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MINISTÉRIO DA ECONOMIA E DO EMPREGO
GABINETE DE PREVENÇÃO E INVESTIGAÇÃO DE ACIDENTES COM AERONAVES

FINAL ACCIDENT REPORT

PRIVATE

Alon A2-A (Aircoupe)

CS-AIG

Herdade “Pinheiro e Cavaleiro”

CIBORRO

MONTEMOR-O-NOVO

6th of March, 2010



FINAL ACCIDENT REPORT Nr. 01/ACCID/2010

**NOTE**

The only aim of this technical report is to collect lessons which may help to prevent future accidents.

Safety investigation is a technical process aiming to accident's prevention and comprises the gathering and analysis of evidences, in order to determine the causes and, when appropriate, to issue safety recommendations

In accordance with Annex 13 to the International Civil Aviation Organisation Convention, Chicago 1944, EU Regulation Nr. 996/2010, from European Parliament and Council, 20th OCT 2010 and article 11th n° 3 of Decree-Law n° 318/99, 11th AUG 1999, the sole purpose of this investigation is to prevent aviation accidents. It is not the purpose of any such investigation process and the associated investigation report to apportion blame or liability.

***This report has been released in Portuguese and English Languages.
In case of conflict, Portuguese version will take precedence.***

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SYNOPSIS

On the 6th of October 2010, in the afternoon, the owner of Alon A2-A aircraft, with Portuguese registration CS-AIG, accompanied by an old friend, travelled to “*Pinheiro e Cavaleiro*” farm, near Ciborro, Montemor-o-Novo, where he used to store the aircraft, inside a hangar, close to a private runway.

That day the weather showed overcast sky, with rain showers and moderate to strong winds from Southwest, improving by middle afternoon, with scattered sky and no rain.

By 16:30 UTC¹ they took off from runway 31 for a local one hour flight.

Around 18:30, farm owner, feeling uneasy with their absence, decided to go to the airfield and look for them. Arriving there he noticed hangar doors were open but the aircraft was not inside or any other place. He drove till the end of runway and noticed a white mark in an adjacent farmland, about 300m away, which rose some suspicion.

After confirming it was the aircraft he informed local police authorities and a GNR² patrol travelled to the site, confirming the presence of two dead bodies within the wreckage of the aircraft.

GPIAA was informed (at 21:42) and a team was sent to the site next morning, in order to start the investigation.

¹ - All timings referred in this report, unless stated differently, are UTC (Universal Coordinated Time) timings. That day, local time in Portugal mainland was equal to UTC+1 hour.

² - Republican National Guard.

1. FACTUAL INFORMATION

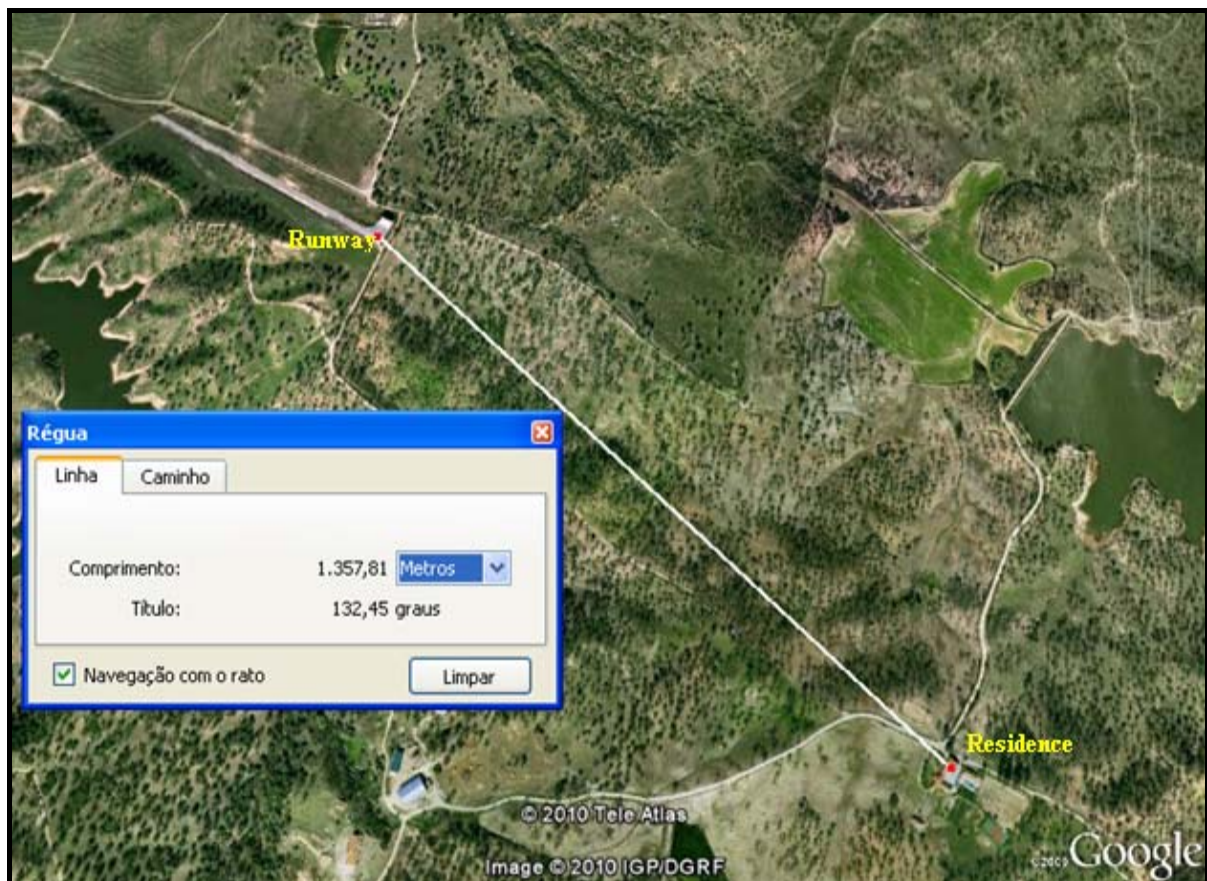
1.1 History of the Flight

Alon A-2A (Aircoupe), s/n B-280, registration CS-AIG aircraft used to be stationed at a private aerodrome, located inside “Pinheiro e Cavaleiro” farm, near Ciborro, Montemor-o-Novo.

On the 6th of March, 2010, his owner called farm owner (his friend) and informed that he was travelling there, accompanied by another friend, to have lunch with him.

After a late lunch, the weather was improving (rain stopped, visibility increased and sky became scattered), the pilot and owner of the aircraft decided to perform a local flight, about one hour duration, to show the plane to his friend.

By 16:00, the farmer took them to the airfield, helped to open hangar doors and put the aircraft outside, after which returned home, located on top of a hill, approximately 1350m south-east of runway (*picture nr 1*), letting pilot and passenger, at the aerodrome, preparing the aircraft for the flight.



Picture Nr 1

Around 18:30, wondering about the delay, the farmer travelled to the airfield searching for the flyers. Arriving there he saw nobody, hangar doors were open and the aircraft was not there.

He drove along the runway until the end, looking around, noticing a white spot, about 300m far from runway end, which called his attention as he had never seen it before.

He approached the point and realized it was the aircraft. After returning home he called GNR at Montemor-o-Novo.

Once the GNR patrol arrived, they travelled together to the site and confirmed the aircraft was substantially damaged, with pilot and passenger lying dead in the wreckage.

1.2 Injuries

Both people on board suffered fatal injuries (*table nr 1*).

Injuries	Crew	Passengers	Others
Fatal:	1	1	0
Serious:	0	0	0
Minor/None:	0	0	0
Total:	1	1	0

Table Nr 1

1.3 Aircraft Damage

The aircraft was destroyed (*picture nr 2*).



Picture Nr 2

1.4 Other Damage

No third party damage was reported.

1.5 Personal

1.5.1 Pilot

Male, Portuguese nationality, 69 years old, the pilot had the following flight qualifications and experience (*table nr 2*):

Flight License:	Type: Validity: Qualifications: Last Medical Examination: Restrictions / Limitations:	ATPL(A) 28-05-2013 SEP; Lockheed L-1011 04-02-2010 VDL; OML	
Flight Experience*:	Total:	Total	On Type
	Total:	16 527:34 ¹	175:35 ²
	Last 90 days:	N/A	N/A
	Last 30 days:	N/A	N/A
	Last week:	N/A	N/A
Last 24 hours:	N/A	N/A	
* - Pilot Flight Log was not updated and it was not possible to confirm real flight experience. 1 - Related to 16-05-2008 (Civil Aviation Authority registry). 2 - As per Aircraft Log Nr 5, until 06-09-2009.			

Table Nr 2

1.5.2 Passenger

Male, Portuguese nationality, 70 years old, the passenger was a retired ex-military pilot and a close friend of the pilot for a long time.

He was invited for a ride and occupied the right-hand seat. It was not intention for him to pilot the aircraft and no clues were found that could suggest he did.

1.6 Aircraft

1.6.1 General

The aircraft (*picture nr 3*) was a single engine, low wing, tricycle fixed landing gear aircraft, with capacity to carry two people and a Maximum Take-off Mass (MTOM) of 1450lbs (657kg).



Picture Nr 3

The Alon A-2A was an improved version of the original Engineering and Research Corporation (ERCO) aircraft, manufactured by Mooney Aircraft Corporation since 1967 until 1970.

Designed in 1839 to be the safest aircraft that aerospace engineering could provide at the time (incapable of spinning) and easy to fly, the then called "Ercoupe" contained many innovative design features. The original version had no ruder pedals, being flown exclusively with

control wheel, which controlled pitch, yaw & roll, together with nose wheel steering. Only in 1964, when “Alon Incorporated” bought the rights and a new 90HP powerful engine was installed, a limited movement rudder pedals were needed to cope with increased torque.

The CS-AIG, built in 1968, under “Mooney Aircraft Corporation” consulate, which meanwhile took in “Alon Incorporated”, presented the following references (*table nr 3*):

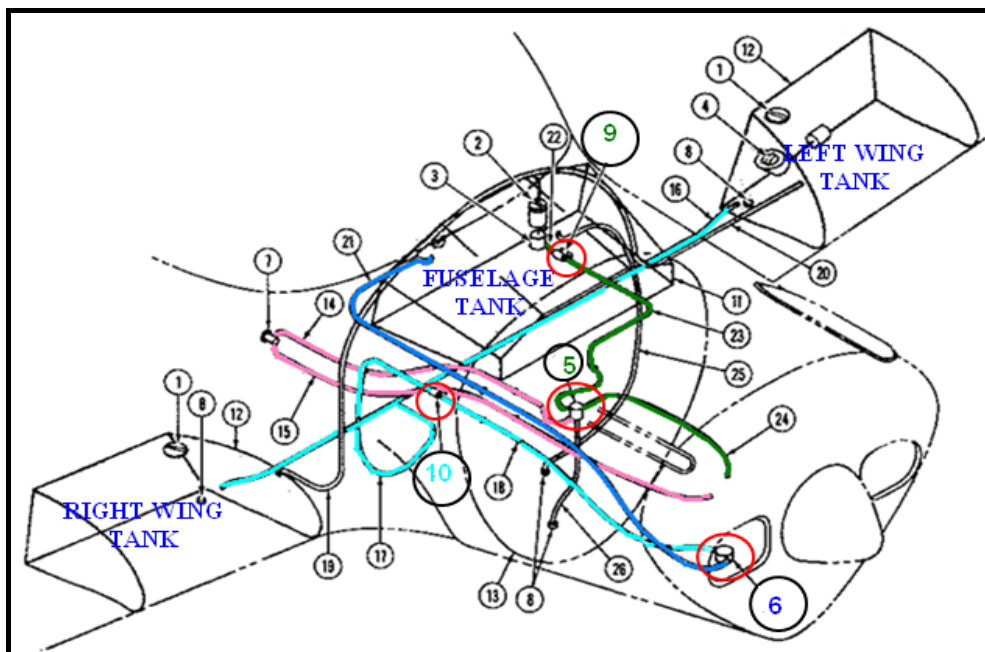
Reference	Airframe	Engine	Propeller
Manufacturer:	Alon Division, Money Corp.	Teledyne Continental	McCauley
Model:	Alon Aircoupe A2-A	C90-16F	1B-90-CM-71-48
Serial Nr.:	B-280	48718-7-16	51161
Year of Manufacture:	1968	1968	1968
Flight Time*:			
Since New:	1067:05	1261:55	1261:25
Since Overhaul:	653:40	N/A	33:45
Landings/Cycles:	1972	N/D	N/D
Last Inspection:	10-07-2009	10-07-2009	10-07-2009

* - Referred timings couldn't be confirmed due some blanks on Aircraft Flight Log. Present figures were extracted from last annual inspection and completed with Flight Log Nr 5 registries, down to 06-09-2009.
 Timer installed on the aircraft showed 1218.23 hours at the moment of the accident.

Table Nr 3

1.6.2 Fuel System

The Aircoupe fuel system consists of two wing tanks, a gravity fuselage tank, fuel pump, primer, fuel drains and a filter (*picture nr 4*).



Picture Nr 4

The wing tanks are interconnected by a fuel line (16), which allows fuel pressure and quantity to equalize and feeds the engine driven fuel pump (6) which transfers fuel from the wing

tanks to the fuselage tank, from where it is then fed by gravity to the carburettor, via a bowl-type filter (5).

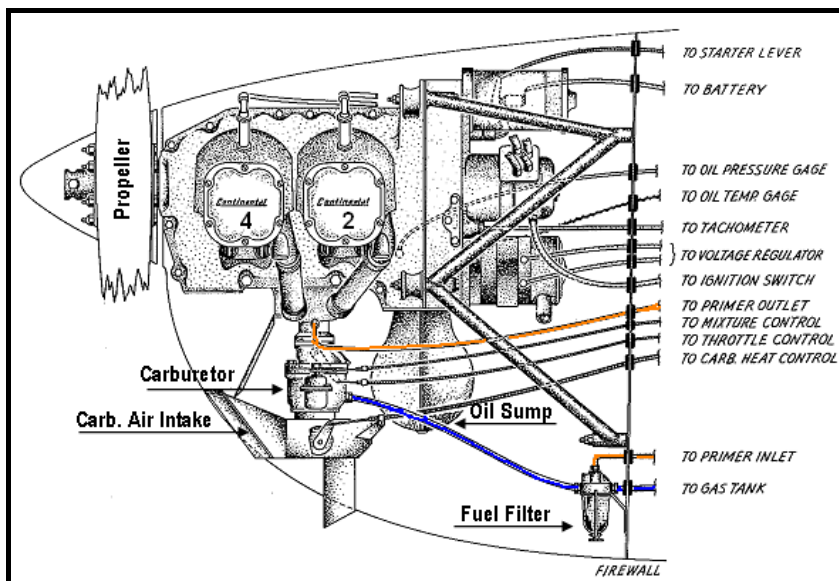
In case of overfilling or surplus fuel transfer by fuel pump to the fuselage tank, an over-flow line, connecting fuselage tank to right wing tank (19) and to left wing tank (20), allows fuel migration to wing tanks and from these to the fuselage tank, in case of heat expansion. Four fuel drains (8) allow the water draining from all tanks and fuel filter.

Fuel feeding is controlled by two fuel shut-off valves, Main fuel shut-off valve (9) controls fuel from fuselage tank to fuel filter and carburettor. Secondary fuel shut-off valve (10) controls fuel flow from wing tanks to engine driven fuel pump.

For engine start, a primer (7) takes fuel from fuel filter and feeds the carburettor, directly.

1.6.3 Power Plant

The Continental C90 engine is a carburetted, horizontally opposed, four cylinder four stroke, spark-ignited, air-cooled, wet sump engine incorporating a bottom induction and exhaust system, and provisions for rear mounted accessories (*picture nr 5*). It is rated to 90HP at sea level, standard atmosphere and 2475RPM.



Picture Nr 5

Continental C90 engine uses aviation gasoline 80/87 octane or 100LL, stored inside three fuel tanks with a total capacity of 20 Imp. Gallons.

Engine bearings, cylinders and all other moving parts are pressure lubricated by oil stored in a sump with 4.8 U.S. Quarts capacity.

Manufacturer recommends inspecting the engine every day, prior and after flight, to detect serious maladjustments, looseness, leaks and other development of dangerous character.

Besides, it must have a regular inspection after each 50 and 100 hours of operation, covering all parts and accessories, as per inspection sheet, carried out by a certified maintenance organization.

After 1800 hours of operation an overhaul should be performed.

MSN 48718-7-16 engine was subjected to a 100 hours (annual) inspection on 10-Jul-2009, at 1256:40 hours, when all required SBs were implemented and all reported defects corrected. After that inspection a final ground and flight test was carried out and the aircraft cleared for flight.

Ground test report showed cylinder's compression (70 – 74psi) was within acceptable limits, even if cylinder nr 3 was close to minimum required of 68psi (*picture nr 6*).

RELATÓRIO DE ENSAIO DE MOTOR(ES) NO SOLO						DATA: 10/7/2009			
AERONAVE	MARCA: ERCCUP	MODELO: A2-A	N.º FABRICO: B-280	MATRÍCULA:	PRODUÇÃO:				
MOTOR(ES)	MARCA: #1: CONTINENTAL	MODELO: #1: C-90-16F	N.º FABRICO: #1: 48718-7-16	CS - AIG	CERTIFICAÇÃO:				
	#2:	#2:	#2:						
INSPEÇÃO: 100 HRS / ANUAL <input type="checkbox"/> REVISÃO GERAL <input type="checkbox"/> REPARAÇÃO <input type="checkbox"/> MODIFICAÇÃO <input type="checkbox"/> OUTRO () <input type="checkbox"/>									
PONTO FIXO: (O PONTO FIXO É REQUERIDO NAS SITUAÇÕES DESCRITAS NO CLICHO À O LADO)		1. Antes de iniciar os trabalhos descritos no Relatório de Recepção de Aeronave a fim de detectar e/ou confirmar eventuais anormalias, reportadas ou não. 2. No final dos trabalhos a fim de se assegurar que as anormalias reportadas e/ou detectadas se encontram correctamente anuladas.							
ASPECTOS EM ANÁLISE		#1	#2	ASPECTOS EM ANÁLISE		#1	#2	COMPRESSÃO DE CILINDROS	
1. SUBIDA DA PRESSÃO DE ÓLEO APÓS O ARRANQUE:		✓	✓	B. VARIAÇÃO DO PASSO DE HÉLICE		✓	✓	PRESSÃO INTOR.: 80 PSI	
2. COMPORTAMENTO DOS COMANDOS DE VOO:		✓	✓	C. AJUSTAMENTO DO CARBURADOR		✓	✓	MOTOR #1	
3. A 75% DE POTÊNCIA ANOTAR: (RPM) 2000		✓	✓	D. CORRENTE GERADA PELO GERADOR (AMP)		✓	✓	Cil. #1 72 Cil. #1	
A- PRESSÃO DE ÓLEO: (PSI/BAR) 45		✓	✓	E- SELECTORA DE COMBUSTÍVEL:		✓	✓	Cil. #2 74 Cil. #2	
B- TEMPERATURA DE ÓLEO (°C/F) 140		✓	✓	F- FUNCIONAMENTO DA MISTURA:		✓	✓	Cil. #3 70 Cil. #3	
C- TEMPERATURA DE CABEÇA DE CILINDROS (°C/F)		✓	✓	5. A POTÊNCIA MÁXIMA ANOTAR: (RPM) 2250		✓	✓	Cil. #4 74 Cil. #4	
D- PRESSÃO DE AGUARD. (NÃO)		✓	✓	A- PRESSÃO DE ADMISSÃO: (NÃO)		✓	✓	Cil. #5 Cil. #5	
E- PRESSÃO E/OU DEBITO DE COMBUSTÍVEL: (PSI/BAR; GAL/MIN)		✓	✓	B- PRESSÃO DE COMBUSTÍVEL: (PSI)		✓	✓	Cil. #6 Cil. #6	
F- VÁCUO: (NÃO)		✓	✓	6. MARCHA LENTA: (RPM) 850		✓	✓	Cil. #7 Cil. #7	
4. NOS REGIMES RECOMENDADOS PELO FABRICANTE, ANOTAR: (RPM)		✓	✓	7. EQUIP. DE RADIO-COMUNICAÇÃO:		✓	✓	Cil. #8 Cil. #8	
A- CORTE DE MAGNETOS: QUEDA RPM DIX: 25		✓	✓	8. EQUIP. DE RADIONAVEGAÇÃO:		✓	✓	Cil. #9 Cil. #9	
Eso: 50		✓	✓	9. OUTROS		✓	✓		
SIMBOLOGIA UTILIZADA: ITENS SATISFATÓRIOS: ✓; ITENS NÃO SATISFATÓRIOS: X; ITEM NÃO APLICÁVEL: --									

Picture Nr 6

No further maintenance report was available and, due holes on Aircraft Logbook filing, it was not possible to determine the total amount of time really flown since that inspection and if there were any malfunction or lack of engine performance during all that time.

1.6.4 Load & Balance

The pilot didn't fill a Load & Balance sheet and it was not known the amount of fuel remaining in tanks, before the flight. On presented calculations (*table nr 4*) an amount of 10 Imperial Gallons of fuel have been considered, making account that the aircraft was not refuelled at Ciborro and it would fly some other sectors, before this flight and after last refuelling. Pilot and passenger were assumed as weighting 165lbs each and aircraft empty weight was retrieved from last weight & balance measurement, performed for Airworthy Certificate renewal (08-May-08).

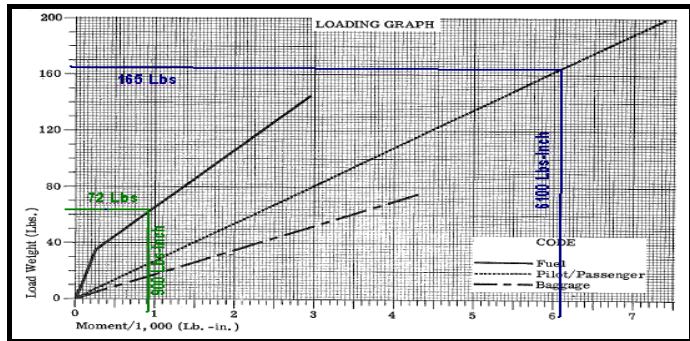
These mass values were introduced on graph nr 1, to determine respective moments.

Handwritten signature

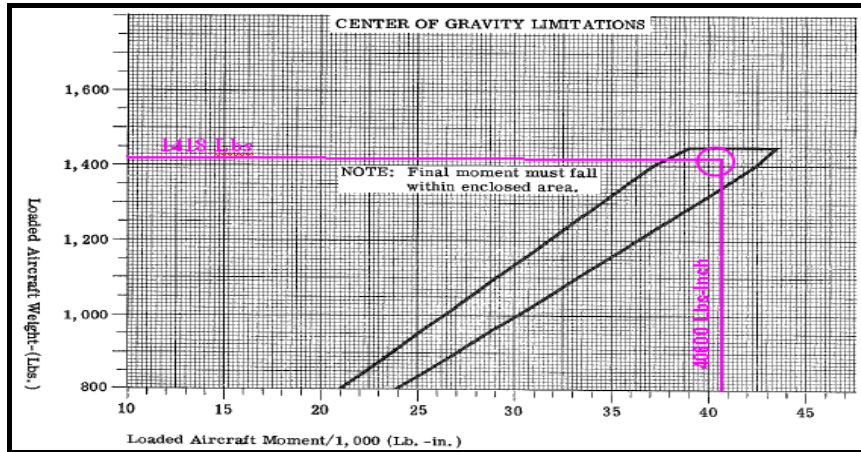
Reference	Mass (Lbs)	Moment (Lbs/inch)
Aircraft (empty)	1016	27500
Pilot	165	6100
Passenger	165	6100
Fuel (10 Imp. Gal)	72	900
Take-Off Mass	1418	40600

Table Nr 4

Inserting load & moment values on graph nr 2, C of G position was found.



Graph Nr 1



Graph Nr 2

Aircraft Centre of Gravity was inside allowed take-off envelope (graph nr 2), which confirmed the Aircraft Load & Balance was correct and within recommended operation limits, at take-off.

1.7 Meteorology

Dawn and morning of that day, 06-MAR-2010, the weather in Évora/Montemor-o-Novo area was characterized by a cloudy sky, with rain, thunderstorms and rain showers. Only by mid-afternoon the rain stopped and the sky became scattered for a short period, until evening, when it became broken to overcast again, as per meteo records (table nr 5) from Évora meteo station and METARs from nearby aerodromes Montijo (LPMT) and Beja (LPBJ). The wind was blowing from Southeast with an average speed of 15kts.

Time	Temp/DewP.	SL Pressure	Visibility	Wind Direction	Wind Speed	Precipitation	Sky Condition
4:00 AM	13°C/13°C	1004 hPa	10.0 KM	Southeast	16.7 km/h / 4.6 m/s	Rain	Rain Showers
3:00 PM	13°C/12°C	1005 hPa	10.0 KM	South-Southeast	25.9 km/h / 7.2 m/s	Rain	Rain Showers
4:00 PM	13°C/12°C	1005 hPa	10.0 KM	South-Southeast	27.8 km/h / 7.7 m/s	Nil	Scattered
5:00 PM	14°C/11°C	1005 hPa	10.0KM	South-Southeast	27.8 km/h / 7.7 m/s	Nil	Scattered
6:00PM	14°C/11°C	1006 hPa	10.0KM	South-Southeast	25.9 km/h / 7.2 m/s	Nil	Overcast

METAR LPMT 060400Z 07004KT 9999 -RA FEW006 SCT010 FEW016CB 13/13 Q1003 RETS
 METAR LPBJ 060400Z 13009KT 9999 -SHRA FEW003 BKN027 BKN040 13/13 Q1004
 METAR LPMT 061600Z 23010KT 9999 SCT020 18/14 Q1004
 METAR LPBJ 061600Z 15015KT 9999 SCT018 SCT030 13/12 Q1005
 METAR LPMT 061700Z 23010KT 9999 BKN020 17/14 Q1005
 METAR LPBJ 061700Z 15015KT 9999 FEW020 SCT030 14/11 Q1005
 METAR LPMT 061800Z 23010KT 9999 BKN020 15/12 Q1006
 METAR LPBJ 061800Z 15014KT 9999 SCT015 BKN028 14/11 Q1006

Table Nr 5

1.8 Navigation Aids

Not applicable.

1.9 Communications

The aircraft didn't establish radio communication with any aeronautical station. Having two way communication equipment on board, it was found switched OFF.

1.10 Aerodrome

Ciborro aerodrome was considered as a private runway and there was no reference on Authority issued Civil Pilot Manual (MPC)³. Located at coordinates 38° 47' 52"N / 008° 12' 09" W, inside "Pinheiro & Cavaleiro" farm, it was referred on Portuguese Aerodromes booklet, published by Pelicano, and its main characteristics were:

Loc. N 38° 47' 52" – W 008° 12' 09"					Alt. – 500'
QFU	Length	Width	Pavement	Aircraft Types	Slope
13 / 31	600m/1970ft	20m/66ft	Asphalt	Light	0,5%

Runway surface was in good condition and there were no obstacles nearby, but terrain showed some gradual up slope starting 50m to the left and about 1000m to the north, with a power line crossing runway axis about 300m north of runway 31 end.

Checking in loco it was discovered that runway length was not correct, being a bit shorter, just 1780ft long only (picture nr 7).



Picture Nr 7

1.11 Flight Recorders

The aircraft was not equipped with flight recorders, as they were not mandatory for that kind of aircraft and operation.

There was portable satellite navigation equipment aboard, from which it should be possible to recover some flight information and reconstruct horizontal and vertical track of the aircraft, but, unfortunately, it was switched off and no trip recording was available.

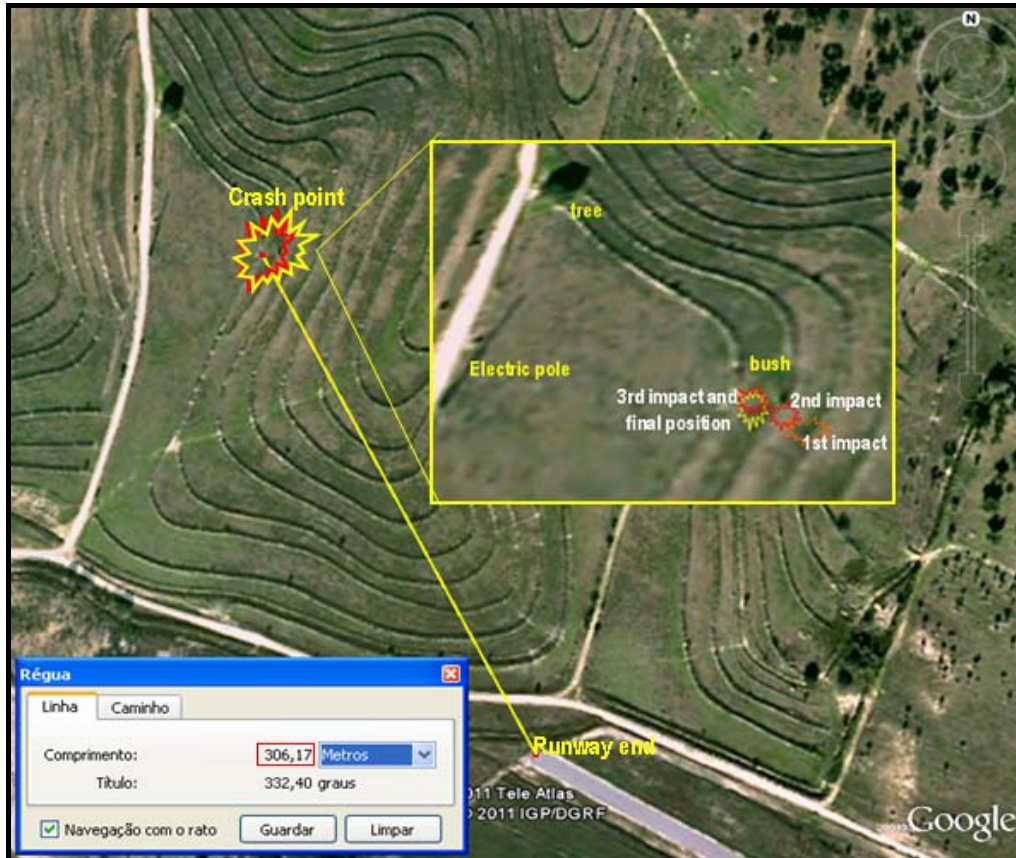
³ - This Civil Pilot Manual (MPC) was later replaced by VFR Manual (MAR 2010).

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1.12 Wreckage & Impact

1.12.1 Impact

The aircraft impacted the ground at 300m (1000ft) from runway end, 30° to the right of runway axis (*picture nr 8*). Three different impact marks were well recognized, about 5m apart, denoting a relatively slow horizontal speed and an attitude of wings levelled with a small pitch angle.



Picture Nr 8

First impact (*picture nr 9A*) was on its belly and almost levelled, making it jump into the air again and, gaining a nose down attitude, the aeroplane impacted a small bank frontally on its nose and right wing leading edge (*picture nr 9B*), losing the nose wheel.



Picture Nr 9

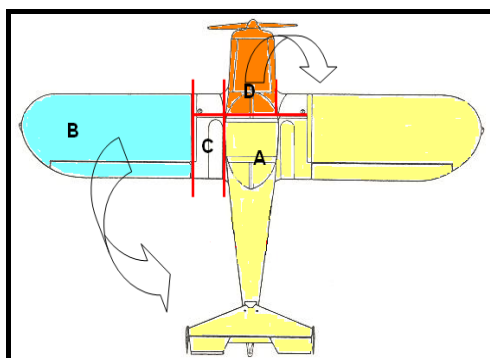
After this second impact it nosed over and came to a rest, upside down, broken in several parts (*picture nr 10*), about 10m far from first impact point, heading about 130° left of initial track.



Picture Nr 10

1.12.2 Wreckage

The aircraft was destroyed when it broke along several breaking lines (*picture nr 11*):



Picture Nr 11

Fuselage and right wing remained connected but upside down (A); Left wing broke up along two different lines, folding inside, becoming the outer wing (B) on top of fuselage and inner wing (C) positioned vertically in front of it; the cabin broke behind windscreen, with instrument panel following the engine block (D) and folding over right wing lower surface (*pictures nr 11 & 12*).



Picture Nr 12

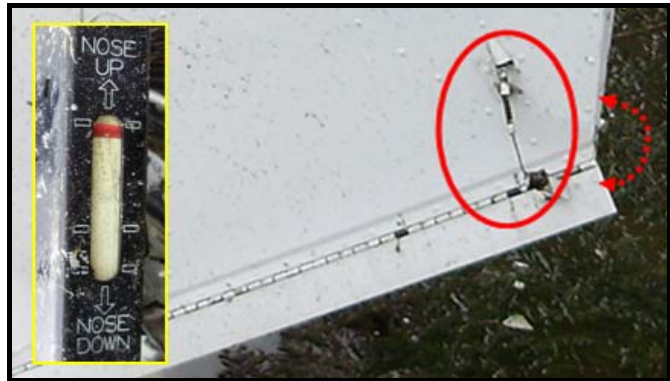
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Tail and rear fuselage (behind cabin) suffered minor damage, but the cockpit became destroyed. Main landing gear remained connected to the fuselage, but nose leg broke-up and was separated on second impact. The engine seemed to be in good condition but propeller had both blades bent rearwards.

1.12.3 Cockpit Controls & Indications

Flight controls remained connected to respective surfaces but it was not possible to determine their position at accident time, due aircraft state of destruction.

The only granted indication was stabilizer trim position, which has been selected to the extreme forward position (FULL NOSE UP) and confirmed by respective surface position and actuating cable (*picture nr 13*). This forced the aircraft towards a pitch-down tendency, requiring higher pulling forces to overcome it.



Picture Nr 13

Inspection to all other control surfaces showed no jamming or any other movement restriction that could impair aircraft control, before impact.

Inside cockpit it could be seen that fuel shutoff valves (main and secondary) were opened, allowing fuel feeding of fuselage tank and carburettor; throttle was fully forward (*full power*) like mixture control (*full rich*); ignition switch was selected "BOTH", with battery and generator switched "ON" (*picture nr 14*).



Picture Nr 14

All circuit breakers were pressed (normal position) and exterior lights and radios' switches were "OFF", with all the equipments installed in their positions but ADF receiver, which has been detached and thrown away, a couple of meters from aircraft rest position.



1.13 Medical &/or Pathological

Both people on board were found dead by the authorities that first arrived on the scene, being the bodies removed after cleared by medical and judiciary authorities, before the arriving of safety investigator, who had to work on statements provided by those authorities.

As per these statements, the bodies were found partially immersed in the water that flooded the accident site, in a state of cadaveric rigidity, and they were subjected to a post-mortem examination, with following results:

a) The pilot presented:

- ✚ No visible traumatic injuries;
- ✚ Some torso contusion and scratches;
- ✚ Arms and legs flagellation;
- ✚ Sternum surgery scar;
- ✚ Stressed encephalic congestion and oedema;
- ✚ Fracture of 3rd, 4th and 5th ribs, near breastbone;
- ✚ Right ventricle 3cm hole, with blood overflow, without typical traumatic agent intrusion sign;
- ✚ Solid food stuff in stomach (not digested);

b) The passenger presented:

- ❖ Deep wound on left forehead region;
- ❖ Haemorrhagic contusion zones on both eyes;
- ❖ Multiple scratches on his face, torso and limbs;
- ❖ Left tibia fracture;
- ❖ Encephalic congestion and oedema, with extravasion;
- ❖ Manubrium fracture;
- ❖ Fracture of all floating ribs;
- ❖ Right lung piercing with pericardial spillage;
- ❖ Liver contusion and kidney oedema;
- ❖ Solid food stuff in stomach (not digested).

1.14 Fire

There was no fire in the aircraft or its surroundings.

1.15 Survival Aspects

Considering the findings in 1.13, it is admitted that pilot death has been due to right ventricle burst, while the passenger dyed due thoracic trauma, which caused right lung piercing.

Regarding seriousness of internal injuries, independent of time elapsed until the arrival of emergency & rescue team, victims' survivability couldn't be granted, even if they had immediate medical assistance.

1.16 Tests & Research

Aircraft wreckage was sent to the Mechanical Laboratory of the Aeronautical Department of a Portuguese University⁴ for inspection and engine testing.

The aircraft was so destroyed that no special examination was performed to the airframe, considering it suffered substantial damage during wreckage transport to the test facility and primary evidences have been collected on site. Special attention was given to power plant examination and testing.

1.16.1 Power Plant Exterior Inspection

On a preliminary exterior inspection some impact damage was noticed, but there were no signs of pre-impact defect or missing parts. Damaged parts include propeller blades & hub, air intake, air filter, exhaust pipes, baffles and engine mountings, showing the first impact occurred on lower right side of the engine.

1.16.2 Engine Accessories

Engine fuel feeding system was checked for continuity and possible leaks and nothing was found that could restrict fuel passage, except the presence of corrosive material inside fuel pump, which prevented fuel passage. Considering the aircraft stood in the water for some hours and more than one year time stored without any preservation treatment, fuselage tank fuel line to the carburettor was clean and there was some fuel in it, it's admissible that corrosion was not present at accident time and it have developed later (*picture nr 15*).



Picture Nr 15

Oil pump was operating normally and showing no defect or abnormality, but some wall marks produced by solid contamination of fluid. Vacuum pump was operating normally as well.

Engine starter was running well, with coupling mechanism operating as expected and magnetos were in good condition and delivering (*picture nr 16*). Spark plugs and ignition cables were checked for condition and continuity. All spark plugs showed normal wear, consistent with its operating time. Ignition cables presented some damage near candle sockets, caused by ground impact. Otherwise its connectivity and continuity were normal.

⁴ - Universidade da Beira Interior (UBI).



Picture Nr 16

Air intake and air filter were obstructed by mud and straws (being too much present on site of accident) and even carburettor mixing chamber was full of dry mud, signalling the engine was aspirating when hitting the ground (*picture nr 17*).



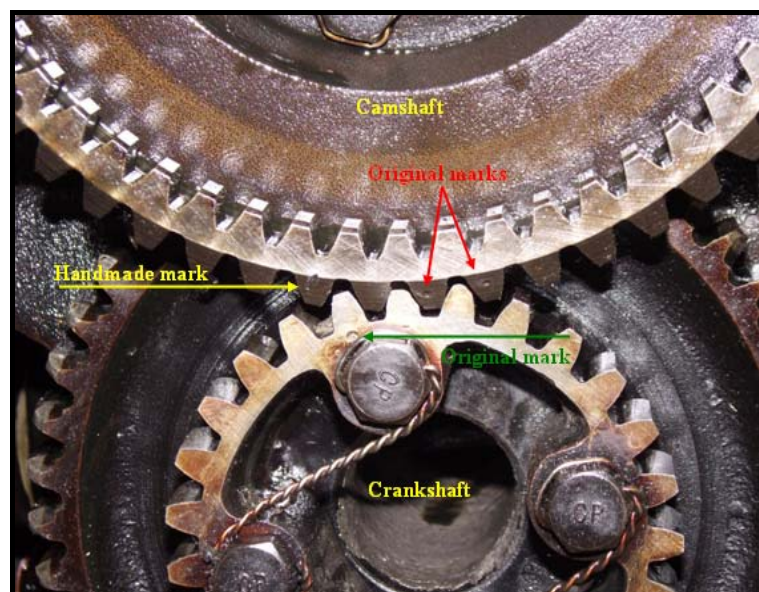
Picture Nr 17

1.16.3 Engine Dismantling & Internal Inspection

1.16.3.1 General

Engine was free to move when rotating the propeller, signalling there was no apparent internal damage, but the light force applied brought suspicion of cylinders' low compression.

A check was made to ascertain engine synchronization and it was discovered, on crankshaft / camshaft synchronization gear, that the original marks were misaligned by two teeth and there was a new handmade mark (*picture nr 18*). Contacted an engine expert, he explained that sometimes it is due to a fuel grade change, in order to avoid detonation, it becomes necessary to alter valve opening timings.



Picture Nr 18

1.16.3.2 Cylinders' Compression & Valves' Condition

Engine inspection continued with cylinders sealing & compression checks, starting with a pneumatic sealing check of all cylinders during a complete cycle. This test showed there were some leaks through casing and admission and exhaust valves.

Considering this would be essential to define if the engine was delivering its nominal power, a cylinder differential compression check was performed, as recommended by Manufacturer's Service Bulletin (SB 03-3), using an entry pressure of 80psi. This check provided the following values (*table nr 6*):

Cyl. Nr.	Pressure (psi)
1	18
2	62
3	12
4	36

Table Nr 6

All cylinders were considered bellow required compression value (68-70psi) and a valve sealing check was carried out, introducing kerosene through admission and exhaust lines, with respective valves closed. The findings are presented bellow (*table nr 7*):

Cyl Nr.	Notes
1	There was a small leakage via admission valve. After disassembly it was detected the spring was good but there was a small slack between exhaust valve rod and guide.
2	No leakage detected and no valve slack.
3	No leakage, but a small slack between exhaust valve rod and guide.
4	Small leakage by admission valve, which presented rod corrosion and a small oil quantity in this component.

Table Nr 7

Dismantling and detailed inspection of valves showed they were in good operating condition, with some light leakage through their seats and only exhaust valve #4 presented some rod corrosion (*picture nr 19*).



Picture Nr 19

1.16.3.3 Cylinders & Pistons' Condition

Cylinders were disassembled and inspected one by one, looking for any clues that could preclude any engine malfunction or power loss.

Cylinder nr 1 (*picture nr 20*) was well tight and combustion chamber showed normal deposits, uniformly distributed on its wall and piston head, without signs of overheating &/or detonation. The amount of deposits was greater than in the other cylinders. Piston wall had no sign of friction or abnormal wear and the segments were in good shape, moving freely and showing normal wear. Cylinder head parts were well lubricated and operating properly.



Picture Nr 20



Picture Nr 21

Cylinder nr 2 (*picture nr 21*) was well tight, combustion chamber and piston head showed normal deposits, uniformly distributed, and there were no signs of overheating &/or detonation. Cylinder wall was in good condition but some wear could be noticed by touching, on its lower surface. Segments showed no defect and were moving freely. Cylinder head parts were well lubricated and no damage was found.

Cylinder nr 3 (*picture nr 22*) was well tight but a silicon bushing was found on its base. Cylinder wall was significantly oxidized with a great amount of severe corrosion, creating some deep craters, identified visually and by touch. Corrosion distribution and piston made wear pointed for an extended process that has been started before the accident. Wall perimeter on lower neutral point shows deep groove, associated with piston mechanical impact. Inside combustion chamber was found a great amount of a sticky brown/reddish deposit (similar to iron oxide) and an abnormal quantity of oil, contaminated with some drops of a non-miscible liquid (water?) flowed from exhaust line. There were no signs of overheating &/or detonation, with piston head showing a uniform layer of carbon deposits. Piston wall showed signs of scuffing, due its friction with chamber wall.



Picture Nr 22

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Pressure segments were intact but all of them had half of its depth blackened along all its length. Additionally, the lubrication segment (lower one) was different from all the others (in this and other cylinders). Cylinder head parts were well lubricated and showed no damage.



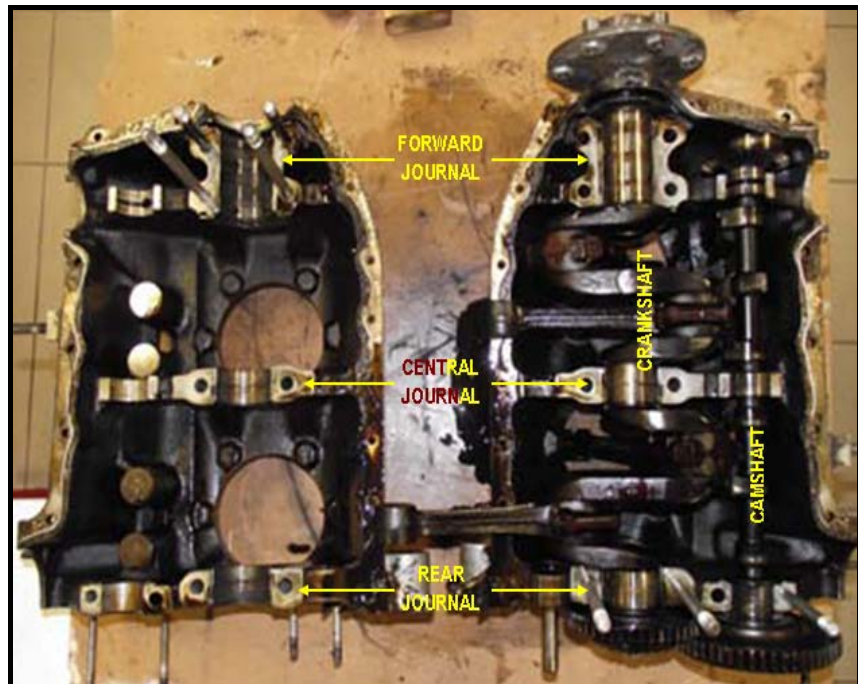
Picture Nr 23

Cylinder nr 4 (*picture nr 23*) was well tight, combustion chamber and piston head showed normal deposits, uniformly distributed and there were no signs of overheat &/or detonation. Segments showed no defect and were moving freely. Admission valve seating presented a greater amount of solid deposits than the other ones. Cylinder head parts were well lubricated and no damage was found.

1.16.3.4 Crankcase & Associated Components

Crankcase disassembly gave access for checking crankshaft, camshaft and connecting rods conditions, together with respective bearings (*picture nr 24*).

All bearings seemed to be adequately lubricated and be operating normally, only crankshaft showed some corrosion marks from bearings on forward journal (3) and central & rear journals (1 each). Flanges showed signs of a continuous process of oil contamination by solid particles as if the engine was operating without a paper oil filter.



Picture Nr 24

Camshaft and accessory gears looked in good condition and were expected to be operating normally, but also showing signs of being operating on contaminated oil with solid particles, for quite a long time.



1.16.4 Engine Inspection Conclusions

Summarizing all findings from engine investigation process three main concerns arise:

- 1st Fuel pump was found completely blocked by internal corrosion, which should be caused by the long period it was exposed to atmospheric elements, after the event, but could have been initiated before. At accident time, its fuel delivery rate could be reduced. Even so, considering the engine is fed directly from fuselage tank, a fuel shortage would be sensed after a certain period of operation only (after depleting fuselage tank), which was not the case, as the event occurred immediately after take-off;
- 2nd A two teeth misalignment was detected between camshaft gear and crankshaft gear and a new mark was handmade, referencing the new position. These two gears should be synchronized, so cylinder's valves would open and close at the right times, coordinated with sparking, for a convenient and smooth running of the engine. Nevertheless piston heads and valves showed no signs of detonation or pre-ignition. Such realignment could be attributed to a change on fuel grade used, after the engine was first tuned-up, which is common to be performed on ancient engines, built to operate on different fuels;
- 3rd The inspection revealed an inadequate compression ratio on all cylinders, with compression values well below the minimum recommended values, especially on cylinder nr 3, which showed marks of friction wear on cylinder walls and piston, together with signs of evident corrosion and piston segments with wear and soot marks, being the lower one different from all the others. In such conditions it was not possible for the engine to deliver the expected and rated power.

1.17 Organizational & Management

Being a private aeroplane, for owner personal use only, it was not expected to have an organization to support and operate it. All maintenance and operational responsibilities were with the owner/pilot, who used to be from certified maintenance providers all maintenance and repair works, necessary to keep aircraft airworthiness. Only daily and pre-flight inspections were performed by himself, each time he wanted to fly.

1.18 Additional Information

There's no other relevant information to refer.

1.19 Special Investigation Techniques

No special investigation techniques were used during this investigation.

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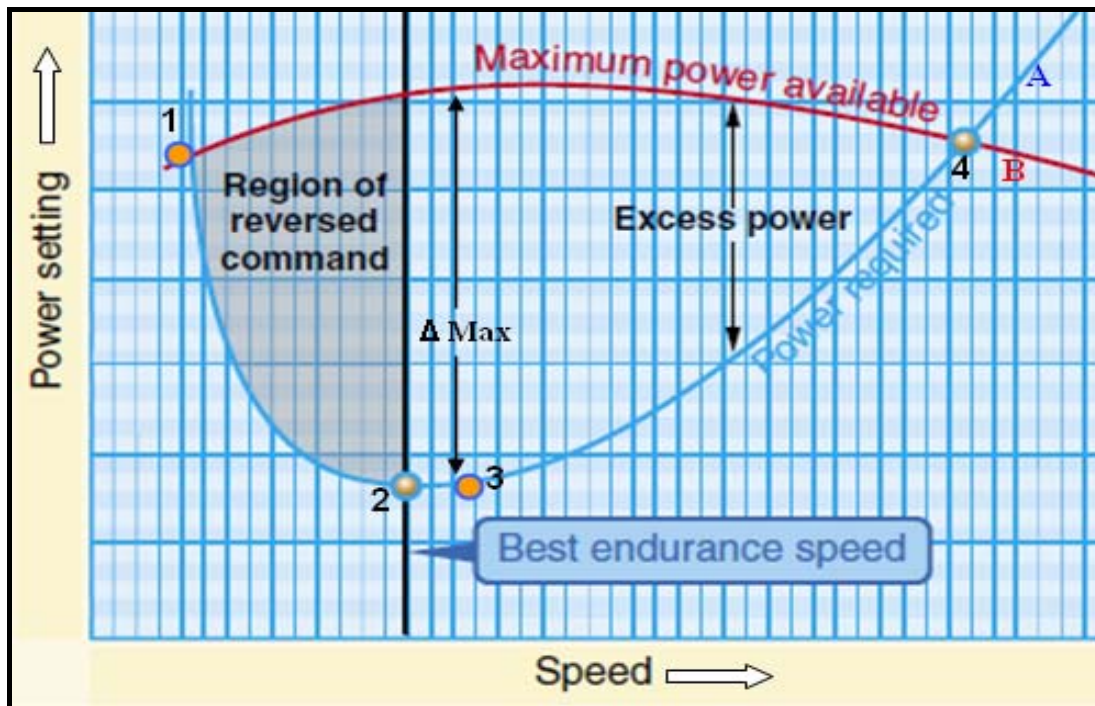
2. ANÁLISIS

2.1 Aircraft Flight Capability

2.1.1 General

2.1.1.1 Power Curves

Having as a reference FAA document “Pilot Handbook of Aeronautical Knowledge” (PHAK), lets remember some fundamentals relating power available, speed and power required curves (picture nr 25).



Picture Nr 25

Blue curve “A” represents aircraft total drag, on level flight at different speeds, which equals the power required to counteract that drag, from where it takes the name of “*power required*” curve. Red curve “B” represents maximum power the engine can deliver at same altitude and speed, being called “*maximum available power*” curve. The area inside these curves represents the excess power available, which allows aircraft manoeuvring. Point nr “1” defines minimum speed for power available (minimum flying speed, or stall speed, is generally defined by other aerodynamic factors and usually is greater than this). Point nr “2” represents speed value that takes less power to maintain, and consequentially is called “best endurance speed”. Point nr “3” (maximum separation between curves) determines speed for a maximum rate of climb. At last point nr “4” represents the maximum cruise sustainable speed.

Flight in the region to the right of point 2 means that while holding a constant altitude, a higher airspeed requires a higher power setting and a lower airspeed requires a lower power setting, contrary to what happens on the region to the left of point 2, where a lower airspeed requires a higher power setting and a higher airspeed requires a lower power setting. In the



first region we may find normal manoeuvring, climb, cruise and descent, while on second one there's slow speed manoeuvring, like take-off and approach for landing.

This shadowed region, to the left of best endurance speed line, where speed / power relation becomes the opposite of what should be expected as normal, is called "**Region of Reversed Command**" or "**Region of Reversed Power**".

An airplane performing a low airspeed, high pitch attitude, power approach for landing, is an example of operation in this reversed region. If an unacceptably high sink rate should develop, it may be possible for the pilot to reduce or stop the descent by applying power. But, without further use of power, the airplane would probably stall or be incapable of flaring for landing. Merely lowering the nose of the airplane to regain flying speed in this situation, without the use of power, would result in a rapid sink rate and corresponding loss of altitude.

If during a short field take-off and climb, for example, the pilot attempts to climb out of ground effect without first attaining normal climb pitch attitude and airspeed, the airplane may inadvertently enter the region of reversed command at a dangerously low altitude. Even with full power, the airplane may be incapable of climbing or even maintaining altitude. The pilot's only recourse in this situation is to lower the pitch attitude in order to increase airspeed, which will inevitably result in a loss of altitude.

Flying in this zone is highly unrecommended and pilots must give particular attention to precise control of airspeed when operating in the low flight speeds of the region of reversed command, avoiding stall the airplane specially at low altitude without margin for recovering, in the event available power is not enough to come out of the situation.

2.1.1.2 Alon A2

Chapter V of Aircraft Flight Manual, issued by Univair Aircraft Corporation, deals with Alon A2 flight performance (and capabilities).

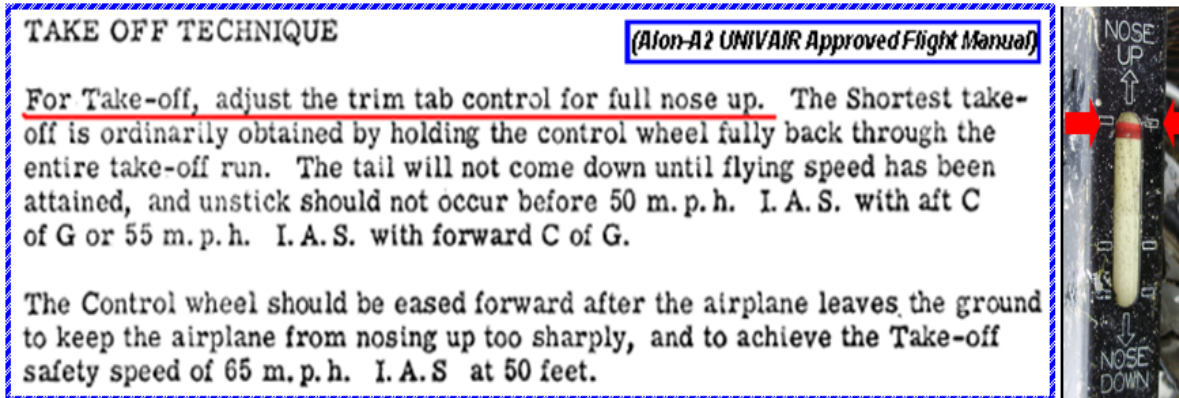
All data retrieved from graphs presented can be validated only if some general conditions are met, like:

- ✚ **Airframe** - No modification;
- ✚ **Engine** - Continental C90-16F at Full Throttle and Carburettor Air - Cold;
- ✚ **Propeller** - McCauley 1B90CM or 1A90CF;
- ✚ **Mass** - Take-off Mass should not be greater than calculated Maximum Permissible Take-off Mass, for altitude and temperature;
- ✚ **Runway** - Hard, level, dry surface;
- ✚ **Flying Techniques** - As per chapter IV of Aircraft Flight Manual.

This section IV incorporates all pertinent information relating to aircraft handling and operation, grouped by the different phases of flight.

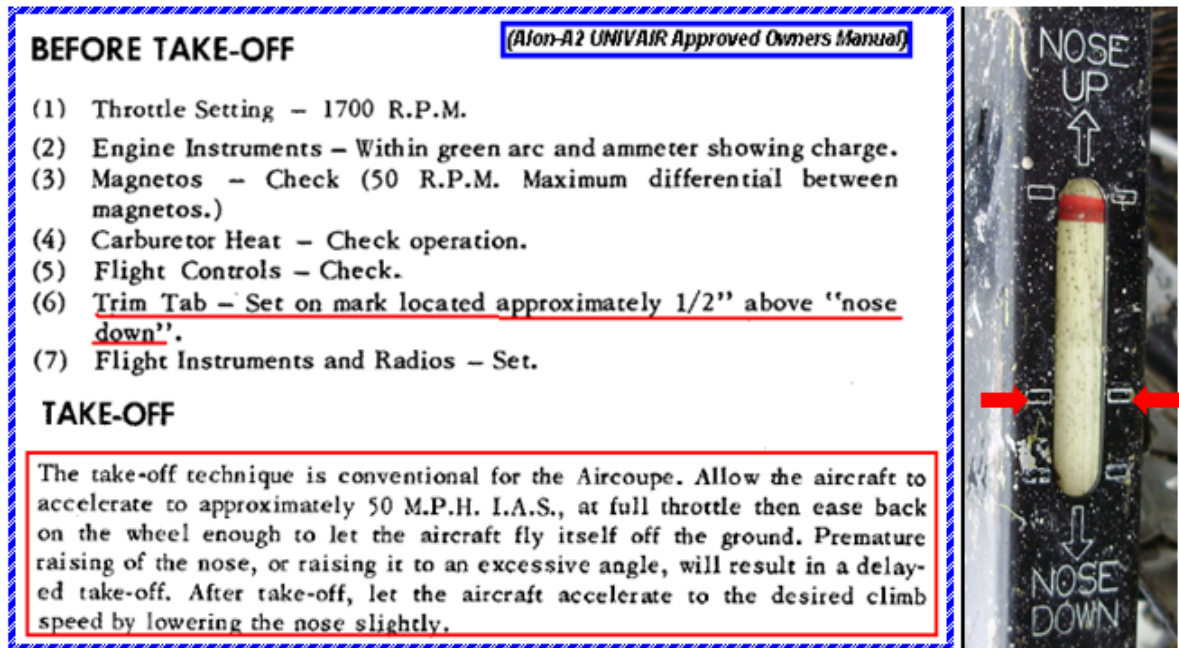
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Concerning take-off phase, following recommendations were displayed on Univair Aircraft Corporation Approved Aircraft Flight Manual (picture nr 26):



Picture Nr 26

Curiously on the Alon A2 Aircraft Owners Manual, issued by the same company (Univair Aircraft Corporation), a substantially different take-off technique and procedure is explained, recommending a pitch trim setting backwards to a reference mark and making the take-off run with flight controls at a neutral position until lift-off speed (reducing drag) when a gentle easing back of pitch control will take the aircraft off the ground (picture nr 27):



Picture Nr 27

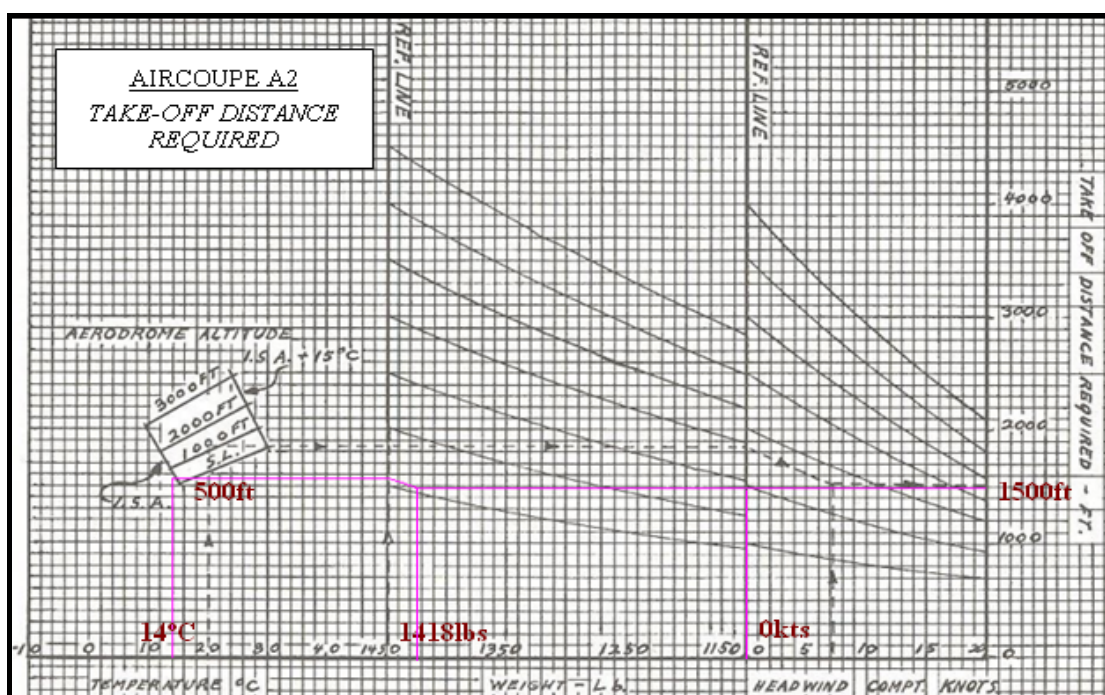
Recognizing that Aircraft Flight Manual must have precedence on Aircraft Owners Manual, for Take-off, Initial Climb and Enroute Climb phases performance calculations we will make use of respective graphs presented in Aircraft Flight Manual, introducing actual parameters required for every phase and applying all recommended corrections, being them included in graphs or determined by other means.

2.1.2 Take-off Capability

2.1.2.1 Take-Off Distance Required

Take-off distance required means the minimum runway distance for the aircraft to accelerate from rest to a height of 50ft above threshold, considering a normal acceleration with full throttle and carburettor cold air selected.

Being determined that the actual take-off mass of **1418lbs** was below the maximum permissible take-off mass for that altitude and temperature (ISA conditions) and maximum structural take-off mass (1450lbs), actual values were introduced on "Take-Off Distance Required" graph (*graph nr 3*). Minimum take-off required distance found was 1500ft, for a zero wind condition, once the graph had no provision for tail wind correction.



Graph Nr 3

Being Runway Take-Off Distance Available (TODA) 1783ft, the runway should accommodate aircraft take-off in such conditions, even if the pilot took position in front of the hangar (1740ft), provided tail wind effect was not to be considered.

Being this a Take-off Distance, this means the real runway distance (*take-off run*) is shorter and so it may include "stop way" or "clear way".

Being this a "net" value, this means that some margin has been included in the chart for the loss of performance due to various factors for which it is difficult to make an allowance operationally, such as small and unavoidable variations from airspeed and variations from the average airframe drag. On the other hand, besides corrections introduced by the graph, other corrections should be included subsequently, like "positive slope" and "grass surface's operation".

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There's no correction for negative slope, being used zero slope, nor for tail wind take-off, reason for not use the graph in such situation, which is not recommended, unless other factors so determine (*picture nr 28*).

(Aton-A2 UNIVAIR Approved Flight Manual)

As the effect of downhill surface gradient is not scheduled, the take-off distance appropriate to zero surface gradient is to be used when there is a downhill gradient.

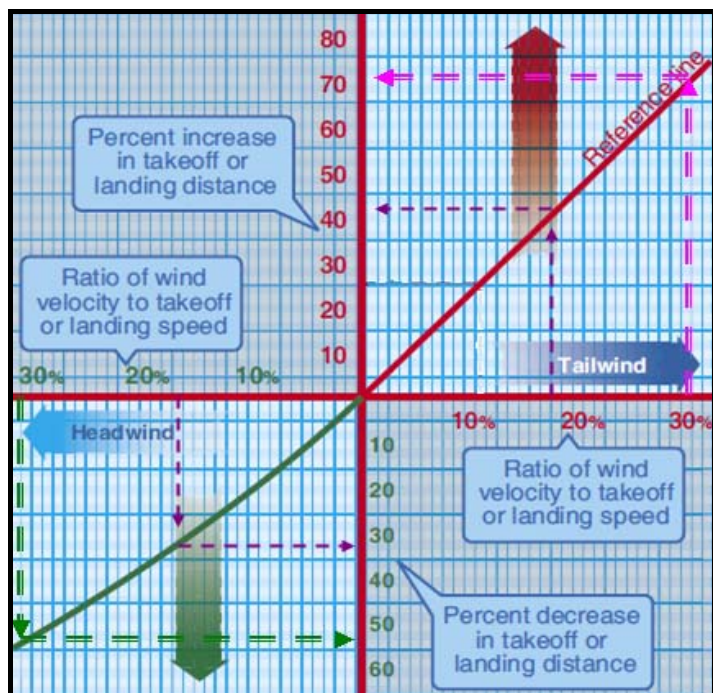
As the effect of tailwind component is not scheduled, the information given on Page 29 is not valid for a down wind take-off.

Picture Nr 28

2.1.2.2 Take-off Wind Correction

Once the Aircraft Flight Manual presents no correcting table for tail wind, a tail wind take-off shall not be attempted, unless relevant factors so determine. Even so it must be considered that for strong winds, there should be a heavy penalty and take-off in such circumstances may be not achievable. Making use of FAA "Pilot Handbook of Aeronautical Knowledge" again, we will try to show how penalizing strong tail wind could be, introducing the actual tail wind of 16MPH (14kts) on the chart (*picture nr 29*).

Considering a take-off speed of 50MPH, actual tail wind represents 32% of that speed and it would require a 75% increase of take-off distance, against 57% decrease if it was a head wind (*large dotting*). Complying with AFM recommendation that the grid on graphs is not compensated and a corrective factor of 50% should be applied, we may find, for a wind factor of 16% a 45% distance increment or 35% distance decrement respectively for tail and head winds (*fine dotting*).



Picture Nr 29

In such conditions, even applying the less penalizing coefficient (45% increase on take-off distance required), instead of 1500ft determined for zero wind (2.1.2.1), the new take-off distance required would be 2175ft. Considering the runway had 1783ft only, take-off in those conditions was seriously endangered.

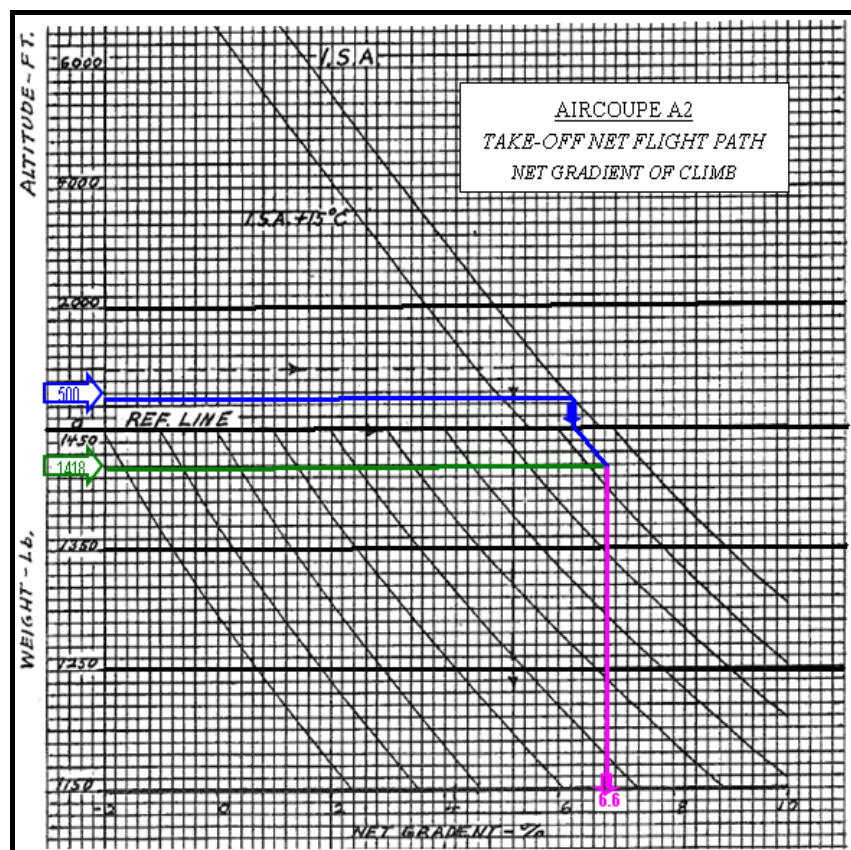
2.1.3 Initial Climb Capability

The capacity of an aircraft to clear the obstacles on its path after take-off can be measured as “Net Gradient of Climb”, which means the height increase (feet) for every 100ft of horizontal travel of the aircraft immediately after liftoff until reaching safety acceleration altitude.

Alon A2 AFM presents a graph (*graph nr 4*) for this calculation, taking account of varying weights, altitudes and temperatures. The associated conditions for graph use are:

- Power – Full Throttle;
- Carburettor Air – Cold;
- Speed – 65MPH IAS;
- No turn of “rate one” (180°/m) or greater should be performed.

Introducing altitude value of 500ft on the graph and proceeding to temperature reference line for ISA (14°C), following to intercept weight line of 1418lbs and going down to Net Gradient scale a 6.6% figure is obtained, which means the aircraft may climb 6.6ft for every 100ft horizontal distance covered.



Graph Nr 4

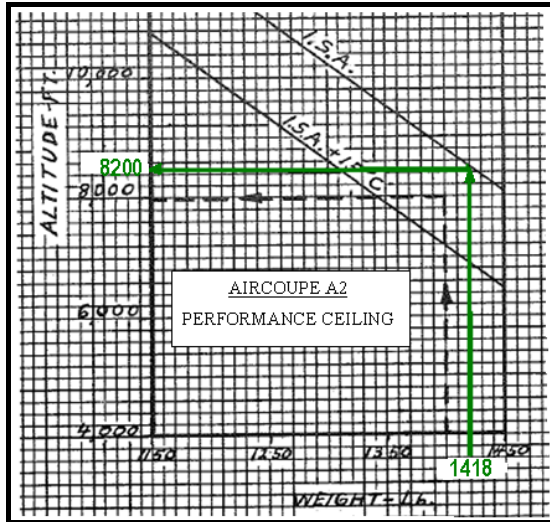
With this figure it becomes easy to determine the possibility of the airplane to clear present obstacles on its take-off path.

2.1.4 Enroute Climb Capability

The study of enroute performance supplies information on aircraft flight capacity, like maximum cruise altitude capability and rate of climb at different weights and altitudes.

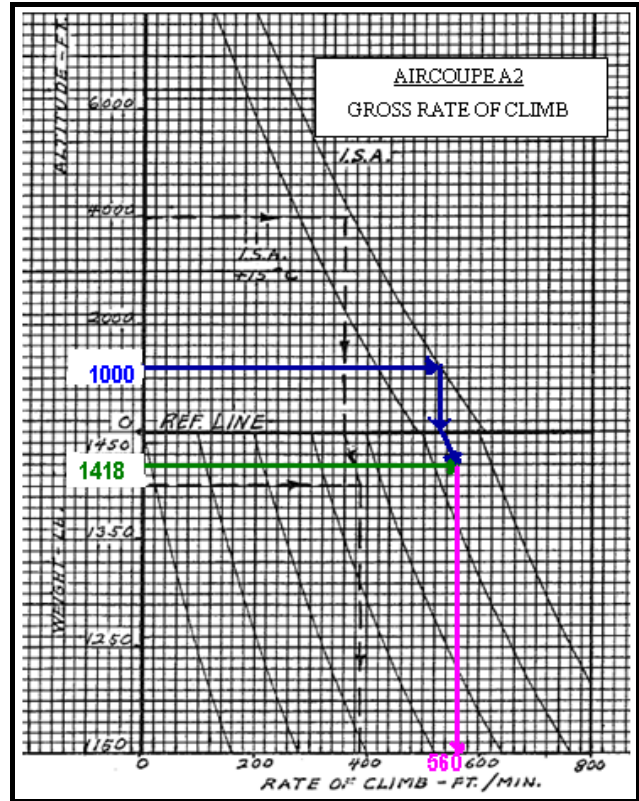
Aircraft “ceiling” means the maximum altitude which the airplane may regularly relied upon to achieve, bearing in mind the adverse conditions likely to occur. At that altitude the aircraft should maintain an airspeed of 70MPH at sea level reduced by 1MPH for every 1000ft altitude, up to the limit of 62MPH minimum, with full throttle and carburettor air intake selected to cold air. Regarding our analysis, that ceiling would be 8200ft (*graph nr 5*).

Handwritten signature



Graph Nr 5

This is not a limitation but represents the maximum altitude the airplane should fly, when establishing compliance with that part of operating regulations which refer to Enroute Flight.



Graph Nr 6

Aircraft rate of climb (enroute) shows its capacity to gain altitude while travelling, keeping speed and configuration as referred above (*airspeed of 70MPH at sea level reduced by 1MPH for every 1000ft altitude, up to the limit of 62MPH minimum, with full throttle and carburettor air intake selected to cold air*). Back to our situation, considering atmosphere conditions were close to standard (ISA), no temperature correction had to be introduced and, for:

- 1418lbs actual total mass;
- At 1000ft altitude;

The airplane should grant a gross rate of climb of 560ft/m (graph nr 6).

This rate of climb would be translated into a net climb path of approximately 9.4% gradient (without wind correction), enough to pass all obstacles present along aircraft take-off and flight path.

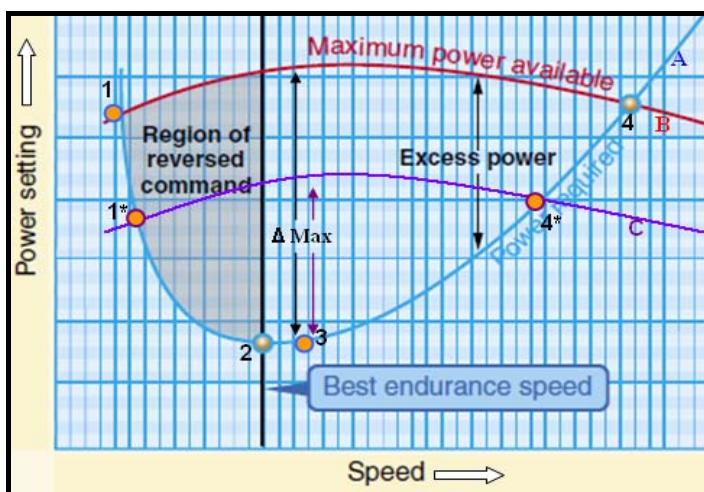
2.1.5 Engine Power Deterioration

Calculated take-off distance required and all other performance values, obtained from AFM graphs, regarding different flight phases, are only valid if aircraft engine is operating normally and delivering rated power, besides other basic conditions, as referred earlier (2.1.1.2).

As demonstrated by engine inspection, its condition and operating status was such that nominal rated power of 90HP could not be delivered. Even if an accurate value can't be as-

certained, engine power degradation reduced aircraft acceleration capability and take-off and initial climb performance were heavily penalized.

Transposing to power curves' chart an aleatory value for engine power degradation, we draw curve "C" which will represent the new Maximum Power Available (*picture nr 30*), determining new airspeeds 1* (minimum sustainable speed) and 4* (maximum cruise speed), but keeping the same 3 (best rate of climb speed), even if rate of climb becomes lower.



Picture Nr 30

In the presence of less power available, maximum cruise speed, situated in the normal side of the curve (to the right of best endurance line) suffers an equivalent reduction, while minimum speeds, situated in the region of reversed command (to the left of best endurance line), suffer a correspondent increase, which means that in case of speed decrease after take-off, entering the reversed region, there will be no power available to come out of the situation without an altitude loss. Speeds 2 and 3 suffered no change but respective climb rate will be less then before, meaning the aircraft lost manoeuvring capacity.

2.2 Flight Preparation

The aircraft was sheltered inside the hangar and the pilot only had to pull it out and perform the pre-flight inspection and follow the before flight checklist.

There were no fuel and control facilities at the aerodrome, so the pilot didn't refuel the aircraft, didn't file a flight plan and didn't receive a pre-flight briefing. People on the ground were unaware of flight destination, knowing only the pilot intended to stay for about one hour airborne.

There was a windsock at middle runway but no speed measurement device available, so the pilot chose to take-off with tail wind, avoiding taxi to the opposite end of runway, without being aware of real wind velocity since the windsock was not dully calibrated and should be only used as a guide for runway selection.

No one on the ground testified the completion of pre-flight aircraft inspection and preparation, engine run-up and take-off.



2.3 Flight Progress

2.3.1 General

From wreckage analysis previous declared performance and flight path were never attained.

In fact, engine was running when the aircraft collide with the ground for the first time, as mud and straws found in air intake and carburettor chamber confirm and engine control's position shows that full power was applied, but the aircraft was not climbing as expected.

Considering the distance between first and second impact was not greater than 5m, aircraft ground speed was relatively slow and it was not enough for the landing gear to break and separate when the aircraft collided with the ground in a landing attitude. Even nose gear was separated only after second impact, against the embankment, under perpendicular forces to its leg stay.

Aircraft nose-over after second impact is well demonstrative of full nose up pitch trimming. When, after first impact, the aircraft went to the air, the nose pitched down and, when hitting the ground again, continued the balance movement, assisted by tail wind acting on stabilizer, and finished upside-down, a few metres ahead.

2.3.2 Take-off Progress

From cockpit interior's inspection, engine and flight controls' position and other switching, we deduced the pilot used take-off procedure recommended on AFM, section IV (*picture nr 26 in 2.1.1.2*).

With pitch trim forcing nose down, the pilot had to keep pulling the control wheel waiting for the aircraft to lift-off at 50MPH, when he should ease forward on control column, avoiding an extremely pitch up attitude and allowing the aircraft to accelerate to take-off safety speed of 65MPH.

Considering all variables referred in 2.1.2.2 and 2.1.5, absence of chart or graph for tail wind effect correction and engine power deterioration, it's assumed the aircraft took all runway available before the pilot managed to have the aircraft airborne at a speed slightly lower than lift-off speed (between 40MPH and 50MPH), when passing runway end (there were no tires' marks on the ground after the asphalted strip).

Runway 0.33% negative slope might have introduced some light acceleration effect to the aircraft, on the ground.

When leaving ground effect, airspeed was bellow take-off safety speed (65MPH), inside the region of reversed command, which compromised airplane acceleration and prevented it to reach a positive rate of climb, especially if considering the engine was not delivering rated power.

2.3.3 Climb Progress

In order to grant a minimum climb performance, the aircraft had to accelerate to take-off safety speed (65MPH) or enroute climb speed (70MPH).

Once the engine was not delivering rated power and the aircraft lifted-off at a lower speed, it was unable to maintain normal acceleration and actual climb gradient was substantially lower than calculated value, most probably negative, which forced the airplane to enter the region of reversed command, where engine degraded power was not enough to grant a climb or even to maintain altitude, requiring an altitude loss to gain airspeed.

When the pilot eased pitch to let the aircraft accelerate, the aeroplane started to sink, losing altitude and forcing the pilot to pull back on control wheel, trading speed for altitude. This required him to ease again on control wheel, when speed came down, and pulling again...and again easing..., keeping the aircraft in the air, flying on a swing slow movement without climbing and without increasing speed, manoeuvring on a stalling edge, like a limb, dragged by the wind blowing from behind (*picture nr 31*).



Picture Nr 31

This slow dance may be explained by aircraft design characteristics, which prevents it to fully stall, as referred on section IV of AFM (*picture nr 32*) but caused a gradual altitude loss, until its collision with the ground.

STALLING:

GENERAL

There is no warning of the approach to the stall apart from gradually less effective aileron control. The aircraft under most conditions does not fully stall. A certain amount of fore and aft pitching will take place except at the aft C of G, when a stall will occur with a gentle nose drop, and there is no tendency to drop a wing.

STALLING SPEEDS

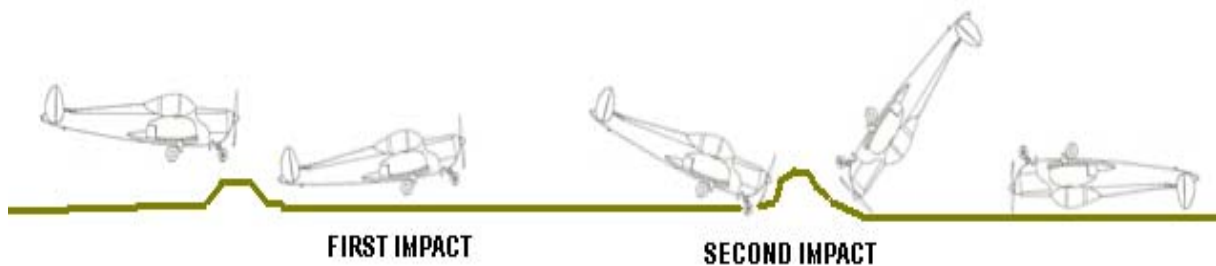
The ability to stall depends on the speed with which the nose is raised and the amount of power used. Due to the fact that the aircraft cannot be stalled in the normal condition, no stalling graph is shown, but the minimum flying speed is approx: 40 m. p. h. I. A. S.

Picture Nr 32

2.3.4 The Crash

In view of that aircraft behaviour, it's understandable that, after airborne due a firm and positive pilot action on pitch control, the airplane couldn't exit reversed command region and accelerate to minimum climb speed of 65MPH. Altitude gained was not enough to allow it to be traded for speed, exit that region and get a minimum gradient of climb.

Instead, the aircraft was kept fluctuating in the air with the pilot struggling to gain control, either sinking, or climbing, covering about 300m until it impacted the ground on one of the several swings it was performing, on a landing attitude, with wings levelled. After that first impact it jumped into the air, put nose down and collided frontally with an embankment, flipped over and rested upside-down, about 10m far from first impact point (*picture nr 33*).



Picture Nr 33

Although we have no support to declare the exact time of pilot's heart attack, which was declared by postmortem medical examination, it's acceptable that the circumstances were favourable for it, regarding pilot's medical record and the extreme stress caused by the inability to keep the aircraft flying and the certainty of being close to crash.

Anyway it cannot be consider pilot incapacitation as probable main cause of the accident, being more likely an effect. In fact, all evidence points to a pilot assisted ground impact and only after first collision the aircraft progressed under natural forces, without any chance of pilot control, once it lost flying speed and engine power.

We may never forget that the passenger was a pilot, as well, and, even if he was not familiarized with that aircraft, he had minimum required skills to fly the aircraft safely and avoid the accident, just in case of pilot incapacitation with a flyable aircraft.



3. CONCLUSIONS

3.1 Findings

- 1st The pilot was entitled with a valid pilot license, which allowed him to fly that aircraft;
- 2nd The aircraft had a valid Airworthiness Certificate, it complied with an annual (100 hours) inspection and accumulated, supposedly, 5 hours flight time since that;
- 3rd The aircraft seems to be flying little for a long period, without exceptional maintenance actions;
- 4th Take-off was performed on tail wind conditions without having required performance data for that situation;
- 5th Pilot managed to liftoff the aircraft but was unable to keep it flying and gaining speed and/or altitude;
- 6th Aircraft speed never exit reversed command region, being the engine, at maximum power setting, incapable of granting a speed acceleration and having no altitude available for speed trading;
- 7th The aircraft crashed 300m far from runway end;
- 8th Engine investigation found that it was delivering less than rated power, with cylinders' compression values well bellow minimum required pressures and engine critical parts showed some kind of corrosion;
- 9th Both people on board suffered fatal injuries;
- 10th The aircraft was considered a total loss and written-off.

3.2 Causes of the Accident

3.2.1 Primary Cause

Aircraft inability to fly, after its liftoff at lower than recommended airspeed and its incapacity to accelerate without losing altitude (flying inside power curve's region of reversed command), was considered the most probable cause of the accident.

3.2.2 Contributory Factors

The following were considered as contributory factors:

- 1st Engine underpower delivery, due lower cylinders compression ratio and other engine deficiencies;
- 2nd Take-off on a short runway with strong tail wind, having no correction charts or graphs and being this considered as a non recommended manoeuvre.



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FINAL ACCIDENT REPORT Nr: 01/ACCID/2010

4. SAFETY RECOMMENDATIONS

No safety recommendations were issued.

Lisbon, the 10th of April, 2012

The Investigator In Charge,



António A. Alves