SOUTH AFRICAN CIVIL AVIATION AUTHORITY

AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

Reference:	CA18/2/3/8658

Aircraft Registration	**ZS-MKG**	**Date of Accident**	27 May 2009	**Time of Accident**	1050Z
Type of Aircraft	Cessna TU206F (Aeroplane)	**Type of Operation**	Commercial (Aerial Survey)		
Pilot-in-command Licence Type	Commercial	**Age**	22	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	329.9		Hours on Type	130.7
Last point of departure	Wonderboom Aerodrome (FAWB)				
Next point of intended landing	Wonderboom Aerodrome (FAWB)				
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)					
Goedgevonden Cole mine near Ogies (GPS position: South 26°06.659' East 029°04.290', elevation 5170 feet)					
Meteorological Information	Surface wind; 270°/7 knots, Temperature; 20°C, Visibility; +10km				
Number of people on board	1 + 1	**No. of people injured**	1 + 1	**No. of people killed**	0

Synopsis

The pilot, accompanied by a camera operator, departed from Wonderboom Aerodrome at approximately 0830Z on the morning of 27 May 2009 on a geographical survey flight in the Bethal and Kriel area.

After being airborne for approximately two hours, the pilot noted a sudden decay in the engine oil pressure. Shortly thereafter, the engine started running rough and then two loud, thumping noise followed. Smoke then entered the cockpit. The pilot opened his window to let the smoke and smell out. Being at a height of approximately 3 000 feet above ground level (AGL), the pilot decided to shut down the engine. He then broadcast a Mayday call on the VHF frequency 127.4 MHz and positioned the aircraft for a forced landing on an open field.

The aircraft touched down on level ground but collided with an embankment approximately 40cm in high on the edge of a mine service road, 13 m after his initial touchdown. The aircraft bounced back into the air and the nose wheel broke off. The aeroplane then impacted with soft soil in a slight nose down attitude. The nose gear strut dug into the soft soil, and the aircraft nosed over, coming to rest inverted.

Probable Cause

Unsuccessful forced landing following an engine failure in-flight.

Contributory Factor:
Mechanical failure associated with the operation of the engine (big-end bearing seizure on the No. 4 and No. 5 connecting rod hardware).

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner/Operator	: Fotogramensura (Pty) Ltd
Manufacturer	: Cessna Aircraft Company
Model	: TU206F
Nationality	: South African
Registration Marks	: ZS-MKG
Place	: Goedgevonden Cole Mine near Ogies
Date	: 27 May 2009
Time	: 1050Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

*In terms of Regulation 12.03.1 of the Civil Aviation Regulations (1997) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and **not to establish legal liability**.*

Disclaimer:

This report is produce without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight:

1.1.1 The pilot, accompanied by a camera operator, departed from Wonderboom Aerodrome at approximately 0830Z on the morning of 27 May 2009 on a geographical survey in the Bethal and Kriel area.

1.1.2 They had been airborne for approximately two hours and had completed the photography. The pilot had just requested clearance from air traffic control (ATC) to descent below the terminal control area (TMA) with the intention to return to Wonderboom Aerodrome when he noted a sudden drop in the engine oil pressure. Shortly thereafter, the engine started running roughly and then two loud thumping noises were heard. Smoke entered the cockpit, and the pilot opened his window to let it out.

1.1.3 At the time they were about 3 000 feet above ground level (AGL). The pilot eventually shut-down the engine and informed ATC of his intention to perform a forced landing. He had identified a field and followed the emergency checklist procedure as stipulated in the Pilot's Operating Handbook (POH) for a forced landing. According to the pilot he touchdown at approximately 80 miles per hour (mph) just before a mine service road, which was elevated about 40 cm above the initial touchdown point. As the aircraft collided with embankment, it bounced back into the air and at the same time the nose wheel broke off. The pilot was, however, not aware of the fact that the nose wheel had broken off. He retained a wings-level attitude, but due to the bounce, was unable to keep the nose up, and the aircraft impacted with the ploughed field 73 m pass the embankment, in a nose down attitude. The nose landing gear strut assembly dug into the soft soil, causing the aircraft to nose over and come to rest inverted.

1.1.4 Both occupants vacated the aircraft unassisted. The pilot sustained a cut to his head and the camera operator had a cut to his right leg, which was caused by the airborne camera that had broken loose from its floor mountings during the impact sequence. Emergency personnel from the mine was quickly on the scene to render assistance and secure the area. Both occupants were taken by ambulance to a Witbank hospital where they received medical treatment. They were discharged from hospital later the same day.

1.1.5 During an interview with the pilot the day after the accident, he stated that he had physically checked the engine oil level as part of his pre-flight checks prior to the flight and the dipstick indicated 10 quarts. According to documented evidence (aircraft flight folio) the last time oil had been put in was on 22 March 2009 at 8663.6 airframe hours, when 1 litre of oil was added. The aircraft had been flown a further 40.2 hours since the entry in the aircraft flight folio.

1.1.6 The accident occurred during daylight conditions at a geographical position determined as South 26°06.659' East 029°04.290' at an elevation of 5 170 feet above mean sea level (AMSL).

1.2 Injuries to Persons:

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	1	-	1	-
None	-	-	-	-

1.3 Damage to Aircraft:

1.3.1 The aircraft was substantially damage when the nose wheel broke off during the forced landing and the aeroplane nosed over.

Figure 1. A view of the aircraft as it came to rest in an inverted attitude in a ploughed field.

1.4 Other Damage:

1.4.1 No other damage was caused.

1.5 Personnel Information:

1.5.1 Pilot-in-command:

Nationality	South African	Gender	Male	Age	22
Licence No.	*****************	Licence Type	Commercial		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	Instrument Rating				
Medical Expiry Date	31 May 2010				
Restrictions	None				
Previous accidents	None				

Flying Experience:

Total Hours	329.9
Total Past 90 Days	44.8
Total on Type Past 90 Days	44.8
Total on Type	130.7

1.6 Aircraft Information:

Airframe:

Type	Cessna TU206F	
Serial Number	U206-03018	
Manufacturer	Cessna Aircraft Company	
Year of Manufacture	1975	
Total Airframe Hours (At time of Accident)	8 703.8	
Last MPI (Hours & Date)	8 622.9	5 December 2008
Hours since Last MPI	80.9	
Last 50-hour inspection	8 671.9	25 March 2009
Hours since 50-hour inspection	31.9	
C of A (Issue Date)	7 August 1989	
C of R (Issue Date) (Present owner)	18 May 2007	
Operating Categories	Standard	

Engine:

Type	Teledyne Continental TSIO-520-M
Serial Number	291453-R
Hours since New	2 331.1
Hours since Overhaul	734.6

*NOTE: A 50-hour inspection was certified on the aircraft on 25 March 2009 during, which period the oil filter and associated gasket were replaced. Since the inspection a further 31.9 hours were flown with the aircraft.

Propeller:

Type	McCauley D3A34C402-C
Serial Number	070099
Hours since New	734.6
Hours since Overhaul	T.B.O. not yet reached

Weight & Balance

Load Station	Weight (pounds)	Arm (inches)	Moment (lbs x inches)
Aircraft Empty	2 180.0	35.1	76 518
Pilot (68 kg)	150.0	37	5 550
Passenger (58 kg)	128.0	37	4 736
Camera (162 kg)	357.0	68	24 276
Baggage (2nd row)	44.0	96	4 224
Oxygen bottle	33.0	127	4 191
Usable fuel	618.0	48	29 664
Take-off Weight	**3 510**	**42.5**	**149 159**
Fuel used (-36 US Gal)	- 216.0	48	- 10 368
Weight at accident	**3 294**	**42.1**	**138 791**

The maximum certified take-off weight for the aircraft according to the Pilot's Operating Handbook (POH), Section 4, Operating Limitation is not allowed to exceed 3 600 pounds (lbs).

For the purpose of the weight-and-balance calculation, a fuel consumption rate of 18 US gallons per hour was used. The aircraft had been airborne for approximately two hours when the accident occurred.

The weight and balance of the aircraft at the time of the accident were found to be within the flight envelope limitations as stipulated in the POH.

1.7 Meteorological Information:

1.7.1 Weather information was obtained from the South African Weather Services, METAR (aviation routine weather report) of the area at 1105Z:

Wind direction	270°	Wind speed	7 knots	Visibility	+ 10km
Temperature	20℃	No. clouds	Clear	Cloud base	Clear
Dew point	Unknown				

1.7.2 The investigator arrived on the accident scene approximately two hours after the accident occurred and assessed the wind to be from the west, light and variable, with clear sky conditions prevailing.

1.8 Aids to Navigation:

1.8.1 The aircraft was equipped with the following navigational aids:

(i) Magnetic Compass
(ii) Transponder
(iii) Panel mounted GPS (Garmin 100)
(iv) Automatic Direction Finder (ADF)
(v) 2 x very High Frequency Omni-directional radio range (VOR)

1.9 Communications:

1.9.1 The pilot was in radio communication with Johannesburg Information North on the VHF frequency 127.4 MHz. Following the engine malfunction, the pilot advised ATC of his situation and that he was going to perform a forced landing. A transcript of the communication between the pilot and ATC is attached to this report as Annexure B.

1.10 Aerodrome Information:

1.10.1 The accident did not occur at or near an aerodrome.

1.11 Flight Recorders:

1.11.1 The aeroplane was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR). Neither was it required by regulation to be fitted to this type of aircraft.

1.12 Wreckage and Impact Information:

1.12.1 The pilot executed a forced landing on a ploughed field he had identified from the air and the aircraft was positioned for the forced landing in an easterly direction.

1.12.2 The first ground markings were caused by the tyres as the pilot landed on level ground. Thirteen metres after the touchdown, the nose wheel and two main wheels collided with an embankment on the edge of a mine service road running diagonally across the aeroplane's path. The road surface was elevated approximately 40 cm above the level ground surface where the aircraft touched down initially. The aircraft bounced back into the air, and simultaneously the nose wheel broke off. (The wheel was afterwards located 73 m further on along the wreckage path, and the nose gear strut and left wing impact markings were found 20m past the wheel. The strut dug into the soft soil of the ploughed field and the aircraft nose over, coming to rest in an inverted attitude some 10 m further on, 103 m pass the embankment.

Figure 2. Indicate the touchdown point of the aircraft (tyre markings) as well as the embankment.

Figure 3. Indicate position of the nose wheel and main wreckage.

1.13 Medical and Pathological Information:

1.13.1 The pilot and passenger sustained minor injuries during the impact sequence.

1.14 Fire:

1.14.1 There was no evidence of a pre- or post-impact fire.

1.15 Survival Aspects:

1.15.1 Both occupants were properly restraint at the time of the accident. The pilot made use of his shoulder strap as well as his lap strap (safety harness). The camera operator was secured by means of his lap strap only. The cockpit and cabin area remained intact during the impact sequence. However, the airborne camera, which was secured to the floor structure, broke loose from and cut to the right leg of the camera operator.

1.16 Tests and Research:

1.16.1 The engine a Teledyne Continental TSIO-520-M, Serial No. 291453-R was removed and subjected to a teardown inspection at an approved maintenance facility, following evidence of an uncontained engine failure.

- The engine remained intact, but there was a hole visible in the crank case in line with the No. 4 cylinder. A substantial amount of oil had drained from the hole as the aircraft ended up inverted after the forced landing.

- All accessory components remained attached to the engine and were removed and inspected. The components listed below did not display any abnormalities that could have contributed to or have caused the engine to fail:

  - Turbo charger – Kelly Aerospace, Serial No. JKL-00145
  - Vacuum pump – Rapco, Serial No. B18641
  - Propeller Governor – McCauley, Serial No. 750550
  - Exhaust system remained attached to the engine, and had some impact damage.
  - Both magnetos (Slick, Part No. 6310-type) were still attached to the engine and had showed no impact damage. Both drive gears were still attached and rotated freely when turned by hand.
  - The ignition harness was intact and no visible damage was noted.
  - Sparkplugs (Champion RHB-32E type) were in good condition overall and

showed a light greyish colour – indicative of normal engine operation. The electrodes exhibited normal wear signatures, according to the Champion AV-27 card. The lower sparkplugs on cylinder No. 3, 5 and 6 display evidence of oil fouling.

- The fuel pump was intact with no visible damage to the unit or gasket seal. All pipe connections to the pump were attached.
- The fuel divider / manifold valve (T.C.M.-type) was intact and safety wire locked. All the fuel lines to the valves were secured. The cover was removed and diaphragm was inspected and found to be in a good condition with some evidence of fuel still present in the unit.
- The fuel control unit (Precision RSA-10AD1 type) appeared to be in good condition with all linkages still connected. The throttle valve / butterfly was intact and functional when the linkage was operated.
- The oil pump was intact and undamaged, and still contained some oil. No visible damage to the gears was observed, nor was there any discolouration.
- The oil sump was intact and still contained a small amount of oil. It also contained a substantial number of debris from inside the engine as result of the failure.
- The oil filter (Champion Aerospace type) was intact with no damage visible.
- The oil cooler was undamaged. It still contained a substantial quantity of oil on removal.
- The oil pick-up tube in the sump assembly was found intact and undamaged, with the pick-up screen free from debris.
- All the valve guides were intact and properly secured. No damage was observed.
- All the accessory gears were accounted for and were intact. None of the gear had lost any teeth.
- The camshaft Part No. Z06LA278, Serial No. 655384 was found to be intact, with minor damage visible to one the cam lobes.
- Cylinders No. 1 and 2 display normal combustion signatures. There was no damage to these two cylinders, nor was any corrosion observed. The piston and conrod assemblies from these cylinders were easily removable and displayed evidence of normal engine operation.

The components listed below sustained substantial damage during the failure:

- Cylinders No's. 3, 4 5and 6. It was possible to remove cylinders Nos 3, 4 and 6 from the crankcase assembly. It was, however, impossible to remove the pistons and conrods from these cylinders due to severe damaghe they had sustained during the failure. It was also impossible to remove cylinder No. 5 from the crankcase due to extensive internal damage.

- The conrods from cylinders No's 4 and 5 failed in the area of the upper conrod cap.
- The crankshaft journals No. 4 and 5 display evidence of smearing caused during the failure sequence of the big-end bearings.
- The crankcase had a hole of approximately 100mm in diameter in the upper casing area in line with No. 4 cylinder.

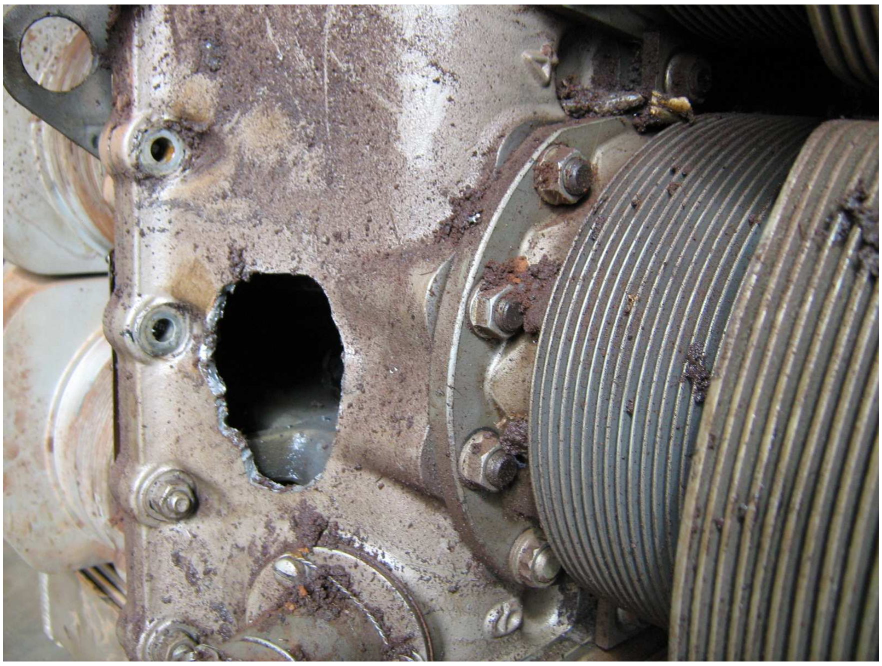

Figure 4: View of the hole in the crankcase in line with the No. 4 cylinder.

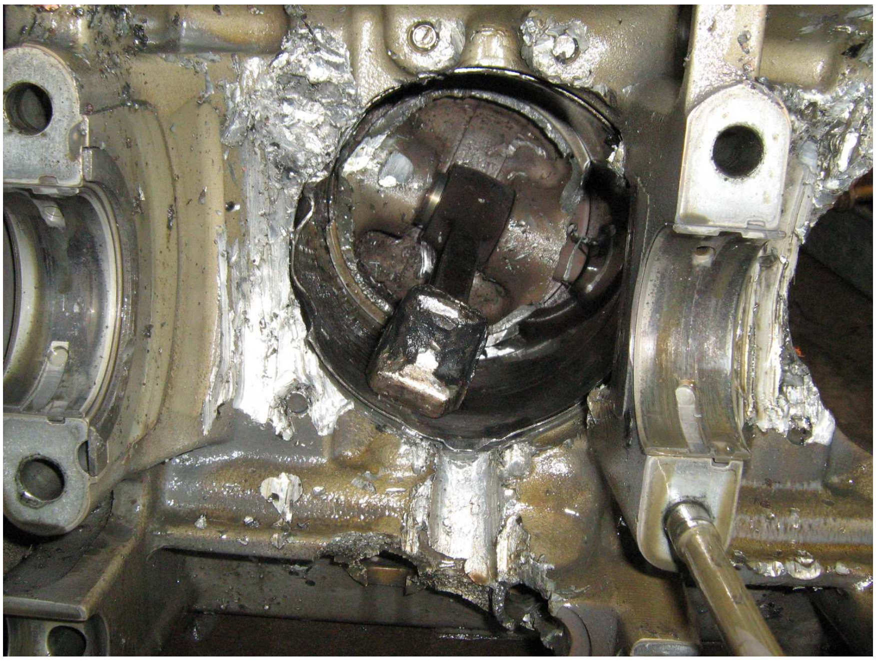

Figure 5: A view of the failed conrod (No. 5), with severe internal engine damage visible.

Following the teardown inspection, a substantial amount of debris as well as several failed components was sent for metallurgical examination and analysis to determine the primary mode of failure. The failure investigation report is attached to this report as Annexure A.

1.17 Organizational and Management Information:

1.17.1 The Operator was in possession of a valid Air Operating Certificate (AOC) at the time of the accident. The AOC was renewed by the SACAA on 5 November 2008 for Part 135 operations, with an expiry date of 9 September 2009.

1.17.2 The last maintenance performed on the aircraft prior to the accident had been certified by Aircraft Maintenance Organisation (AMO). The maintenance facility was in possession of a valid AMO Approval issued by the SACAA with an expiry date of 28 February 2010.

1.18 Additional Information:

1.18.1 Low Engine Oil Pressure Incident:

On 11 October 2008, while flying in the Klerksdorp area, the pilot noted a decay in the engine oil pressure indication and saw oil on the left-hand side of the aircraft.

He diverted to Klerksdorp aerodrome, where he executed an uneventful landing.

Technical personnel were dispatched from Wonderboom aerodrome to assess the probably cause of the oil leak. It was concluded that the dipstick had not been prroperly secured during the flight, resulting in a substantial amount of oil being pumped out of the engine while in operation.

The engine oil filter was removed, cut open and inspected for any evidence of metal particles, of which none was found. The oil filter was replaced and the engine oil replenished with new oil. A ground run was performed and a compression differential test conducted without any anomalies being noted. On 16 October 2008, an oil sample were taken three hours after the oil and filter were replaced. This was subjected to laboratory analysis (an oil analysis program), and the subsequent report indicated normal engine operation. On 31 October 2008, a second oil sample was taken 20 hours after the first sample. Again, the laboratory result indicated normal engine operation.

Subsequent to the incident, the aircraft had been flown 136.7 hours. This information was considered significant in the build-up to the failure of the engine which resulted in the accident. The possibility that a critical components (i.e. bearings) associated with the operation of the engine could have sustained damage during the incident could not be ruled out.

It is of great concern that the pilot made no entry or remark at all about this incident in the aircraft flight folio. This information only came to the attention of the investigating authority during inspection of the engine logbook, where it was found as the first entry, dated 19 October 2008, on page 46.

1.18.2 Detonation (abnormal combustion - engine)

Reference: website; “http://en.wikipedia.org/wiki/Engine_knocking”

When unburned fuel/air mixture beyond the boundary of the flame front is subjected to a combustion of heat and pressure for a certain duration (beyond the delay period of the fuel used), detonation may occur. Detonation is characterized by an instantaneous, explosive ignition of at least one pocket of fuel/air mixture outside of the flame front. A local shockwave is created around each pocket and the cylinder pressure may rise sharply beyond its design limits. If detonation is allowed to persist under extreme conditions or over many engine cycles, engine parts can be *damaged or destroyed. The simplest deleterious effects are typically particle wear caused by moderate knocking, which may further ensue through the engine's oil system and cause wear on other parts before being trapped by the oil filter. Severe knocking can lead to catastrophic failure in the form of physical holes punched through the piston or head (i.e., rupture of the combustion chamber), either of which depressurizes the effected cylinder and introduces large metal fragments, fuel, and combustion products into the oil system.*

Detonation can be prevented by any or all of the following techniques; the use of a fuel with high octane rating, which increases the combustion temperature of the fuel and reduces the proclivity to detonate; enriching the fuel/air ratio, which adds extra fuel to the mixture and increases the cooling effect when the fuel vaporizes in the cylinder; reducing peak cylinder pressure by increasing the engine revolutions, increasing mixture turbulence or swirl by increasing engine revolutions; decreasing the manifold pressure by reducing the throttle opening; or reducing the load on the engine. Because pressure and temperature are strongly linked, knock can also be attenuated by controlling peak combustion chamber temperatures at the engineering level by compression ratio reduction, exhaust gas recirculation, appropriate calibration of the engine's ignition timing schedule, and careful design of the engine's combustion chamber and cooling system.

1.18.3 Engine Lubrication System

Reference: *Pilot's Operating Handbook, Section VII, Systems Description*

The engine oil system is of the full pressure, wet sump type, with a full flow, integrally mounted oil filter and has a 12-quart capacity. Oil operating temperatures are controlled by an automatic thermostat bypass control. The bypass control will limit oil flow through the oil cooler when operating temperatures are below normal and will permit the oil to bypass the cooler it is should become blocked.

The oil system may be checked through access doors in the engine cowling. A calibrated dip stick attached to the filler cap indicates the oil level.

The oil grades listed in the Approved Engine Oils in the Servicing section are general recommendations only, and will vary with individual circumstances. The determining factor for choosing the correct grade of oil is the average ambient temperature.

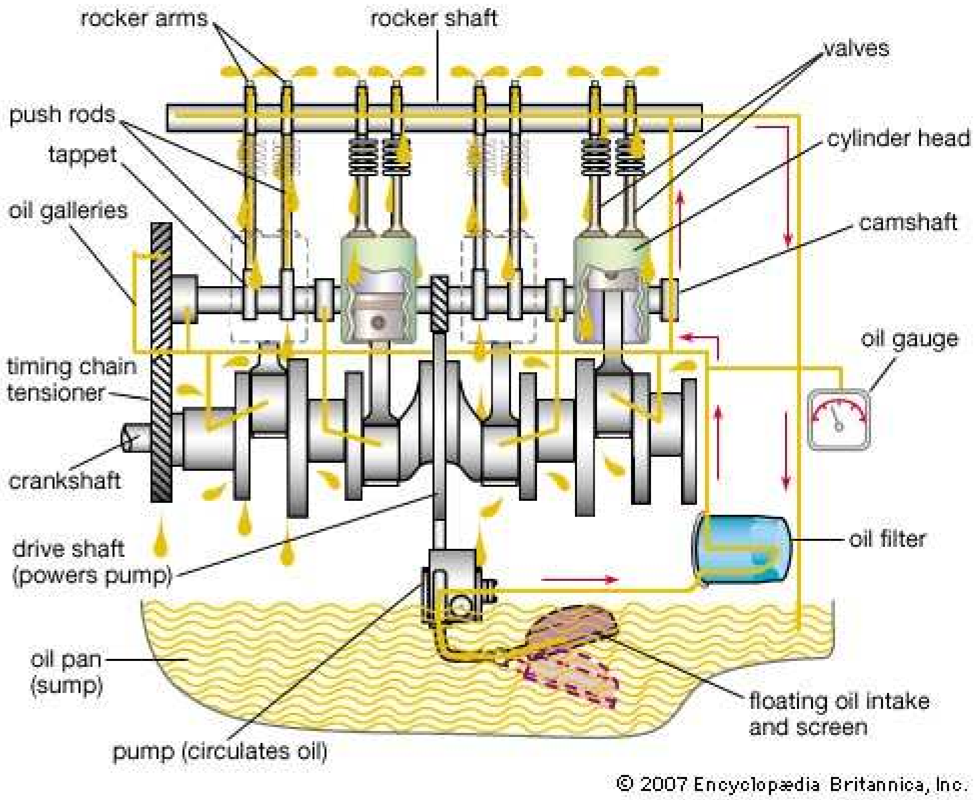

Figure 6, The diagram display a basic engine lubrication system (for illustration purposes only).

1.18.4 Forced Landing without engine power.

Reference: *Pilot's Operating Handbook, Section 3, Emergencies, Pg. 3-2*

If all attempts to restart the engine fail, and a forced landing is imminent, select a suitable field and prepare for the landing as follows:

(i)	*Airspeed*	-	*90 mph (flaps UP)* *80 mph (flaps DOWN)*
(ii)	*Mixture*	-	*Idle Cut-off*
(iii)	*Fuel Selector Valve*	-	*OFF*
(iv)	*Ignition Switch*	-	*OFF*
(v)	*Wing Flaps*	-	*As required (40° recommended)*
(vi)	*Master Switch*	-	*OFF*
(vii)	*Doors*	-	*Unlatched prior to touchdown*
(viii)	*Touchdown*	-	*Slightly tail low*
(ix)	*Brakes*	-	*Apply Heavily*

1.18.5 Aircraft Flight Folio

Part 91.03.5 of the Civil Aviation Regulations of 1997;

(1) The owner or operator of a South African registered aircraft shall ensure that the aircraft carries a flight folio or any other similar document which contains the information as prescribed in Document SA-CATS-OPS 91, at all times.

(2) The flight folio shall be kept up-to-date and maintained in a legible manner.

(3) All entries shall be made immediately upon completion of the occurrence to which they refer.

(4) In the case of maintenance being undertaken on the aircraft, the entry shall be certified by the person taking responsibility for the maintenance performed.

5) The owner or operator shall retain the flight folio for a period of five years calculated from the date of the last entry therein.

1.19 Useful or Effective Investigation Techniques:

1.19.1 None.

2. ANALYSIS

2.1 During the engine teardown inspection, it was noted that several components associated with the operation of the No. 4 and No. 5 connecting rods and associated bearings display displayed decolourisation, a sign of very high temperatures. The connecting rods (No. 4 and No. 5) both failed due to the seizure of the corresponding big-end bearings on the crankshaft, resulting in a catastrophic engine failure, with crankcase penetration.

2.2 Due to the extensive post-failure damages to the No. 4 and No. 5 sleeve bearings, no clear failure mechanism could be determined. Evaluation of all the other bearing surfaces indicates that oil was available and under pressure, which makes oil starvation or the failure of any oil supply components (e.g. oil pump) unlikely.

2.3 Following an assessment of all relative aircraft documentation, it came to the attention of the Investigator that the aircraft was involved in an incident on 11 October 2008 where the pilot observed a decay in engine oil pressure. He was able to perform an uneventful landing, and on investigation it was noted that a substantial amount of engine oil had been pumped overboard due to the improper fitment of the dipstick. Oil samples were collected for analysis three hours after the incident and again after 20 operational hours. Both instances involved oil and filter replacement. The oil analysis programme results from both tests indicated that the engine was operating normally. This incident was considered significant to this investigation as the amount of engine oil that was pumped overboard during the incident could not be determined. The possibility was considered that there might have been a period where oil supply to the bearings and associated components could have been limited or completely interrupted, and bearing damage could not therefore be excluded. The engine failure in question occurred 136.7 operational hours after this incident. Although only two oil samples were tested subsequent to the incident no conclusive evidence could be found indicating that the oil loss incident had contributed to the failure of the engine under investigation. Although information was obtained from the two oil samples and analysed, it would have been of much greater value for an accurate assessment of the engine and the prolonged functioning thereof if a more comprehensive oil analysis programme had been followed at regular intervals.

2.4 According to the aircraft flight folio, no engine-related defects were experienced with the aircraft following the incident on 11 October 2008 until the engine failure in question.

The flight folio indicated that the last time oil was uplifted (1 litre) was on 22 March 2009. Since the entry, the aircraft had flown a further 40.2 hours. According to the pilot of the accident flight, he had checked the engine oil content during his pre-flight inspection and it indicated 10 quarts on the dipstick, which was well within the required limits for normal engine operation. It should be borne in mind that oil could have been added to the engine following the entry on 22 March 2009, however, no documented evidence could be found to prove this.

2.5 Due to the lack of available evidence of oil starvation or of failure of any oil component, including the oil pump, or a lack of lubricant in the engine, the following scenario were considered to have contributed to the seizure of the No's 4 and 5 big-end bearings. However, neither scenario could be proved to have caused it.

(i) The 'nipping' of the big-end bearing(s) and subsequent seizure thereof could have been due to detonation, which is associated with 'hot spots' in the engine. The shock waves created by detonation can cause severe overloading of the piston, rings, spark plugs and connecting rod bearings. Prolonged or heavy detonation over a period of time could be very damaging to the engine.

2.6 At the time of the engine failure, the aircraft was at a height of approximately 2500-3000 feet above ground level. The pilot identified an open area that appeared suitable for a forced landing – a large ploughed field on a coal mine property. Seconds prior to touchdown, the pilot noted a mine service road in front of him. He was unable to stretch the glide sufficiently, however, and the aircraft touched down 13m before the road, which ran diagonally across his glide path. The nose wheel of the aeroplane collided with the embankment of the road, which was elevated about 40cm above the flat surface of the initial touchdown point. Due to the substantial speed of the landing roll, the nose wheel broke off as it struck the embankment. The aircraft bounced back into the air and impacted the ground in a nose-down attitude. The nose strut assembly dug into the soft soil and the aircraft nosed over, coming to rest inverted. It is the opinion of the writer that the area the pilot elected for the forced landing was adequate. If he had been able clear the road, the nose wheel would in all likelihood have remained in place and the damage to the aircraft would have been limited to the engine only. The pilot followed the emergency procedures as stipulated in the POH for a landing without engine power.

3. CONCLUSION

3.1 Findings:

3.1.1 The pilot was the holder of a valid commercial pilot's licence and had the aircraft type endorsed in his logbook.

3.1.2 The pilot was the holder of a valid aviation medical certificate that was issued by a designated CAA-approved medical examiner.

3.1.3 The aircraft was in possession of a valid certificate of airworthiness at the time of the accident.

3.1.4 The aircraft was maintained in accordance with the approved maintenance schedule.

3.1.5 The operator was in possession of a valid Air Operating Certificate (AOC) issued in terms of the CAR and the Air Service licence issued in terms of the Domestic Air Service Licensing Act.

3.1.6 A flight plan was filed prior to the flight and the aircraft was tracked on secondary surveillance radar (SSR).

3.1.7 The pilot was in radio contact with Johannesburg Information North on the frequency 127.4 MHz, which was accordingly informed of the engine malfunction.

3.1.8 During the forced landing the aircraft collided with an embankment, which caused the nose wheel to break off. The aeroplane bounced, and on striking the ground again, nosed over.

3.1.9 The engine suffered from an uncontained engine failure with subsequent internal destruction and damage to the crankcase.

3.1.10 The two occupants on board the aircraft sustained minor cuts and bruises during the impact sequence.

3.1.11 No documented evidence was found in the aircraft flight folio relating to the oil leak incident that occurred on 11 October 2008.

3.2 Probable Cause/s:

3.2.1 Unsuccessful forced landing following an engine failure in-flight.

3.3 Contributory Factor:

3.3.1 Mechanical failure associated with the operation of the engine (big-end bearing seizure on the No. 4 and No. 5 connecting rod hard-ware).

4. SAFETY RECOMMENDATIONS

4.1 It is recommended that Air Operating Certificate (AOC) holders be reminded of the importance of reporting defects and incident properly. Should any defect be encountered that could jeopardise the safety of the flight, it should be accurately documented and reported to the Civil Aviation Authority.

It came to the attention of the investigating authority that certain operators do not allow their pilots or aircrew to make any defect entries in the aircraft's official documents. Instead, they record these in a separate book or file. This prevents such events from being traced, which could be detrimental to an investigation, as these earlier incidents might have a direct bearing on the current accident.

4.2 It is recommended that the Civil Aviation Authority (Airworthiness Department) draft an AIC informing all AMOs that a proper oil analysis programme should be followed after an engine had suffered an in-flight oil leak.

Following such an incident, all oil system filters should be replaced and the engine replenished with new oil. Oil samples should be taken at regular intervals not exceeding 20 operational hours. Such a program should be performed for a minimum period of 100 operational hours.

5. APPENDICES

5.1 Annexure A (Craslab Metallurgical Report)

5.2 Annexure B (Transcript of communication between pilot and ATC)

COMPILED BY	**CrashLAB**	PAGE 1 OF 8	
COMPILED FOR: SACAA	FAILURE INVESTIGATION REPORT: TSIO 520 M TELEDYNE LYCOMING ENGINE	DOCUMENT NUMBER MET-001-07-09	
		DATE 2009-07-03	ISSUE 1

ITEM: CONNECTING RODS AND CRANKSHAFT, TSIO 520 M TELEDYNE LYCOMING ENGINE, SN 291453-R

1. INTRODUCTION

1.1. Various failed components from a Teledyne Lycoming TSIO 520M engine, serial number 291453-R, from a Cessna 206, aircraft number ZS-MKG, were submitted to determine the possible reason/s for failure formation during operation.

1.2. The relevant aircraft was involved in an incident involving oil loss during flight (see attached maintenance log) approximately 136.7 operational hours before final failure of the aircraft engine.

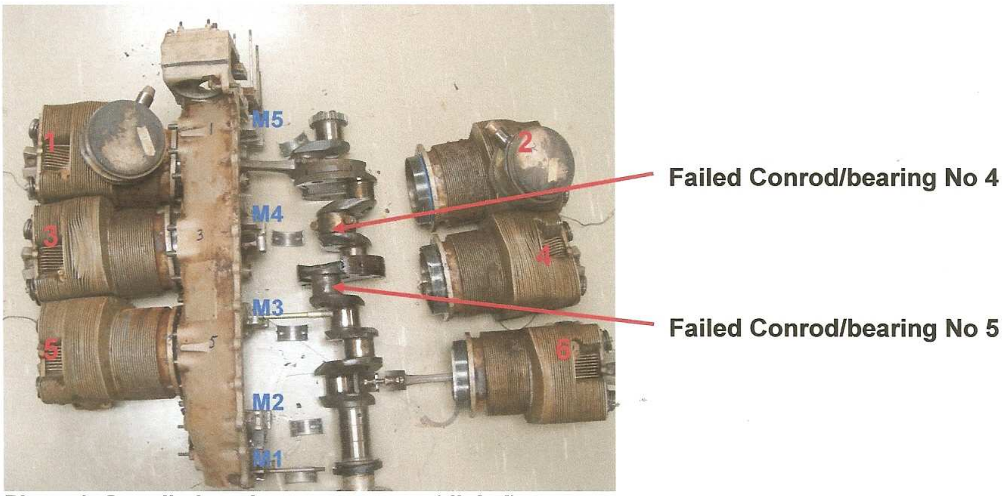

Photo 1: Supplied engine components (digital)

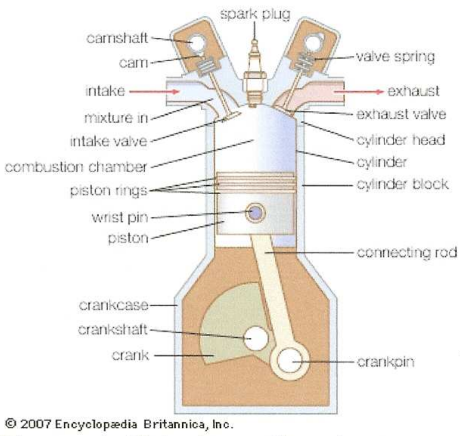

Diagram 1: Piston/conrod/crankcase assembly and terminology

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1.3. This report is divided into the following sections:

2. APPLICABLE DOCUMENTS

(a) None

3. DEFINITIONS

(a) OEM Original Equipment Manufacturer
(b) CAA Civil Aviation Authority
(c) SEM Scanning Electron Microscope
(d) EDS Energy Dispersive X-ray analytical system

4. PERSONNEL

The investigative member and compiler of this report is Mr C.J.C. Snyman, ID number 6406105057080. Mr Snyman is a qualified Physical Metallurgist (H.N.Dip Metallurgical Engineering, Tech. PTA), Radiation Protection Officer (RPO) registered with the National Nuclear Regulator (NNR) and Aircraft Accident Investigator (SCSI).

5. APPARATUS AND METHODOLOGY

(a) The apparatus employed for this investigation are Stereo Microscopes, Digital Camera, Micro-hardness tester and a SEM equipped with EDS.
(b) The methodology included a visual investigation of supplied parts followed by a Stereoscopic and SEM investigation.

6. INVESTIGATION

6.1. **Visual and Stereo- Microscope Investigation.** The visual inspection revealed extensive damages to the number 4 and 5 connecting rods (Photo 1), corresponding bearings and inner walls of the crankcase. The crankshaft serial number is depicted in Photo 2 and is of VAR quality (Photo 3).

The fracture surfaces from both the failed connecting rods (Photo's 4 and 5) were extensively damaged after failure and revealed no clear signs of pre-existing cracks. The damages to connecting rod number 5 relative to number 4 may be an indication that the former failed first in the sequence of events. Taking into account the evidence of temperature exposure to the big end sides of both connecting rods as well as to the remains of the big ends (Photo 6), it

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can be derived that both connecting rods failed due to seizure of the relevant bearings onto the crankshaft during operation and not due to existing material or other deviancies. No clear indications of big end bolt failure or other was detected from the remains of the connecting rod big ends (Photo 6). The undamaged connecting rods (Photo 11) were evaluated but no clear indications of distortion or other defects could be exposed.

Due to extensive damages, the remains of both the number 4 and 5 sleeve bearings (Photo 7) revealed no clear indications toward the failure mechanism/s during operation. The remainder of the big end sleeve bearings revealed signs of extensive metal impregnation (Photo 12) prior to final failure of the engine. This proved to be an indication that lubricant was available and under pressure during operation.

All oil feeding lines to the crankpin bearing surfaces proved to be unblocked and serviceable. The number 5 feeding line exit was slightly smeared close due to temperature exposure but did not contribute to the initial failure of the corresponding bearing.

The crankpin bearing surfaces (Photo's 8 and 9) from positions 4 and 5 revealed extensive temperature induced damages. Again, the variation in surface damages corresponds with the notion that the number 5 bearing failed first in the sequence of events. The remainder of the crankpin surfaces showed slight temperature exposures, most probably due to the extensive metal impregnation of the bearing surfaces during operation.

The main bearings (Photo 1, M1-5) proved to be in relative good condition (Photo's 13 and 14) except for various levels of metal impregnation on the corresponding bearing surfaces (Photo 15). The oil feed lines toward the crankpin surfaces showed no signs of blockage. Again, the metal impregnation and relative low temperature exposures to the main bearings positions are an indication of available lubricant under pressure.

The pistons showed no clear signs of pre-detonation or other damages (Photo 1).

Photo 2: Crankshaft serial number (digital)

Photo 3: Crankshaft Vacuum Arc Re-melt stamp (digital)

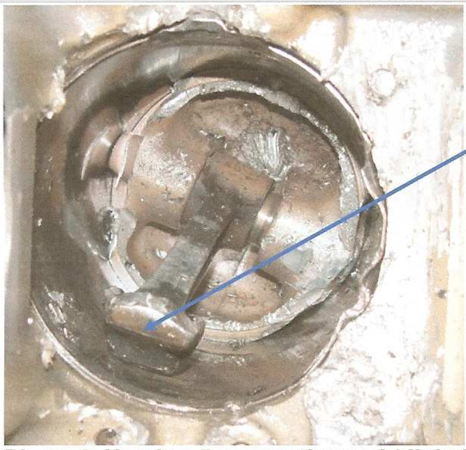

Photo 4: Number 5 connecting rod (digital)

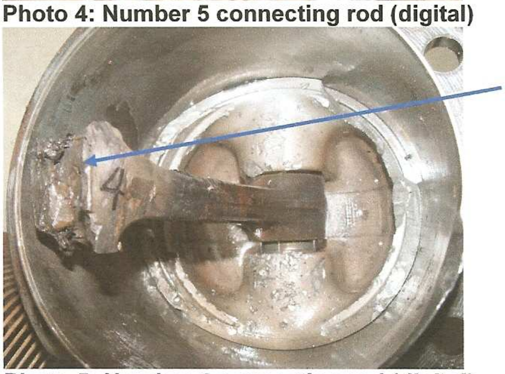

Photo 5: Number 4 connecting rod (digital)

Photo 6: Remains of number 4 and 5 big ends showing extensive temperature exposure (digital)

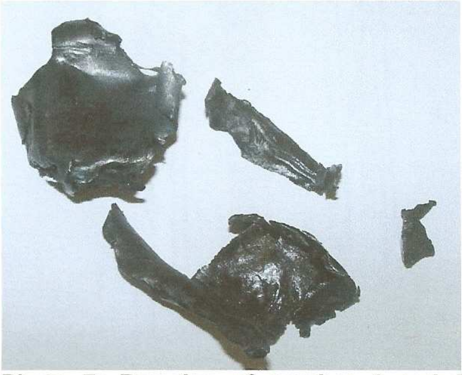

Photo 7: Remains of number 4 and 5 sleeve bearings showing extensive temperature exposure (digital)

Photo 8: Number 4 crankpin surface showing extensive wear and temperature exposure (digital)

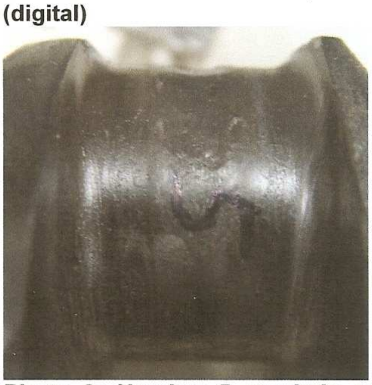

Photo 9: Number 5 crankpin surface showing extensive wear and temperature exposure (digital)

Photo 10: Remainder of crankpin surfaces (digital)

Photo 11: Condition of remaining connecting rods (digital)

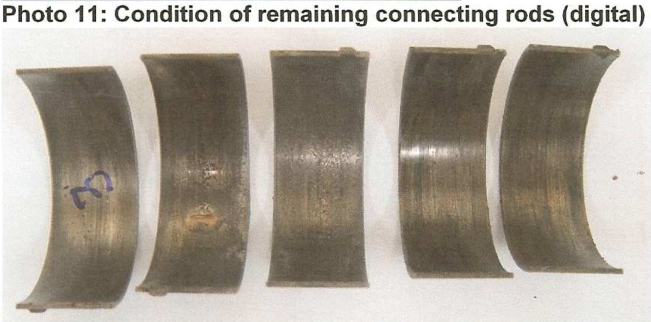

Photo 12: Remainder of big end bearings showing metal impregnation (digital)

Photo 13: Condition of main bearing surfaces (digital)

Photo 14: Condition of main bearing surfaces (digital)

Photo 15: Main sleeve bearing surfaces showing metal impregnation (digital)

7. DISCUSSION AND CONCLUSIONS

No other part/s from the relevant assemblies was available for this investigation. Therefore all conclusions were derived from the investigation results obtained from the supplied parts only.

7.1. Taking into account the clear signs of high temperature exposures to all the parts of the failed number 4 and 5 connecting rods, it can be derived that both failed due to the seizure of the corresponding bearings unto the crankshaft and not due to other discrepancies.

7.2. Due to extensive post-failure damages to the number 4 and 5 sleeve bearings, no clear failure mechanism/s could be determined. Indications from all other bearing surfaces are that lubricant was available and under pressure rendering oil starvation and/or oil pump failure unlikely.

7.3. Oil samples were collected 3 hours after the incident involving loss of lubricant and again after 20 operational hours. Both instances involved oil and filter replacement. No wear debris analysis was completed. The Oil Analysis Program (OAP) results from Wear Check (attached) indicated that the engine was 'operating normally'. After consultation with other OAP specialists it was concluded that the test results would have shown any clear abnormalities after 20 hours, particularly when the extent of the engine damages are taken into account. **Therefore it can be derived that the oil loss incident are not the primary contributing factor toward the final failure of the engine.** Also, the engine operated for 603 hours since major overhaul; therefore it is highly unlikely that any defects from this operation contributed to the final failure of the engine.

7.4. Lacking clear evidence of oil starvation and/or oil pump failure, the investigation results points toward one of the following to be probable causes toward the failure of the engine during operation:

7.4.1. Instance/s of over-boosting of the turbocharged engine may have resulted in changes in the ovality of the number 4 and 5 connecting rod big ends. The resulting effect will be the 'nipping' of the sleeve bearing/s and subsequent failure/seizure during operation.

7.4.2. Pre/Post-detonation due to 'hot spots' or other resulting in the over-straining of the connecting rods with comparable effects as stated in par 7.4.1.

8. RECOMMENDATIONS

8.1. It is advisable to expose engines after an incident as described to an extended period for oil analysis sampling with no more than 20 hour intervals. This should be applicable to at least 100 operational hours following such an incident.

9. DECLARATION

9.1. All digital images has been acquired by the author and displayed in an un-tampered manner.

ANNEXURE B

Transcript between the Air Traffic Controller (ATC) (Johannesburg Information North) and the pilot of ZS-MKG on the VHF frequency 127.4 MHz as well as cell phone conversation with pilot following the forced landing.

Time	From	To	Message
10:49:52	ZS-MKG	ATC	Mike Kilo Golf survey completed and request descent and routing for ……back to Wonderboom.
10:50:00	ATC	ZS-MKG	Mike Kilo Golf report …confirm you are routing VFR back to Wonderboom?
10:50:03	ZS-MKG	ATC	Affirm.
10:50:04	ATC	ZS-MKG	Mike Kilo Golf arrange your flight to cross the Johannesburg TMA 7500 feet or below the QNH 1024, broadcast 125.4 special rules, Good day.
10:50:11	ZS-MKG	ATC	Copy we can broadcast 125.4 I will cross below the TMA at 7500 feet, Mike Kilo Golf.
10:50:21	ATC	ZS-MKG	Mike Kilo Golf.
10:52:54	ZS-MKG	ATC	Mike Kilo Golf we just lost an engine and we just overhead a field her and I am going to try and land near the field.
10:53:01	ATC	ZS-MKG	Last caller that is going to land in a field just say again your call sign please?
10:53:08	ZS-MKG	ATC	Mike Kilo Golf we have an engine failure I think I am still trying to work her I think we lost some cylinders on our engine.
10:53:18	ATC	ZS-MKG	Mike Kilo Golf thank you sir, confirm you are able to land?
10:53:21	ZS-MKG	ATC	Yes my position currently, are you happy?
10:53:22	ATC	ZS-MKG	Mike Kilo Golf I do have your position would you like to have emergency services dispatched to that position?
10:53:28	ZS-MKG		Not yet, I have some power, I am gone try to make it to Kriel airfield, I think it is about on my nose now on a heading 150.
10:53:41	ATC	ZS-MKG	Mike Kilo Golf, affirm sir, that would be Kriel, Kriel from present position 14 nautical miles on a heading 150.
10:53:52	ZS-MKG	ATC	We are going to try and make the field this time, we are sort of maintaining, we will try and make it, I think our turbo might have went, Mike Kilo Golf.
10:54:03	ATC	ZS-MKG	Mike Kilo Golf confirm you do have forward power?
10:54:07	ZS-MKG	ATC	I do have and is maintaining forward power.
10:54:11	ATC	ZS-MKG	Mike Kilo Golf thank you very much sir, confirm you do have a cell phone onboard?
10:54:15	ZS-MKG	ATC	Affirm affirm, but I just like to concentrate on the flying

			I will call you on reaching the field or what ever.
10:54:24	ATC	ZS-MKG	Mike Kilo Golf we will dispatch emergency services to Kriel.
10:54:41	ZS-MKG	ATC	We are not going to make the field, I am shutting it down.
10:54:51	ATC	ZS-MKG	Mike Kilo Golf thank you, is there a road that you can possibly land in?
10:55:00	ZS-MKG	ATC	Affirm I have a road, maybe, a road that I can land on, Mike Kilo Golf.
10:59:00	Pilot ZS-MKG	ATC	(Pilot of ZS-MKG via cell phone) Hallo Sir, yes, we crash landed in an open field, we did not make it to the field I believe we are north of the field about 5 nautical miles, in a field.
	ATC	Pilot	Sir, can I get your cell phone number, please sir, in case we loose contact.
	Pilot	ATC	Pilot provide ATC with cell phone number.
	ATC	Pilot	Confirm, are you injured sir?
	Pilot	ATC	Yes me and my crew, we are fine.
	ATC	Pilot	How many onboard?
	Pilot	ATC	Just two onboard.
	ATC	Pilot	We will be sending emergency services over to you immediately sir.
	Pilot	ATC	We are near a mine I have no idea where this mine is.
	ATC	Pilot	Do you still have radio contact on your aircraft?
	Pilot	ATC	No sir my aircraft is upside down, I flipped it.
	ATC	Pilot	We are going to dispatch emergency services to your position.
	Pilot	ATC	Thank you.

There was no further communication between ATC and the pilot of ZS-MKG.

Report reviewed and amended by Advisory Safety Panel: 29 September 2009.

-END-