-BI, acknowledging the instruction that had just been received.

At 20:25:51 UTC, TWR-BI inquired the aircraft about its distance to SBBI, but did not receive any replies from the aircraft any longer.

According to the flight plan filed by the crew for the first leg, the fuel endurance was four hours and thirty minutes, meaning that the aircraft was fully refueled (approximately 2,452 liters). The estimated aircraft average fuel consumption was 545 lb./h, according to information provided by the company flight coordinator.

Since the aircraft logbook was not updated by the crew on the day of the accident and, with the intention of verifying the aircraft remaining fuel before the first takeoff of the

day (leg SBBI-SBCA), the commission did a survey of the pieces of information relative to the previous day (5 November 2012) contained in the logbook, when another crew made a round trip to SSBL.

With the purpose of verifying whether lack of fuel had taken place, the commission considered the values of 545 lb./h and 50 lb. respectively for the aircraft average consumption and amount of fuel spent during the taxi, based on information provided by the Flight Coordinator and also contained in the company General Operating Manual.

From that moment on, according to the latest information contained in the aircraft logbook, that is, takeoff from SSBL toward SBBI on 5 November 2012 with 1,200 lb., and considering factors such as average consumption, fuel consumed during the taxi, as well as the refueling for all the legs prior to the accident, one obtains the following result for the amount of fuel in the aircraft at the moment of the accident:

Date	Leg	Initial Fuel (after refueling)	Leg time (H)	Fuel consumed in the leg + taxi	Remaining fuel
5NOV2012	SBBI-SSBL	1,500	0.3	300	1,200
5NOV2012	SSBL-SBBI	1,200	0.7	431.5	768.5
6NOV2012	SBBI-SBCA	1,624.5	1.1	649.5	975
6NOV2012	SBCA-SBBI	975	1.2	704	271
6NOV2012	SBBI-SBDO	1,851	1.7	976.5	874.5
6NOV2012	SBDO-SBBI	874.5	1.6	922	<b>-47.5</b>

Figure 12 – Fuel Calculation relative to the accident flight.

The fuel required for the leg SBDO-SBBI would be 1,416 lb., that is, the aircraft had to have enough fuel for: flying to SBBI (flight time 1h 34 min, consumption 872 lb.); flying to the alternate airport (SBJV) (flight time 15 min, consumption 136 lb.); and then, flying for 45 minutes at normal cruise speed (consumption 408 lb.)

According to the flight plan for the leg SBDO-SBBI, the aircraft fuel endurance would be three hours and thirty minutes (1,910 lb.) and, therefore, the aircraft would have more fuel than the necessary in the planning.

However, the aircraft took off from SBDO, destined for SBBI, with approximately 825 lb., with the amount consumed for taxiing already discounted. The fuel necessary, however, was 1,416 lb.

According to pilots' and fuel providers' accounts, if the refueling flow rate were higher than the outflow between the tank cells, there would be the possibility of formation of air bubbles in the fuel cells, leading to a false indication of tanks fully replenished. To mitigate this problem, pilots and fuel providers mentioned the procedure of rocking the aircraft wings for a quicker fuel settling.

### 1.19 Additional information.

For planning the minimum fuel for VFR and IFR flights, the General Operating Manual of the company established that the quantity of fuel in the aircraft had to be sufficient for it to fly to the intended destination and, after that, divert to the alternate airport with normal cruise flight fuel consumption, with a further 30-minute fuel endurance after reaching the alternate airport during the day (VFR), or 45 minutes if at night (or IFR).

Such criteria would even be stricter than the prescriptions of the Brazilian Civil Aviation Regulation (RBAC) 135, which governs the complementary and on-demand operations, and would be rigidly controlled by the Chief of Operations and by the crew.

The MGO also prescribed that the monitoring of the flight would be done by means of the navigation form, under the copilot's responsibility.

The navigation form was part of the documentation on board the aircraft describing the legs, distances, estimated time between fixes, airway crossings, radio-aids, among other pieces of information.

Figure 13 – Navigation form.

In addition, the navigation form was to contain the fuel at departure, the flight duration, distance and route.

The MGO also established that the captain and the copilot had to be onboard the aircraft while it was being refueled, checking the markings of the tanks. After the refueling, one of the pilots had to check the amount of fuel provided and enter the pertinent records, putting away the refueling invoice.

The aircraft cargo manifest had to be prepared before each leg, and the captain was supposed to send it to the company via FAX, or inform the cargo data to the sector of operations, and keep a copy until arriving at the main base of operations, where the referred document would be handed in for control.

The responsibility for the planning control belonged to the Chief of Operations, who had the prerogative of checking and controlling the planning prepared by the copilot or another pilot on duty.

Such planning was to be kept together with the flight plan until termination of the flight, and could be attached to all the other forms, before being handed in to the company administration for purposes of storage and control.

In short, it was the pilot-in-command's duty to strive to know all the information on the intended operation. The information had to include, in addition to details of the aerodrome traffic zone, an accurate study of the weather information available, radio and light aids of the aerodromes involved, fuel requirements, and diversion procedures.

The aircraft checklist contained procedures relative to the verification of the fuel quantity by the pilots.

The quantity of fuel had to be determined at the pre-flight and before-takeoff checks.

According to the item 9.3 of the IAC 3151 (dated 2 June 2002), the aircraft logbook was to be filled in so that all the data referring to the flight leg was contemplated, and then signed by the aircraft captain, before the crew left the aircraft at the completion of the flight.

The investigation commission also observed that neither the mission order nor the flight coordination control form had a specific file for entering the fuel necessary for the flight legs.

There was also discrepancy between the amount of fuel for taxiing the aircraft (50 lb. in the MGO, and 70 lb. in the weight and balance form).

TIPO DE MISSÃO		ATENDIMENTO		
<input type="checkbox"/> Carga	Data: xxx/xx/20xx	Responsável pela Missão: _____		
<input checked="" type="checkbox"/> Passageiro		Responsável pela Distribuição: _____		
<input type="checkbox"/> UTI				
<b>DADOS DA MISSÃO</b>				
Solicitante: _____		Horário(s): 00:00		
Data do Voo: xxx/xx/xxxx		Percurso(s): SBXX/SBXX/SBXX/SBXX		
Aeronave: PT-	Tripulação: Cmte: _____	Cop: _____		
<b>OBSERVAÇÕES</b>				
HOTEL: N/A				
TRANSPORTE: N/A				
PASSAGEIROS: 1- _____	2- _____			
3- _____	4- _____			
5- _____	6- _____			
OBSERVAÇÕES: _____				
<b>TRIPULAÇÃO</b>				
<b>COORDENAÇÃO DE HORÁRIOS:</b>				
Origem	Destino	Decolagem	Pouso	Tempo de voo
COMENTÁRIOS TRIPULAÇÃO:				
<b>ASSINATURAS</b>				
Comandante _____		Co-piloto _____		
- Após a conclusão da missão e retorno à Base, entregar essa Ordem de Missão à Coordenação de Voo.				

Figure 14 – Flight Coordination Control form.



ORDEM DE MISSAO

Voo	Data-Hora	Cliente			
Aeronave PT-MFW	Tipo de Voo CARGA	Tripulacao 1/Funcao PILOTO EM COMANDO			
	Valor	Tripulacao 2/Funcao CO-PILOTO			
Situacao REGISTRADO	Base CURITIBA				
Oservacoes		Situacao REGISTRADO			
Responsavel		Data do Registro 05-11-2012			
Trajetos SBB/SSBL/SBBI					
Trecho	AD Origem	Data/Hora Partida	AD Destino	Data/Hora Chegada	Tempo
01	SBB/		SSBL		
02	SSBL		SBB/		

DIARIO DE BORDO

Data	Diano	Tempo de Voo	Pousos	Ciclos	Disp Manuf

Anotacoes

Assinatura

Figure 15 – Mission Order form.

## 1.20 Useful or effective investigation techniques.

Nil.

## 2. ANALYSIS.

The prevailing weather conditions were VMC, and the communications between the aircraft and ATC were uneventful.

As for the medical aspect, there were no concrete signs of fatigue. However, according to witnesses, the pilots' workday used to be busy. In relation to the physiological factors and the most recent health-checkups of the pilots, no evidence was found of relevant medical events that could have contributed to the occurrence of the accident.

The investigation commission verified that neither the Flight Coordination Control form nor the Mission Order had a specific space for entering the minimum fuel required by the aircraft for each flight leg up to the destination, then to the alternate airport, plus 30 minutes of flight (VFR) or 45 minutes (IFR), which would be one more barrier for the crew to prevent of a mistaken calculation of the fuel quantity.

On the day of the accident, none of the crewmembers monitored the refueling process in SBBI. It was conducted by the fuel provider alone, in opposition to the prescriptions of the MGO relative to the aircraft refueling procedure.

In relation to the amount of fuel utilized by the aircraft during the taxi, there as a difference in the MGO, which prescribed 50 lb. of fuel, while the cargo manifest said 70 lb.

The cargo manifestos of the legs SBBI-SBDO and SBDO-SBBI were not found aboard the aircraft by the investigators during the field investigation (Initial Action), and the company's main base of operations (SBBI) had not received copies/information of the referred manifestos (item 8.11.3 of the MGO).

The analysis of the wreckage during the field investigation showed that the engines had failed due to lack of fuel.

Likewise, the exam of the engines showed that they were operating but not developing power. The main evidence was the phenomenon of cavitation observed in the fuel pumps of both engines. This phenomenon occurs when there is lack of fuel, resulting in an abrupt pressure increase and quick elevation of temperature in the pump. Besides, it is worth stressing that, with the lack of fuel, the gears expanded for not being cooled, and rubbed the pump frame.

On the day of the accident the crew did not enter the data relative to the legs of the flight SBBI-SBCA-SBBI (in the morning) and the leg SBBI-SBDO, thus failing to comply with the item 9.3 of the IAC 3151 – Diário de Bordo.

According to calculations based on the item 1.18 – Operational Aspects, the aircraft took off from SBDO with approximately 825 lb. of fuel, flew one hour and 30 minutes, and crashed into the ground at a distance of 9 nautical miles from SBBI due to lack of fuel in the engines.

The aircraft was not refueled in SBDO on account of the captain's decision to refuel the aircraft only in SBBI, and the company chose to not interfere with his decisions.

Another important operational aspect that could have been utilized as a barrier by the crew was the adequate use of the checklist, since there were procedures/inspections enabling the pilots to verify the quantity of fuel by means of the pre-flight and before-takeoff checks.

Although it may not have contributed to the occurrence of the accident, the investigation commission verified the existence of a possible condition of risk associated with the procedure for refueling the PA-31T2 aircraft (Cheyenne), which could lead the pilots to the wrong conclusion that the aircraft tanks had been filled up with fuel (when, in fact, air bubbles had formed in the fuel cells). In addition, it would be necessary for the pilots to calculate accurately the fuel consumption for each segment to be flown, since the aircraft fuel gauges would not be considered dependable, according to tests performed in a similar aircraft (PA-31T).

The poor supervision and monitoring of the operation became evident, in view of the fact that the methodology utilized at the time of the accident for planning the flights and refueling the aircraft did not receive any interference from the company management, leaving the issue to the aircraft captain's discretion.

The crew's attitude of not complying with the MGO and IAC 3151 may have been a result of this inadequate supervision, since this process is one of the means that the organization should have utilized for reinforcing compliance with standardized procedures.

Since the flight routine was busy, there were not meetings for the exchange of operational information between the crews; there were neither briefings nor debriefings of the flights, causing degradation of communications, poor control of the operational performance, and insufficient time for training and standardization meetings.

In addition to the fact that the flight schedule did not consider appropriately the crews' rest periods, the company, in view of its own needs, also changed their vacation periods.

The captain himself had worked two continuous years without holidays. In his desire to show gratefulness to the company which gave him his current job, he was always available for any flights, something that contributed to his excessive workload.

The situation as a whole was contributing to the high workload of the crews, and the captain started showing signs of irritation.

When high workload becomes the routine in the work environment, the workers' performance is affected, since their ability to accomplish the tasks begins to suffer from the limitations created by the situation, such as concentration difficulties, irritation and stress,



which interfere in the process of judgment and decision making, with impact on flight safety.

The objective of the company flights was to transport valuables, something that caused concern in relation to safety issues while the aircraft was on the ground. Therefore, some of the decisions made by the pilots might be influenced by this complexity (for example, they might choose not to refuel the aircraft in a given location).

At last, but not least, the commission verified that some tasks related to flight safety were shared by the Chief of Operations, by the company manager (who accumulated the function of Operational Safety Manager), and by a Flight Safety Agent (ASV).

Allowing part of the activities related to flight safety to be performed by other managers within the company weakens the authority that should belong to the Operational Safety Manager.

As the one responsible for flight operations, the Chief of Operations may have his risk analysis ability compromised if he/she is directly involved with such operations.

### **3. CONCLUSIONS.**

#### **3.1 Facts.**

- a) The pilots held valid aeronautical medical certificates (CMA);
- b) The pilots held valid technical qualification certificates (CHT);
- c) The pilots had qualification and experience for the flight in question;
- d) The aircraft had a valid airworthiness certificate;
- e) The aircraft weight and balance was within the prescribed parameters;
- f) The airframe, engine, and propeller logbook records were up-to-date;
- g) The aircraft departed from SSDO destined for SBBI;
- h) At about 20:22 UTC, TWR-BI received the first call from the aircraft;
- i) SBBI was open for VFR operations;
- j) TWR-BI cleared the aircraft for the final approach;
- k) At 20:25 UTC, TWR-BI lost radio contact with the aircraft;
- l) The aircraft crashed into the ground in a rural area of the municipality of *Almirante Tamandaré*, *Paraná* State, at a distance of 18km short of SBBI runway 18 threshold;
- m) The aircraft crew did not declare emergency;
- n) The analysis of the aircraft components did not reveal any technical problems prior to the impact;
- o) The engines were running, and had low power at the moment of the impact;
- p) There were signs of lack of fuel in the aircraft;
- q) The Flight Coordination Control form and the Mission Order did not present the minimum fuel for each leg of the flight;
- r) In SBBI, the crew did not monitor the aircraft refueling;
- s) On the day of the accident, the crew had not entered the data relative to each leg of the intended flight in the aircraft logbook;
- t) The aircraft took off from SBDO with approximately 825 lb. of fuel in the tanks

u) The fuel necessary for the leg was 1,416 lb.;

v) The aircraft was destroyed in the crash; and

Three aircraft occupants perished in the crash, and the fourth one died in a hospital on the following day.

### 3.2 Contributing factors.

#### - **Fatigue – undetermined.**

Fatigue is likely to have occurred, since there are reports of high workload, capable of affecting the perception, judgment, and decision making of the crew.

#### - **Motivation – undetermined.**

In view of the fact that the captain displayed an attitude of gratefulness toward the company which hired him, working for consecutive hours and many times more than was prescribed for his daily routine, it is possible that such high motivation may have been present in the accident flight, harming his capacity to evaluate the conditions required for a safe flight.

#### - **Decision-making process – a contributor.**

The crew neither gathered nor properly evaluated the available pieces of information for the correct refueling of the aircraft, something that led to their decision of not refueling the aircraft in SBDO.

#### - **Work-group culture – a contributor.**

The company crews did not usually keep fuel records, and made approximate calculations based on the fuel remaining from previous flights, whose control parameters were not dependable. Such attitudes reflected a work-group culture that became apparent in this accident.

#### - **Stress – undetermined.**

The pilots were presumably undergoing a condition of stress on account of the company flight routine, in which they flew every day, with little time dedicated to rest or even holidays. Under such condition, the pilots may have had their cognitive processes affected, weakening their performance in flight.

#### - **Tasks characteristics – undetermined.**

The flights had the objective of transporting valuables, causing concern in relation to security issues involving the aircraft on the ground. Thus, it is suspected that decisions made by the pilots may have been affected by this complexity, such as, for example, deciding not to refuel the aircraft on certain locations.

#### - **Work organization – undetermined.**

The way the work was structured in the company was giving rise to overload due to the routine of many flights and few periods of rest or holidays. This situation may have affected the crew's performance, interfering in the analysis of the conditions necessary for a safe flight.

#### - **Organizational processes – a contributor.**

The company did not monitor the performance of its pilots for the identification of contingent deviations from standard procedures, such as non-compliance with the MGO.

- **Cockpit coordination – undetermined.**

Failures in the application of operational norms, as well as in the communication between the crew members, may have occurred on account of inadequate management of tasks by each individual, such as, for example, the use of the checklist and the filling out of control forms relative to fuel consumption contained in the company MGO.

- **Piloting judgment – a contributor.**

The crew judged that the amount of fuel existing in the aircraft was sufficient for the flight in question.

- **Aircraft maintenance – a contributor.**

The fact that the fuel gauges were not indicating the correct quantity of fuel had direct influence on the flight outcome, since the planning factors and the pilots' situational awareness were affected.

- **Flight planning – a contributor.**

The crew did not analyze appropriately the amount of fuel necessary for the flight leg between SBDO and SBBI.

The Mission Order did not establish the minimum amount of fuel necessary for the flight legs, and the crew had to take responsibility for the decision.

- **Managerial oversight – undetermined.**

The company was not rigorous with the filling out of aircraft logbooks and cargo manifestos, resulting that it did not have control over the operational procedures performed by the crews, and this may have contributed to the aircraft taking off with an amount of fuel that was insufficient for the flight.

Although the MGO had parameters established for calculating the endurance necessary for VFR/IFR flights, the company did not define the fuel necessary in the Mission Orders, transferring the responsibility for the decision to the aircraft captain.

#### **4. SAFETY RECOMMENDATION.**

*A measure of preventative/corrective nature issued by a SIPAER Investigation Authority or by a SIPAER-Link within respective area of jurisdiction, aimed at eliminating or mitigating the risk brought about by either a latent condition or an active failure. It results from the investigation of an aeronautical occurrence or from a preventative action, and shall never be used for purposes of blame presumption or apportion of civil, criminal, or administrative liability.*

*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".*

#### **Safety Recommendations made by the CENIPA:**

##### **To the National Civil Aviation Agency (ANAC):**

**A-526/CENIPA/2015 – 01**

**Issued on 03/06/2016**

Take the necessary measures before *Taxi Aéreo Hércules Ltda.*, in order to guarantee the implementation of procedures prescribed in the MGO for the aircraft operation, seeking to obtain standardization in the planning of the flight, aircraft preparation, flight regimen, endurance, inspections, checklist use, refueling, and aircraft logbook annotations.

**A-526/CENIPA/2015 – 02****Issued on 03/06/2016**

Take the necessary measures before *Taxi Aéreo Hércules Ltda.*, in order to refine the preparation of the Mission Order in relation to the planning of the flights, emphasizing the minimum fuel required for each leg of the flight.

**A-526/CENIPA/2015 – 03****Issued on 03/06/2016**

Take the necessary measures before *Taxi Aéreo Hércules Ltda.*, so that CRM training is delivered to all crewmembers, taking advantage of the information made available in this investigation. The objective is to refine cockpit management by the crews, stressing the importance of interpersonal communication, judgment, assertiveness, decision-making, and situational awareness.

**A-526/CENIPA/2015 – 04****Issued on 03/06/2016**

Take the necessary measures before *Taxi Aéreo Hércules Ltda.*, for the development of a procedure to control the crews' duty time, taking into consideration their rest periods and vacations.

**A-526/CENIPA/2015 – 05****Issued on 03/06/2016**

Take the necessary measures before *Taxi Aéreo Hércules Ltda.*, aimed at the establishment of a methodology for the company flight coordination sector to take responsibility for remote monitoring and supervision of aircraft operations outside of their main base in the aspects associated with planning, refueling, and endurance concerning each leg of the flights to be operated, thus allowing the identification, analysis, and suppression/mitigation of risks.

**A-526/CENIPA/2015 – 06****Issued on 03/06/2016**

Take the necessary measures before *Taxi Aéreo Hércules Ltda.*, aimed at including (in the initial and recurrent crew training) aspects related to the importance of flight safety and faithful observance of all the norms contained in the company's manuals (MGO, Operational Safety Management Manual, and Training Program).

**A-526/CENIPA/2015 – 07****Issued on 03/06/2016**

Take the necessary measures before *Táxi Aéreo Hércules Ltda.*, aimed at including (in the initial and recurrent crew training) classes on the performance of its fleet aircraft, as well as observance of the planning requisites established in the RBAC 135.

**A-526/CENIPA/2015 – 08****Issued on 03/06/2016**

Conduct a Special Audit of the *Táxi Aéreo Hércules Ltda.*, aimed at verifying conformity of operational procedures with the applicable requirements, and whether the activities related to operational safety area are being performed by the agent responsible in an independent manner.

**A-526/CENIPA/2015 – 09****Issued on 03/06/2016**

Take the necessary measures before *Táxi Aéreo Hércules Ltda.*, aiming at the correction of the problems affecting its fleet aircraft fuel quantity indicators.

**5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.**

Nil.

On June 3<sup>th</sup> 2016.

