AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/9234		
Aircraft registration	**ZU-EUI**	**Date of accident**	17 October 2013		**Time of accident**	1030Z	
Type of aircraft	Sycamore MK1 (Gyrocopter)		**Type of operation**		Private		
Pilot-in-command licence type		National pilot	**Age**	39	**Licence valid**	Yes	
Pilot-in-command flying experience		Total flying hours	140.0		Hours on type	140.0	
Last point of departure	Mokopane Aerodrome, Limpopo province						
Next point of intended landing	Mokopane Aerodrome, Limpopo province						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
Private farm 14 nm northwest of Mokopane (GPS position: 24°05.863ôSouth 028°46.587ôEast)							
Meteorological information	Surface wind: 360°/8kt, Temperature: 30°C, Visibility: + 10 km						
Number of people on board	1 + 1	**No. of people injured**	0	**No. of people killed**	0		

Synopsis

The pilot, accompanied by a passenger took-off from Mokopane aerodrome on a private flight over the area with the intention to land back at the aerodrome. After take-off the pilot turned out left and was still ascending at approximately 300 feet per minute when they heard a sudden loud noise from behind the cabin area, following the noise the gyrocopter immediately pitched nose down approximately 30°. The pilot stated that he had difficulty controlling the gyrocopter from then onwards.

He had identified a narrow dirt road from the air which was basically straight ahead and allowed the gyrocopter to descend. With the limited amount of control available, he steered it in the direction of the road. He stated that when he initiated the flare prior to touchdown he had to use both arms to pull back on the control stick, which had very little effect in changing the attitude of the gyrocopter, and they touched down hard in a nose-down attitude on the roadway, which was located in mountainous terrain. This resulted in substantial damage to the gyrocopter, which remained in an upright position. Nobody was injured in the accident.

Probable cause

An unsuccessful forced landing following the deformation of the main rotor attachment brackets as well as the bending of the mast assembly during flight, which resulted in limited flight control authority.

ASP date		Release date	

AIRCRAFT ACCIDENT REPORT

Name of Owner	**:** Groensirkel Besproeing CC
Name of Operator	**:** Private
Manufacturer	**:** Chayair
Model	**:** Sycamore MK1
Nationality	**:** South African
Registration Marks	**:** ZU-EUI
Place	**:** Private farm 14 nm northwest of Mokopane
Date	**:** 17 October 2013
Time	**:** 1030Z

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 produced 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 passenger, took-off from Mokopane aerodrome on a private flight over the area with the intention to land back at the aerodrome. After take-off the pilot turned out left and was still ascending at approximately 300 feet per minute when they heard a sudden loud noise from behind the cabin area, following the noise, the gyrocopter immediately pitched nose down by approximately 30°. The pilot stated that he had difficulty controlling the gyrocopter from then on.

1.1.2 He had identified a narrow dirt road from the air which was basically straight ahead, and he allowed the gyrocopter to descend. With the limited amount of control available, he steered it in the direction of the road. He stated that when he initiated the flare prior to touchdown he had to use both arms to pull back on the control stick, which had very little effect in changing the attitude of the gyrocopter, and they touched down hard on the road, which was located in mountainous terrain. This resulted in substantial damage to the gyrocopter, which remained in an upright position. Nobody was injured in the accident.

1.1.3 The accident occurred during daylight conditions at a geographical position that was determined to be 24°05.863ôSouth 028°46.587ôEast at an elevation of 4 436 feet above mean sea level (AMSL). The accident site was 14 nautical miles (nm) from Mokopane aerodrome (their point of departure).

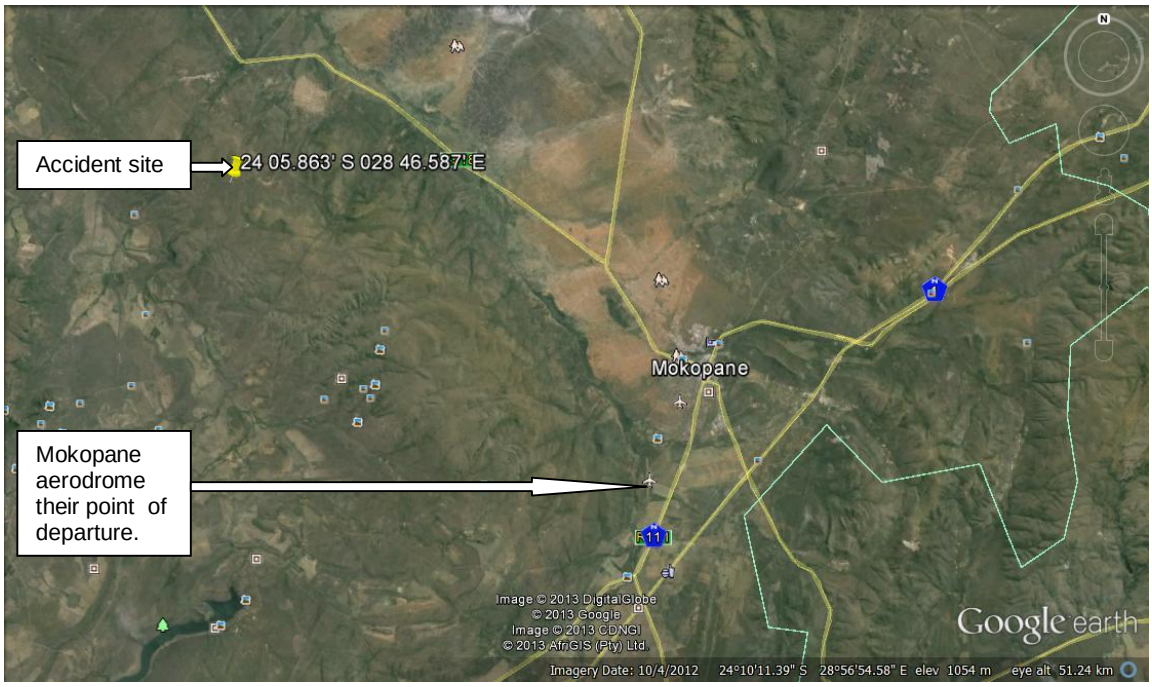


Figure 1. Google Earth map indicating the take-off aerodrome and accident site 14 nm away

1.2 Injuries to persons

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

1.3 Damage to aircraft

1.3.1 The gyrocopter sustained substantial damage when landing hard on a dirt road in mountainous terrain.

1.4 Other damage

1.4.1 No other damage was caused.

1.5 Personnel information

Nationality	South African	Gender	Male	Age	39
Licence number	0279006662	Licence type	National pilot		
Licence valid	Yes	Type endorsed	Yes		
Ratings	None				
Medical expiry date	31 May 2014				
Restrictions	None				
Previous accidents	None				

Flying experience:

Total hours	140.0
Total past 90-days	11.5
Total on type past 90-days	11.5
Total on type	140.0

1.6 Aircraft information

Airframe:

Type	Sycamore MK1
Serial number	0053
Manufacturer	Chayair
Year of manufacture	2008
Total airframe hours (at time of accident)	240.2

Last annual inspection (hours & date)	228.2	25 March 2013
Hours since last annual inspection	12.0	
Authority to Fly (issue date)	18 April 2013	
Authority to Fly (expiry date)	24 March 2014	
C of R (issue date) (present owner)	23 January 2008	
Operating categories	Private	

Engine:

Type	Rotax 914
Serial number	4417678
Hours since new	240.2
Hours since overhaul	T.B.O. not yet reached

Propeller:

Type	Arplast Helice
Serial number	84400
Hours since new	240.2
Hours since overhaul	T.B.O. not yet reached

This gyrocopter was fitted with 33 foot diameter main rotor blades. The manufacturer had two options 30 foot and the 33 foot diameter blades.

1.6.1 Weight and balance

Item	Weight (kg)
Aircraft empty weight	356.4
Pilot	95
Passenger	95
Zero fuel weight	**546.4**
Fuel weight (52 litres)	37.0
Take-off weight	**581.4**
Fuel used 6 litres	- 4.3
Weight on impact	**577.1**

The maximum certified take-off weight for this gyro-copter was 590 kg. The gyro-copter was last weighed on 12 April 2013.

1.7 Meteorological information

1.7.1 The weather information entered in the table below was obtained from the pilotôs questionnaire.

Wind direction	360°	Wind speed	8 kt	Visibility	+ 10 km
Temperature	30°C	Cloud cover	Nil	Cloud base	Nil
Dew point	Unknown				

1.8 Aids to navigation

1.8.1 The gyrocopter was equipped with standard navigation equipment.

1.9 Communication

1.9.1 The pilot was flying outside controlled airspace below the terminal control area (TMA) and was broadcasting his intensions of the VHF frequency 124.8 MHz.

1.10 Aerodrome information

1.10.1 The accident did not occur at or close to an aerodrome.

1.11 Flight recorders

1.11.1 The gyrocopter was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor were these required by regulation to be fitted.

1.12 Wreckage and impact information

1.12.1 The pilot had limited control of the gyro-copter following the in-flight upset as the nose pitched down by approximately 30°. The pilot managed to execute a hard landing on a narrow dirt road in mountainous terrain, which resulted in damage to the nose and right main wheel assemblies. Due to inadequate vegetation clearance

the main rotor blades collided with some trees on the right-hand side of the gyrocopter as it came to rest in an upright position.

1.12.2 It was observed that the main mast had bent backwards and slightly to the right. This caused the engine cradle as well as the propeller to also move backwards and down a few degrees as the engine cradle was attached to the main mast, and as a result the propeller blades struck the oil cooler on the left side as can be seen in Figure 3 on the next page. All three the propeller blade tips were substantially damaged as a result of the impact.

Figure 2. The gyrocopter as it came to rest

Figure 3. Propeller impact markings on the engine oil cooler

1.13 Medical and pathological information

1.13.1 Not applicable.

1.14 Fire

1.14.1 There was no pre- or post-impact fire.

1.15 Survival aspects

1.15.1 The accident was survivable. Both occupants were properly restrained by making use of the gyrocopterôs safety harness. The cockpit/cabin area remained intact during the forced landing. Although the flight characteristics of the gyrocopter had changed substantially after the main rotor mast had bent, the pilot was still able to control it to a certain extent and execute a forced landing.

1.16 Tests and research

1.16.1 A post-impact inspection of the gyro-copter revealed that the main mast had bent backwards several degrees during flight. After the main rotor mast fairing had been removed, it was noted that the main rotor head attachment brackets, which were positioned on both sides of the mast, displayed signs of deformation. The main mast as well as the two attachment brackets were removed and were submitted for metallurgical examination.

Figure 4. Main mast and rotor head assembly prior to removal of the mast fairing

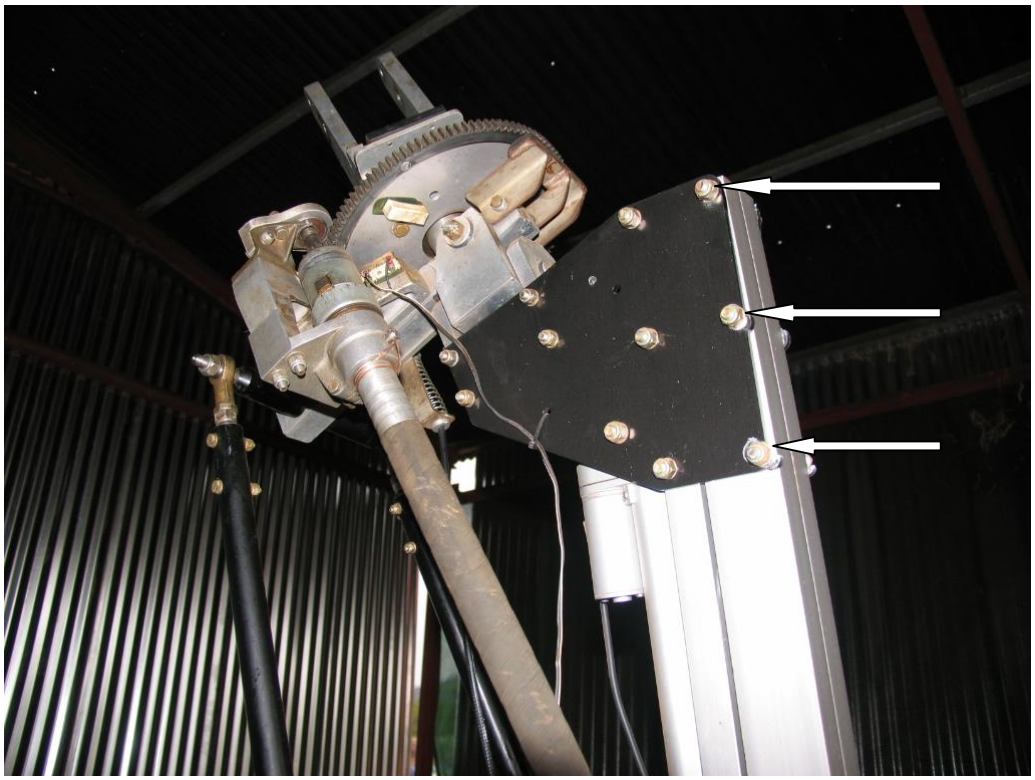


Figure 5. The main mast attachment bracket displaying evidence of deformation as indicated by the arrows

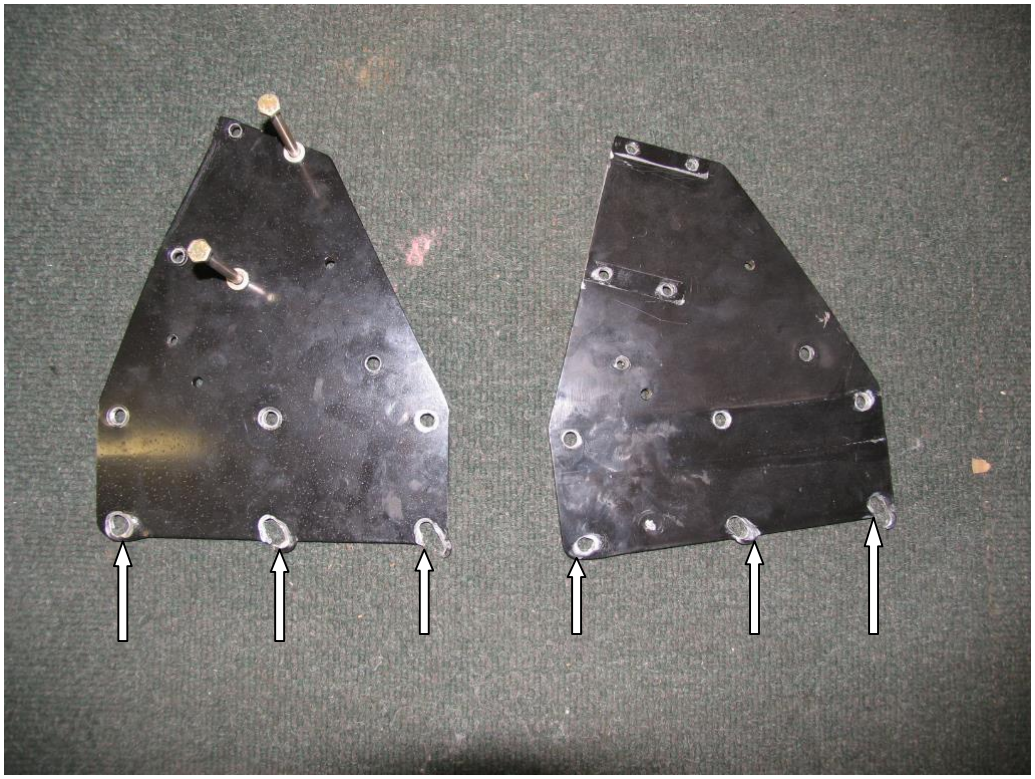


Figure 6. Deformation of the two attachment brackets after removal from the mast

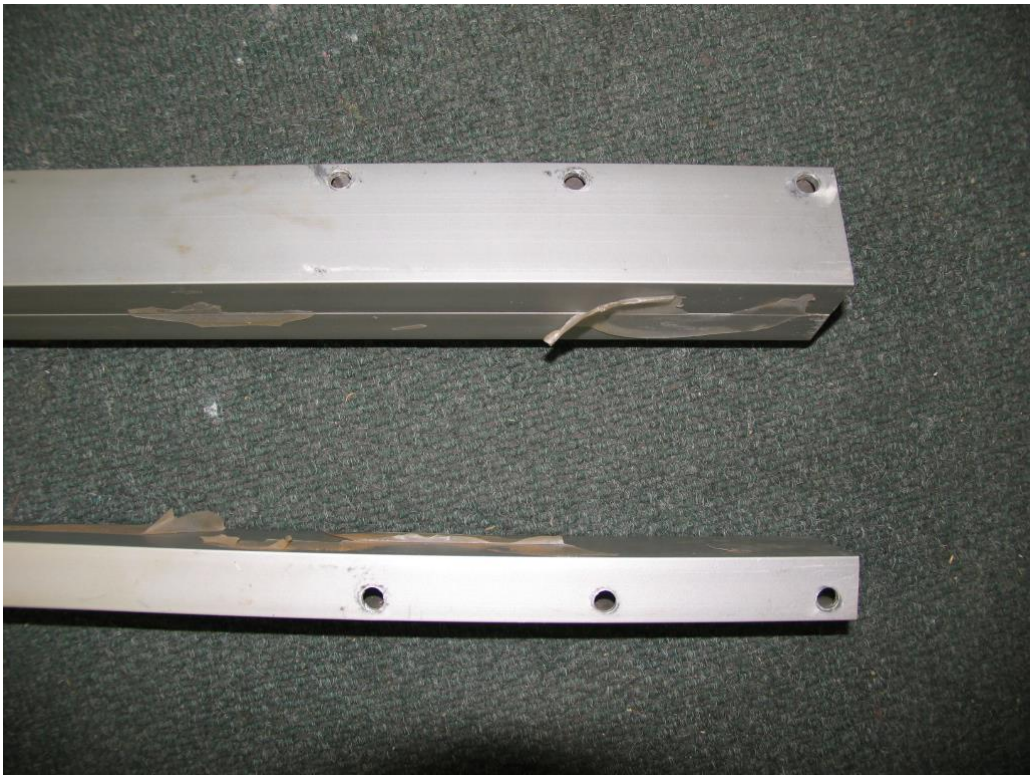


Figure 7. The mast attachment bracket holes which present evidence of elongation

Figure 8. An indication of the bending the main mast suffered

It was found that the brackets were made of an inferior quality material, which had deformed over an undetermined period of time. Further to that, the main mast attachment brackets had no traceable history as they had no part numbers or serial

numbers. The main mast material was found to meet the specification for the application. The main mast and attachment brackets were removed from the gyrocopter and were made available to a metallurgist for examination and analysis. A detailed report was compiled and is attached to this report as Annexure A.

1.17 Organizational and management information

1.17.1 This was a private flight, with the gyrocopter owner also being the pilot.

1.17.2 The last annual inspection prior to the accident flight was carried out on 25 March 2013. The inspection was certified by an Approved Person (AP) No. 139, who was duly accredited by the Aero Club of South Africa.

1.18 Additional information

1.18.1 None.

1.19 Useful or effective investigation techniques

1.19.1 No new methods were applied.

2. ANALYSIS

2.1 Man (Pilot)

The pilot was the holder of a valid National pilot licence. Once he heard the loud noise from behind the cabin, he immediately encountered difficulty in controlling the gyrocopter as it pitched nose down by approximately 30°. He opted for a forced landing on a narrow dirt road he had identified from the air, which was basically straight ahead. He stated he had to use both arms to pull back on the control stick, but managed to lower the gyrocopter and execute a forced landing. Apart from experiencing control difficulty, the pilot had no idea what went wrong, but with the control authority available to him he was able to fly the gyrocopter all the way to the ground and land it in a nose-down attitude, which resulted in substantial damage to

the gyrocopter.

2.2 Machine (Aircraft)

The gyrocopter in question was serial number 53, and according to available information 54 of these gyrocopters were built. The gyrocopter in question was delivered to the owner in 2008, and manufacturing of these gyrocopters ceased after the last machine was delivered. The gyrocopter had accumulated a total of 240.2 hours when the accident occurred.

This gyrocopter was fitted with the 33 feet diameter aluminium main rotor blades. The customer could opt for either the 30 feet or the 33 feet diameter main rotor blades.

According to available records the gyrocopter was not involved in any previous incidents/accidents, and the annual inspections were performed as called for, with the last maintenance (Annual) inspection prior to the accident flight being certified on 25 March 2013.

Both the main mast to rotor head attachment brackets displayed evidence of deformation after the mast fairing was removed. The fact that these attachment brackets were concealed behind the main mast fairing prevented the pilot from inspecting these attachment brackets prior to or after flight. The presence of a mast fairing was found not to be common practice on gyrocopters, and it was most probably fitted to this gyrocopter for cosmetic reasons. The installation of the mast fairing became a hazard as it obstructed critical components, which included flight control rods, a section of the main mast as well as the main mast attachment brackets. It was not possible for the pilot to conduct a detailed pre-flight/visual inspection on these critical components, which jeopardised the safe operation of the gyrocopter.

The absence of such a fairing would have allowed the pilot and maintenance personnel immediate access to inspect the brackets in question; however, this does not mean that the pilot would have observed any possible deformation prior to the accident flight, as the event most probably occurred when they heard the noise from behind the cabin and the gyrocopter pitched nose down. Although the mast bent several degrees backwards, neither of the control rods to the rotor system failed, which allowed the pilot to keep control of the gyrocopter, even though it was limited due to excessive bending of that occurred within the control rods.

The fact that neither of the attachment brackets possessed a part number or a serial number hampered the traceability of such components, this was aggravated by the fact that the manufacturer had ceased to exist several years prior to this accident.

The metallurgical report determined that the attachment brackets were made of an inferior quality material when compared with a single ôreferenceô unit. The ôreferenceô bracket, which was supplied by an aviation consulting company that specialises in component design and has conducted extensive work in the field of gyrocopters, including the main rotor attachment brackets used on the gyrocopter in question.

3. CONCLUSION

3.1 Findings

3.1.1 The pilot was the holder of a valid National pilot license and had the gyrocopter endorsed on his licence.

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

3.1.3 The gyrocopter was in possession of a valid Authority to Fly at the time of the accident flight.

3.1.4 The last annual inspection prior to the accident flight was certified on 25 March 2013. Following the inspection a further 12.0 hours were flown with the gyrocopter.

3.1.5 The main mast assembly, including the two attachment brackets was concealed behind the mast fairing, therefore the pilot was unable to visually inspect these brackets prior to or after flight.

3.1.6 According to available information the gyrocopter was not involved in any previous incidents/accidents that could have contributed to the accident in question.

3.1.7 The material used for the manufacture of the attachment brackets was found to be of an inferior quality for the application.

3.1.8 The main mast attachment brackets had no traceable history, as they contained no part or serial numbers.

3.2 Probable cause/s:

3.2.1 An unsuccessful forced landing following the deformation of the main rotor attachment brackets as well as the bending of the mast assembly during flight, which resulted in limited flight control authority.

3.3 Contributory factor:

3.3.1 The deformation of the main rotor head attachment brackets, which occurred most probably over an undetermined period of time, was attributed to an inferior quality of material used for the application.

3.3.2 Both main mast to rotor head attachment brackets displayed evidence of deformation. As these attachment brackets were concealed behind the main mast fairing, the pilot could not visually inspectd these attachment brackets prior to or after flight.

4. SAFETY RECOMMENDATIONS

4.1 An urgent safety recommendation was forwarded to the Director of Civil Aviation on 21 November 2013, which called for an Emergency Safety Directive to be issued on all Sycamore gyrocopters on the SA Register, as failure of the main mast attachment brackets posed a serious safety concern and immediate remedial action was required in order to prevent a recurrence of this nature. According to available records, fifty-four (54) of these gyrocopters were manufactured by a South African manufacturer.

4.2 It is recommended to the Director of Civil Aviation that the CAA ensure that all critical components on non-type certified aircraft (NTCA) are issued with a part number as well a serial number in order to ensure that the traceability of such a part/component is not compromised.

5. APPENDICES

5.1 Annexure A (Metallurgical Examination Report)

ANNEXURE A

ITEM: **MAIN ROTOR MAST ATTACHMENT BRACKETS, SYCAMORE GYROCOPTER, ZU-EUI**

1. INTRODUCTION

1.1. The main rotor head mast with attachment brackets and bolts (Photo 2) from a crashed Sycamore Gyrocopter aircraft, registration number ZU-EUI (Photo 1), were submitted to determine the most probable reason/s for failure during operation.

Photo 1: ZU-EUI crash site (courtesy SACAA)

1.2. 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

4. PERSONNEL

(a) 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-, Electron Microscopes, spectrometer, micro-hardness tester and Digital Camera.
(b) The methodology included a visual investigation of supplied parts followed by a Microscope investigation.

6. INVESTIGATION

6.1. **Visual Investigation.** The visual inspection revealed impact induced bending damages to the main rotor mast (Photo 4) and severe elongation of the attachment bracket bolt holes (Photo's 5, 7, 8 and 9, red arrows).

The supplied bolts (Photo 6) revealed no clear indications that may be considered as possible causational factors towards the in-flight failure of the attachment brackets.

Considering the orientation of the relevant assembly (Photo 2), the applied operational loads onto the attachment brackets (Photo 2, red arrow) can be projected as shown (Photo's 2 and 3, red dashed arrows). The resultant loads on the three forward positioned bolts can therefore be anticipated as per Photo 3, yellow arrows, explaining the variation in the direction, and degree, of the elongation damages (Photo's 3 and 9).

The amount of plastic deformation before final failure was notable (Photo 9) pointing towards the low anticipated strength of the brackets fitted on the accident aircraft.

The similarity in damages (Photo's 7, 8 and 9) suggests that both brackets have been exposed to similar (in flight operational) loads.

The direction of elongation damages point towards operational- and not impact load/s (Photo 3, yellow arrows). Furthermore, the extensive damages to the bolt holes and surrounding areas indicate that the brackets failed over a period of operational time.

At higher magnification the fractographs from the failed bottom holes (Photo's 10 and 11) reveal a clear ductile geometry with a definite directional orientation.

The visual inspection revealed extensive surface porosity (Photo 9, yellow arrow) on the brackets from ZU-EUI when compared to the supplied reference unit. At higher magnifications, the extent of porosity became even more apparent (Photo's 12 and 13, yellow arrows). The exact cause of the noted porosity could not be determined but may be attributable to the quality of the base material as well as the manufacturing process followed.

EDS results from the base materials of both ZU-EUI and the reference unit indicated a 1XXX Series Aluminium alloy (EDS Results). The micro-hardness test results revealed the brackets from ZU-EUI to be less than 35% of the hardness number of the reference bracket material. This an indication that the reference bracket's base material was exposed to some level of strengthening cold working process allowing it to correspond with a 'H18' condition while the brackets from ZU-EUI corresponds more closely with the as fabricated 'F' condition.

Photo 2: Similar aircraft type showing orientation of main rotor assembly (courtesy SACAA)

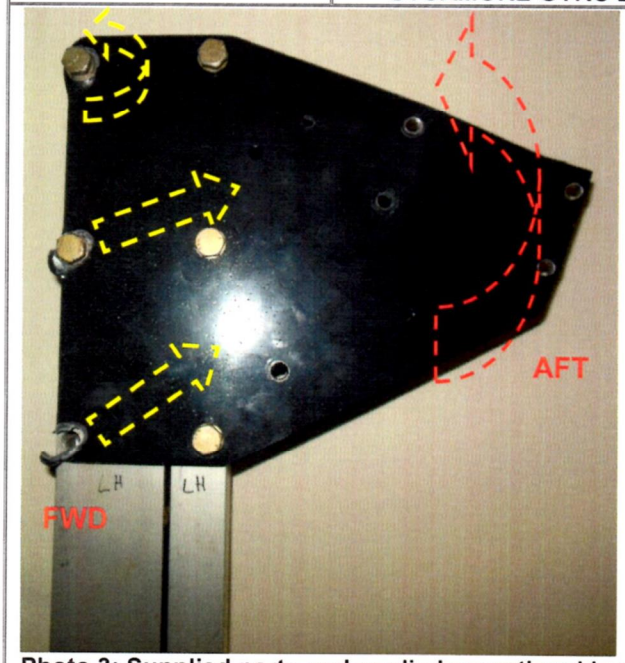


Photo 3: Supplied parts and applied operational loads (digital)

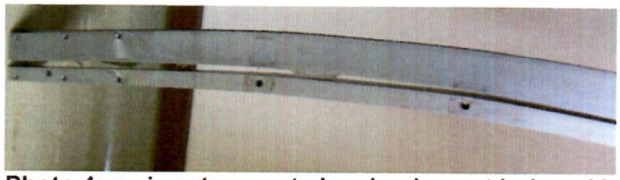


Photo 4: main rotor mast showing impact induced bending damages (digital)

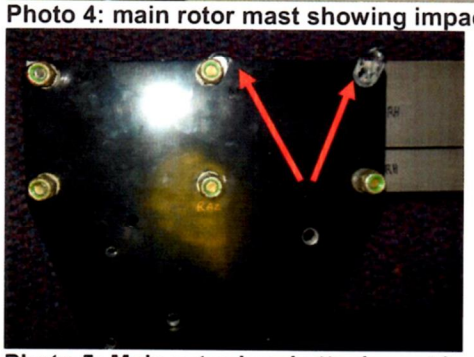


Photo 5: Main rotor head attachment bracket assembled (digital)

Photo 6: Supplied bolts (digital)

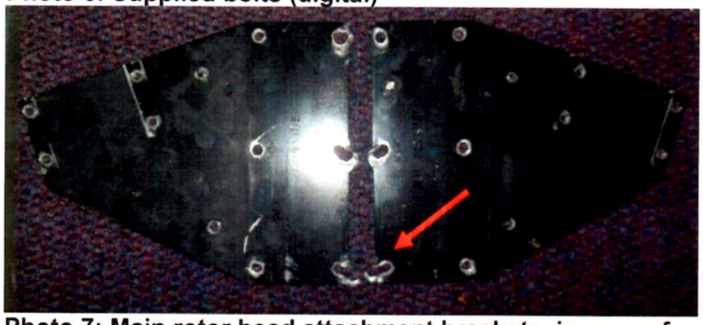


Photo 7: Main rotor head attachment brackets, inner surfaces (digital)

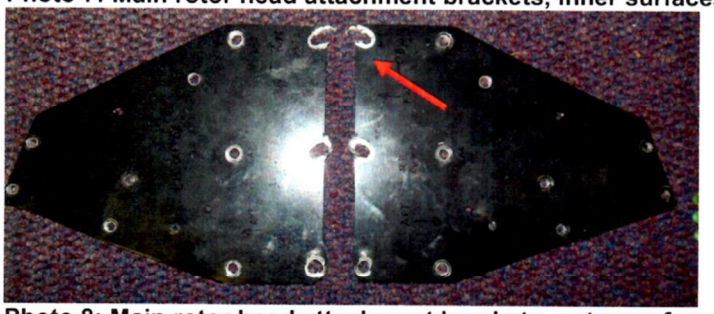


Photo 8: Main rotor head attachment brackets, outer surfaces (digital)

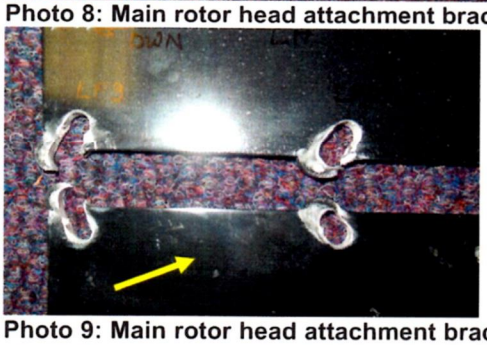


Photo 9: Main rotor head attachment brackets showing comparable damages surfaces and surface porosity (digital)

Photo 10: Fractograph, LF3 bolt hole (x55, SEM)

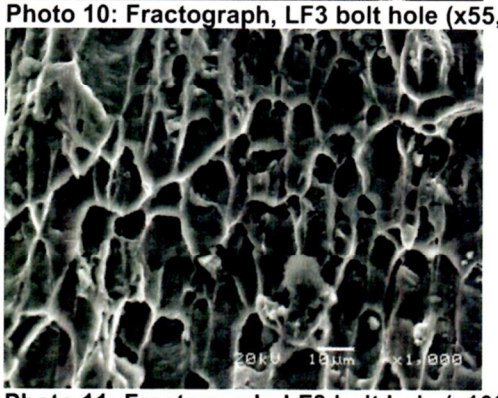


Photo 11: Fractograph, LF3 bolt hole (x1000, SEM)

Photo 12: Reference bracket surface, etched (x500, SEM)

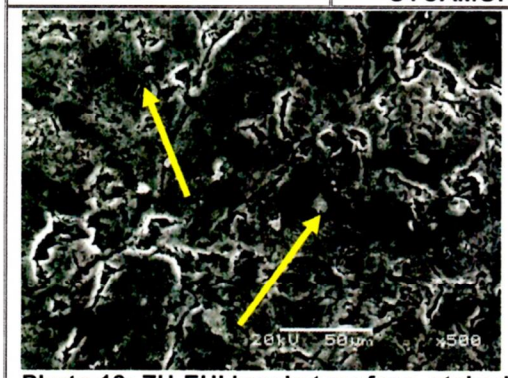
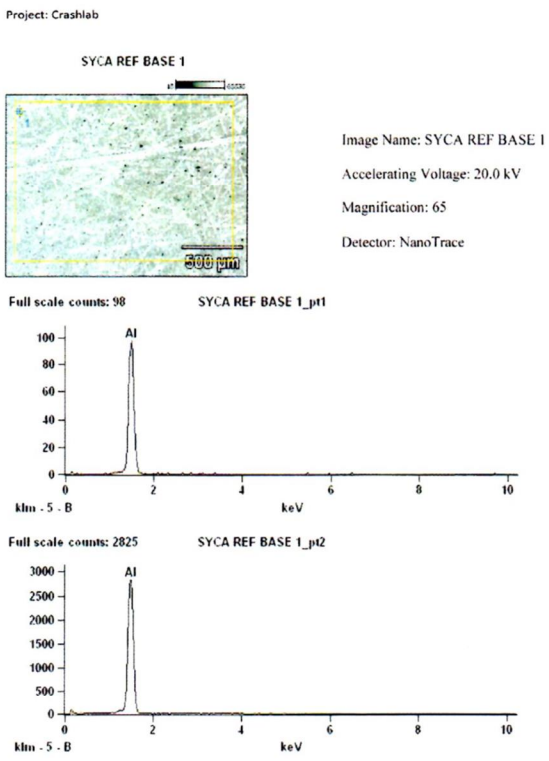


Photo 13: ZU-EUI bracket surface, etched (x500, SEM)



Weight %

	Al
SYCA REF BASE 1_pt1-No Data.	
SYCA REF BASE 1_pt2	100.0

Weight % Error (+/- 1 Sigma)

	Al
SYCA REF BASE 1_pt1-No Data.	
SYCA REF BASE 1_pt2	+/-0.7

Atom %

	Al
SYCA REF BASE 1_pt1-No Data.	
SYCA REF BASE 1_pt2	100.0

Atom % Error (+/- 1 Sigma)

	Al
SYCA REF BASE 1_pt1-No Data.	
SYCA REF BASE 1_pt2	+/-0.7

EDS results: Reference bracket

Project: Crashlab

EUI BASE 1

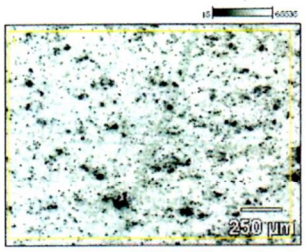


Image Name: EUI BASE 1

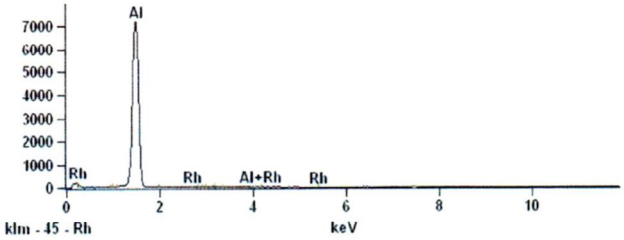
Accelerating Voltage: 20.0 kV

Magnification: 70

Detector: NanoTrace

Full scale counts: 7183

EUI BASE 1_pt1



Weight %

	Al	Rh
EUI BASE 1_pt1	99.0	1.0

Weight % Error (+/- 1 Sigma)

	Al	Rh
EUI BASE 1_pt1	+/-0.5	+/-0.2

Atom %

	Al	Rh
EUI BASE 1_pt1	99.7	0.3

Atom % Error (+/- 1 Sigma)

	Al	Rh
EUI BASE 1_pt1	+/-0.5	+/-0.1

EDS Results: ZU-EUI failed bracket

	VHN	
Indent No	ZU-EUI	Reference
1	43.4	121
2	42.5	125
3	40.3	121
Average	42.1	122
Standard Deviation	*1.59*	*2.31*
Coefficient of Variation	*3.79*	*1.89*

VHN Indenter, 0.5N, 10 sec

Micro-Hardness test results: ZU-EUI vs. Reference

7. DISCUSSION AND CONCLUSIONS

The conclusions are based on the investigation results obtained from the supplied parts/components only.

7.1 The investigation results revealed that the main rotor head attachment brackets failed over an undetermined period of operational time and under operational- and not impact loads.

7.2. The metallographic investigation revealed extensive porosity within the base material from the brackets originating from ZU-EUI. In addition, the micro-hardness results revealed the brackets from ZU-EUI to be less than 35% in value in comparison to the supplied 'reference' unit. Both these factors have a serious detrimental effect on the ultimate strength of the brackets.

7.3. The relevant aircraft was fitted with an upgraded main rotor system extending the diameter thereof from 30ft to 33ft. Due to the unavailability of the manufacturing history and/or origin of the brackets from ZU-EUI, the influence of this upgrade towards the cause of the accident could not be conclusively determined, nor the operational envelope this aircraft was utilized within.

7.4. The results from proved that the main rotor head attachment brackets fitted to ZU-EUI are of inferior quality when compared to a single 'reference' unit and are therefore considered to be the primary contributing factor towards the failure during operation.

8. RECOMMENDATIONS

8.1. The investigation revealed no clear part-, serial- and/or batch numbers on both the reference and/or accident aircraft units. This leaves the tracing of such a crucial component, and the possible rectification action/s, almost impossible. It is recommended that the SACAA address this issue as matter of urgency.

8.2. Taking into account the application of the failed components as well as the possible negative effect on Flight Safety, it is recommended that the relevant certification section/s within the SACAA suggest a redesign of this component/s on the relevant aircraft to the OEM. In the absence of a certified OEM, it is then recommended that the relevant sections within the SACAA engage in a detailed qualification and certification process regarding the utilization of these components on standard (30ft rotors) as well as the upgraded (33ft rotors) versions.

8.3. Due to the traceability concerns mentioned, it is strongly suggested that the SACAA involve all owners/operators of similar aircraft to engage in a controlled inspection program before further operation of the type is allowed. This inspection methodology should involve the following as a minimum – (a) and (b) can be performed by the owner/operator while (c) to (e) should only be inspected by a qualified person/entity:

(a) Removal of the mast covers, if fitted.
(b) Visual inspection around the bolt holes for cracks or <u>any</u> indications of plastic deformation, in particular along the forward facing edges of the attachment brackets. Any of the above must render the brackets unserviceable with immediate effect.
(c) Indications of surface pitting/porosity pointing towards a low quality base material.
(d) Surface Hardness test.
(e) Non destructive test

9. DECLARATION

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