AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

Reference:	CA18/2/3/9695

Aircraft Registration	**ZU-BUA**	**Date of Accident**	1 June 2018	**Time of Accident**	1035Z
Type of Aircraft	Chayair, Sycamore MK1 (Gyroplane)		**Type of Operation**	Operation of Non-type Certificated Aircraft (Part 94)	
Pilot-in-command Licence Type	National Pilot Licence		**Age** 36	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours		7017	Hours on Type	6107.1
Last point of departure	Klipriver Airfield Gauteng Province				
Next point of intended landing	Klipriver Airfield Gauteng Province				

Location of the accident site with reference to easily defined geographical points (GPS readings if possible)

Klipriver Airfield – Walkerville – Gauteng Province – 26°28'31.87"S 028°6'42.45"E, at elevation 4997 ft.

Meteorological Information	Wind direction 050°, Wind speed 4 knots, Visibility >10 km, Temperature +11°C, Cloud cover - none.				
Number of people on board	1+1	**No. of people injured**	1	**No. of people killed**	0

Synopsis

On the 1 June 2018, the flight instructor (pilot in command - PIC) and the student pilot (Pilot Flying - PF) were performing circuit training at Klipriver Airfield to do a Sycamore (Y017) conversion. The conversion was carried out on aircraft ZU-BUA, a modified Chayair Sycamore MK1 gyroplane.

According to the PF, they flew for approximately 45 minutes of circuit training, including many standard and glide-approach landings. During the last take-off, the PF felt a slow cyclic knocking through the joystick. The PF reported to the PIC that something was wrong. The PIC took control of the aircraft and instructed the PF to switch off the engine due to the high vibration felt and instantly set up for emergency landing. According to the PF, approximately 10 seconds after handing control over to the PIC, the engine stopped without him switching it off.

The PIC further stated that, after taking control, he did a 90° banked turn to the right to avoid the power lines ahead. The PIC stated that he lost control of the aircraft and that the aircraft rolled violently over to the right and impacted the ground very hard. The aircraft came to rest on its right-hand side, facing in a southerly direction. Shortly after impact with the ground, the PIC urged the PF to get out as there was smoke coming from the back of the aircraft. The PF stated that he used the aircraft-equipped hand-held Halon fire extinguisher and dowsed the engine area. The PF further stated that it was only then that he turned off all the switches that were in use on the dashboard. The ignition key was turned to the off position and the key was removed.

The aircraft sustained damages to the main rotor blades, tail section and landing gear. The PIC sustained minor injuries and the PF was not injured.

The investigation revealed that the aircraft had lost control after take-off as a result of engine stoppage in flight due to undetermined reasons.

SRP Date: February 19	12 February 2019	Publication Date	20 May 2019

List of Abbreviation and Descriptions

ABBREVIATION	DESCRIPTION
AGL	above ground level
AIID	Accident and Incident Investigations Division
AMSL	above mean sea level
AP	Approved Person
CAR	Civil Aviation Regulations
CG	centre of gravity
CVR	cockpit voice recorder
FDR	flight data recorder
ft	feet
kg	kilogram
km	kilometre
kt	knot
MAUW	Maximum All Up Weight
mph	miles per hour
PF	Pilot Flying
PIC	Pilot in Command
POH	Pilot's Operating Handbook
rpm	revolutions per minute
RSA	Republic of South Africa
SACAA	South African Civil Aviation Authority
TGM	technical guidance material
UTC	Co-ordinated Universal Time
VHF	Very high frequency

Reference Number	**:**	CA18/2/3/9695
Name of Owner/Operator	**:**	L.E. Tollemache
Manufacturer	**:**	Chayair Sycamore (Musina, South Africa)
Model	**:**	Sycamore MK1
Nationality	**:**	South Africa
Registration Marks	**:**	ZU-BUA
Place	**:**	Klipriver Airfield
Date	**:**	1 June 2018
Time	**:**	1035Z

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 (CAR) 2011 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 apportion blame or liability****.*

Investigations process:

The accident was reported to the Accident and Incident Investigations Division (AIID) two days late on 03 June 2018 at about 0600Z. The Investigator/s went to Walkerville on 04 June 2018. The Investigator/s coordinated with all authorities on site by initiating the accident investigation process according to CAR Part 12 and investigation procedures. AIID of the South African Civil Aviation Authority (SACAA) is leading the investigation, as the Republic of South Africa is the State of Occurrence.

Notes:
1. Whenever the following words, written with an initial capital letter below, are mentioned in this report they shall mean the following:

- *Accident – the current investigated accident;*
- *Aircraft – the Sycamore MK1 involved in this accident;*
- *Investigation – the investigation into the circumstances of this accident;*
- *Pilot – the pilot involved in this accident; and*
- *Report – this accident report.*

2. Photos and figures used in this report are taken from different sources and may be adjusted from the original for the sole purpose of improving the clarity of the report. Modifications to images used in this report are limited to cropping, magnification, file compression, or enhancement of colour, brightness, contrast, or addition of text boxes, arrows or lines.

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 On Friday 01 June 2018 a gyroplane flight instructor (Pilot in Command – PIC) accompanied by a student pilot (Pilot Flying – PF) was conducting a type conversion (Y017), involving take-off and landing exercises at Klipriver airfield, when the accident occurred. According to the PIC, there were no anomalies noted before departure and the aircraft had about 40 litres of fuel on board. The PIC

reported good weather conditions, with a wind direction of 050° and a speed of about 05 kt. The PIC reported that after 0.9 hours (54 minutes.) nine take-offs and landings were completed. The PIC stated that during the 10th touch and go, at about 100 to 150 ft above ground level (AGL), a very bad shudder was felt on the control column emanating from the rotors. The PIC instantly took control of the aircraft. Furthermore, the PIC reported that he instructed the PF to switch off the engine whilst looking for an open space with the intention to perform a forced landing. The PF confirmed that he did not switch the engine off, but the engine stopped approximately 10 seconds later. During a 90° banked turn, the PIC lost control of the aircraft, which entered into a right-hand spiral and an uncontrolled descent. The aircraft impacted heavily with the ground and was substantially damaged. The PIC sustained minor injuries and the PF vacated the aircraft unhurt.

1.1.2 The PF reported that on the day of the accident, he had arrived at the airfield with the owner of the aircraft. On arrival they completed a thorough pre-flight inspection and refuelled the aircraft. The PF mentioned that the aircraft was ready for flight with 35 litres of fuel on board. The PF reported that the PIC arrived at the airfield and completed a pre-flight check and was happy to proceed with the flight. They started the engine and proceeded to the holding point of runway 02 for take-off. The PF stated that they did approximately 45 minutes of circuit training, which included glide-approach landings. During the 10th touch and go, the aircraft climbed to approximately 80 ft AGL when a slow cyclic knocking shudder was felt on the control column. He further stated that he immediately looked back at the PIC, informing him that something was wrong. The PIC's response was "my control", which as per the PF meant that he must hand over control to the PIC immediately and refrain from touching any of the flight controls. Approximately 10 seconds later, the engine stopped. The PF stated that the PIC levelled the attitude of the aircraft and executed a 90° banked turn to the right. At this point the PIC pulled the control column backward and continued flaring the aircraft. Nonetheless, he felt no reduction in the descent rate, whereupon the aircraft rolled violently to the right and made contact with the ground at an estimated angle of approximately 45°. Shortly after impact, the PIC requested the PF to disembark quickly as there was smoke coming from the back of the aircraft.

1.1.3 Both occupants vacated the aircraft quickly, whereupon the PF promptly grabbed the aircraft-equipped hand-held Halon fire extinguisher and dowsed the engine area. The PF reported that he then turned off the ignition master key, including all the switches on the dashboard and removed the key. Post interview with the owner revealed that the aircraft had 35 litres of fuel on board before the flight. According to the owner who was standing next to the hangar watching the aircraft take-off, he stated that after the crash he rushed to the accident site to help the crew. Upon arrival he found that the crew had exited the aircraft. He further stated that he checked if the aircraft had fuel inside and the tank was empty. There was no rupture in the tank and on the fuel lines. The ground where the aircraft came to rest was dry and no fuel smell was present.

1.1.4 The accident occurred during daylight conditions, at a geographical position determined to be 26°28'31.87"S 028°6'42.45"E, at an elevation of about 4997 ft AMSL.

Figure 1: Google Earth overlay of the accident scene

1.2 Injuries to Persons

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

1.3 Damage to Aircraft

1.3.1. The aircraft suffered substantial damage.

Figure 2: Damage to nose landing gear (courtesy of the owner of the aircraft)

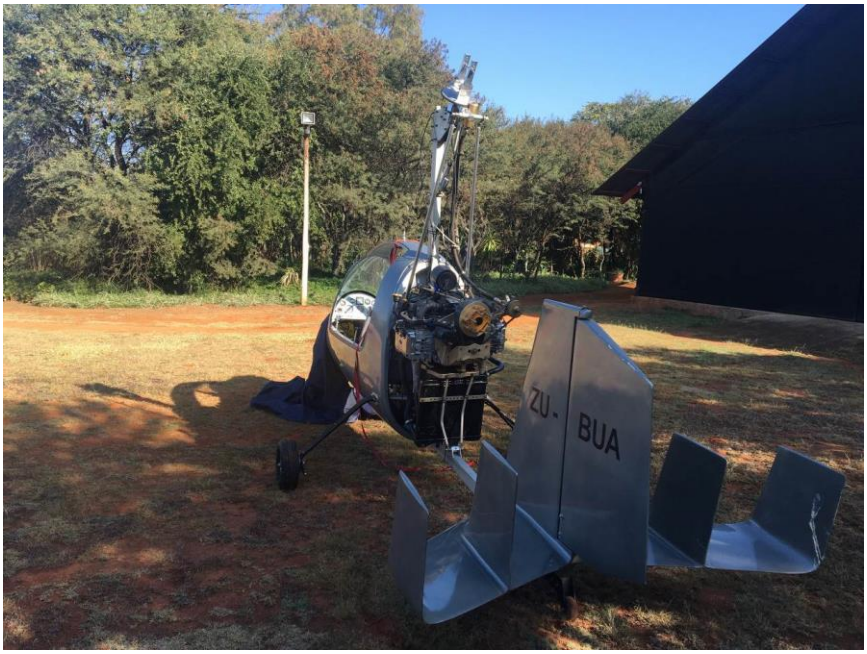

Figure 3: Shows damage to right-hand vertical stabiliser (picture taken after recovery)

1.4 Other Damage

1.4.1 None

1.5 Personnel Information

1.5.1 PIC Information

Nationality	RSA	Gender	Male	Age	36
Licence Number	*****	Licence Type	National Pilot Licence		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Post-Maintenance Test Flight (GYR); Pilot and Instructor (Y014, Y017, Y018, Y019, Y020, Y021, Y023, Y024, Y026 and Z199).				
Medical Expiry Date	30 September 2020				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	7017
Total Past 90 Days	94.9
Total on Type Past 90 Days	2.4
Total on Type	6107.1

Note: The information entered in the table above was obtained from the pilot questionnaire.

1.5.2 PF Information

Nationality	RSA	Gender	Male	Age	38
Licence Number	*****	Licence Type	National Pilot Licence		
Licence Valid	Yes	Type Endorsed	No		
Ratings	GYR Y018 and WCM Z159.				
Medical Expiry Date	30 September 2020				
Restrictions	Corrective Lenses				
Previous Accidents	None				

Flying Experience:

Total Hours	26.3
Total Past 90 Days	1
Total on Type Past 90 Days	1
Total on Type	26.3

Note: The information entered in the table above was obtained from the pilot's logbook.

1.6 Aircraft Information

Airframe:

Type	Sycamore MK1	
Serial Number	SYCA 0004	
Manufacturer	Chayair Aviation, Musina, South Africa	
Date of Manufacture	3 March 1999	
Total Airframe Hours (At time of Accident)	94.7	
Last MPI (Date & Hours)	26 October 2017	90 Hours
Hours since Last MPI	4.7	
C of A (Issue Date)	1 December 2017	
C of R (Issue Date) (Present Owner)	6 June 2017	
Operating Categories	NTCA Private (part 94)	

1.6.1. Historically the Sycamore type was removed from the production-built type category and placed under the amateur-built category. This gyroplane is a Part 94 aircraft, operated by the owner for private pleasure.

1.6.2. In October 2017, a new logbook was opened with the following entry: "First entry in old style logbook 03/03/1999. No accidents or incidents recorded in old style logbook. Last entry in old style logbook 05/05/2004". On 18 October 2017, an entry was made in the new logbook to the effect that the aircraft history is unknown and the aircraft was rebuilt. A Subaru engine from a damaged RAF 2000 gyroplane was installed.

The Modifications section of the logbook has the following entry: "Subaru EJ25 normally aspirated engine was recovered from a RAF 2000 gyroplane and built into the Sycamore frame. Engine mounting from RAF was used and modified to fit the Sycamore frame. Modification carried out by owner."

The aircraft was originally fitted with a Rotax 914 engine, which had an installed weight of 78 kg. The

Subaru EJ25 engine that was installed has a weight of 135 kg.

1.6.3. According to the records, the mast plate of the gyroplane was modified in an attempt to correct the aircraft's centre of gravity. The centre of gravity was determined to be 2 degrees nose down with 80 kg for the pilot, this was determined through the hang test method. A project status report of the modification was compiled by an Approved Person (AP), highlighting several limitations of the modification to the owner. According to the document, the owner signed and acknowledged each page of the report. The concerns of the AP on the modification, as set out in the report, are attached to this report as an annexure.

1.6.4 The latest Certificate of Release to Service was issued on 26 October 2017 at 90 tacho hours by the AP, with expiry date of 26 January 2018 or at 115 tacho hours whichever come first, and the subsequent authority to fly was issued on 1 December 2017, with expiry date of 25 October 2018.

1.6.5 The mass and balance record shows that the aircraft was last weighed on 26 October 2017, with an empty mass of 446 kg. The original empty weight of the aircraft according to the POH was 380Kg. According to the Pilot's Operating Handbook (POH), the aircraft is certified for a Maximum All Up Weight (MAUW) of 590 kg.

The pilots combined weighed 159 kg. The PF and the owner stated that 35 litres (around 27 kg) of fuel was added to the aircraft prior to flight. This is a minimum total take-off weight of 632 kg. According to the POH, the MAUW was exceeded by 7%.

1.6.6 It was noted that the POH did not contain information relating to the fuel consumption of the modified Sycamore MK1 with the Subaru EJ25 engine and the 4-blade warp propeller that was taken from the RAF 2000. The Sycamore MK1 Flight Operator's Handbook document the fuel consumption with a Rotax 914 engine and three-bladed propeller as 2.5 hours per 55 litres (22 litres per hour) at a 75% power setting. A factory built Sycamore MK1 with the Subaru EJ25 engine is documented to have a 2.5-hour range with a 55-litre fuel tank capacity. That is 22 litres per hour.

According to the RAF 2000 POH, the RAF 2000 with the Subaru EJ25 engine has a documented fuel consumption of 25 litres per hour (6.5 US gallons) at 80% or 4200 rpm.

According to available information, very little fuelling history was collected between the modification and the accident. It was noted in the flight folio that 45 litres of fuel was added for the duration of 3.4 hours (13.2 litres per hour) and a total of three flights were accomplished during that time. No passengers were accompanying the pilot during the previous flights. According to the PF the aircraft was fuelled up to 35 litres for the last flight, and with this fuel the gyroplane accomplished 0.75 hours (45 minutes) of flying with nine landings and 10 take-offs at varied power settings. The PIC reported that the flight time was 0.9 hours (54 minutes). According to the AP, who is a gyro plane expert, the aircraft with the modified configuration could be expected to have burnt fuel at around 35 – 45 litres per hour.

Engine:

Type	Subaru EJ25
Serial Number	P096733
Hours since New	941.4
Hours since Overhaul	101.4

Note: The Maintenance records show that the engine was recovered from a RAF 2000 gyroplane with registration ZU-DKW. The engine was first installed on ZU-DKW in June 2004, with airframe S/N: B478495.It was noted in the aircraft logbook that during installation, the engine accumulated a total of 936.7 hours and accrued 96.7 hours since rebuild.

Propeller:

Type	Warp Drive 4 blade
Serial Number	N15805
Hours since New	100.5
Hours since Overhaul	100.5

Note: According to aircraft logbook history, the propeller originates from the damaged RAF 2000 gyroplane. The propeller had accumulated 95.8 hours on ZU-DKW before installation on ZU-BUA.

Rotor:

Type	Unknown
Serial Number	Unknown
Hours since New	Unknown
Hours since Overhaul	Unknown

Note: There are no records or history available in the logbook for the rotors which were installed on the aircraft. No data plates were found on the rotors. The AP stated that in the project status report of the aircraft, the owner informed him that the rotor blades were the original rotor blades that came with the Sycamore MK1 aircraft when he bought it.

1.7 Meteorological Information

1.7.1 The information entered in the table below was obtained from the pilot questionnaire – METAR 126.2MHz - CAVOK.

Wind direction	050°	Wind speed	4 kts	Visibility	>10km
Temperature	+11°C	Cloud cover	N/A	Cloud base	N/A
Dew point	Unknown	QNH	Unknown		

1.8 Aids to Navigation

1.8.1 The aircraft was equipped with the standard factory-fitted navigational equipment approved by the regulator. No defects to this equipment were recorded prior to the flight.

1.9 Communications

1.9.1 The aircraft was equipped with one VHF (very high frequency) radio, as approved by the regulator. No defects to this equipment were recorded before the flight.

1.10 Aerodrome Information

Aerodrome Location	Klipriver Airfield	
Aerodrome Co-ordinates	26°28'31.87"S 028°6'42.45"E	
Aerodrome Elevation	4997 ft AMSL	
Runway Designations	02L 20R	07L 25R
Runway Dimensions	850 m (2780 ft)	420 m (1380 ft)
Runway Used	02L	
Runway Surface	Grass	
Approach Facilities	None	

1.11 Flight Recorders

1.11.1 The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it required by the regulations to be fitted to this type of aircraft.

1.12 Wreckage and Impact Information

1.12.1. According to the PF's statement, the aircraft did a 90° banked turn to the right shortly after take-off when an inflight upset was experienced. The aircraft lost height rapidly and it went into a right-hand spiral dive before impacting with the ground. During impact, the landing gear impacted hard with the ground and the aircraft rolled over onto its right-hand side. See Figure 4. From evidence obtained from the aircraft after the accident it was noted that the propeller blades were still intact. No signs of rotational damage were found on the propeller. The main rotor blades were substantially damaged during the accident. The damages seen on the rotor blades are consistent with damage caused by impact with the ground. The right-hand main landing gear and nose landing gear sustained substantial damage due to impact with the ground. The tail section sustained damage to the right-hand vertical fin caused by rotor blade impact to the tail.

Figure 4: Aircraft in the final resting position (courtesy of the owner of the aircraft)

1.13 Medical and Pathological Information

1.13.1 None.

1.14 Fire

1.14.1 There was evidence of smoke emanating from the engine after impact. No signs of a post impact fire was found, however the PF did use an aircraft fire extinguisher to dowse off the engine area.

1.15 Survival Aspects

1.15.1 The accident is considered survivable because the damage was limited to the main rotors, the landing gear and the right-hand vertical stabiliser. The cockpit structure was still intact and both occupants made use of the aircraft safety harnesses that were provided inside the aircraft.

1.16 Tests and Research

1.16.1 The engine was tested on the aircraft after the accident and the engine operated without any defects recorded.

1.17 Organisational and Management Information

1.17.1. The aircraft is a Part 94 privately owned aircraft and was used in a training flight.

1.17.2. The gyro plane was modified by the owner. An AP was approached to certify work done by the owner as required by the CAR. The AP stated that he completed and submitted an application for approval of the modification to the SACAA, but did not receive feedback. The SACAA Airworthiness Division was consulted regarding this matter and the feedback that was received is that they don't issue modification approvals for non-type certificated aircraft.

1.18 Additional Information

1.18.1. An analysis was done on a few gyroplane definitions to provide some insight on the causes of vibrations felt on the control sticks (rotor shake) and also the nature of rotor flap on gyroplanes.

Greg Gremminger and participants of the Rotorcraft.com Conference Forum characterised rotor shake as the vibration of the rotor system felt in the controls and in the fuselage of a gyroplane. The predominant vibrations are either experienced once per revolution (at the same frequency as the rotor is turning) or twice per revolution (twice the frequency of the rotor) in a two-bladed rotor system.

They also say that a once-per-revolution rotor shake can be the result of a mass and/or aerodynamic imbalance of the rotor. A once-per-revolution imbalance rotor shake could also be the result of either the mass centre or the aerodynamic centre not being exactly concentric with the spinning axis of rotation of the rotor. Imperfect rotor blade tracking is a contributor to aerodynamic imbalance, leading to once-per-revolution rotor vibrations. Rotor vibrations may be felt in either the cyclic control stick or in the airframe. Once-per-revolution vibrations can be verified if they continue in a zero airspeed vertical flat descent, with no forward airspeed to create confusion with twice-per-revolution vibrations.

Twice-per-revolution vibrations refer to rotor vibration cycles that occur twice for every complete revolution for a 2-bladed rotor system. Some twice-per-revolution rotor vibrations are inevitable to some extent in semi-rigid 2-blade rotor systems at forward airspeeds, due to varying total rotor drag as the blades move from lateral alignment to longitudinal alignment. Other twice-per-revolution rotor vibrations can be generated by a miss-match of the teeter height and the coned centre of gravity of the rotor, and by looseness or “slop” in the teeter pivot and support. Twice-per-revolution rotor vibrations or shake is usually felt more in the cyclic control stick rather than in airframe vibrations. Twice-per-revolution vibrations can be verified if they decrease or disappear at very low or zero forward airspeeds.

Teeter height is the vertical distance from the hub of a rotor to the teeter pivot. Another term for this is undersling. Teeter height or offset above the hub of the rotor is intended to match the vertical centre of gravity (CG) location of the coned rotor under normal steady state load in flight. Mismatch of the teeter height to the actual coning angle of the rotor is the most common source of rotor shake – especially with forward airspeed which requires a steady mismatch of the spindle with the rotor spin axis.

In semi-rigid 2-blade rotor systems, the term flapping is commonly used to refer to the abnormal excessive forceful teeter action of the rotor impacting the teeter stops upon significant dissymmetry of lift or retreating blade stall – such as on take-off. This is also referred to as flap or blade flap.

1.18.2. The PIC reported that he made a 90° right-hand banked turn after the engine shut-down. There after he had lost control of the aircraft.

An enquiry was done on the effect that turning a gyroplane after engine failure at low forward speed could have on the flight characteristics. Autogyro History and Theory by jefflewis.net provides the insight as set out below.

The vector diagram in Figure 5 illustrates autorotation. The diagram in the lower right shows the winds relative to the rotor. Since the rotor is spinning, there will be relative wind due to this spin,

which is labelled as Relative Wind due to Rotor. The Relative Wind due to Aircraft Movement is due to the fact that the aircraft is moving forward, and the rotor is mounted in such a way that the plane of rotation is at a slight angle to the direction the aircraft is moving in. The sum of these two vectors is the relative wind to the aerofoil and is labelled as Resultant Relative Wind.

The main diagram shows a cross section of the rotor at a point in time where it is moving forward relative to the aircraft. The Resultant Relative Wind from the smaller diagram is shown on this as the Relative Wind. Any wind passing over an aerofoil will create both lift and drag. The lift will be perpendicular to the airflow, and the drag will be parallel to the airflow. This is true for all aerofoils, not just for the rotor in an autogyro. When the lift and drag vectors are added together they create a Resultant Force. In autorotation, this resultant force is in front of the Axis of Rotation, so in addition to providing lift, it also pulls the rotor forward.

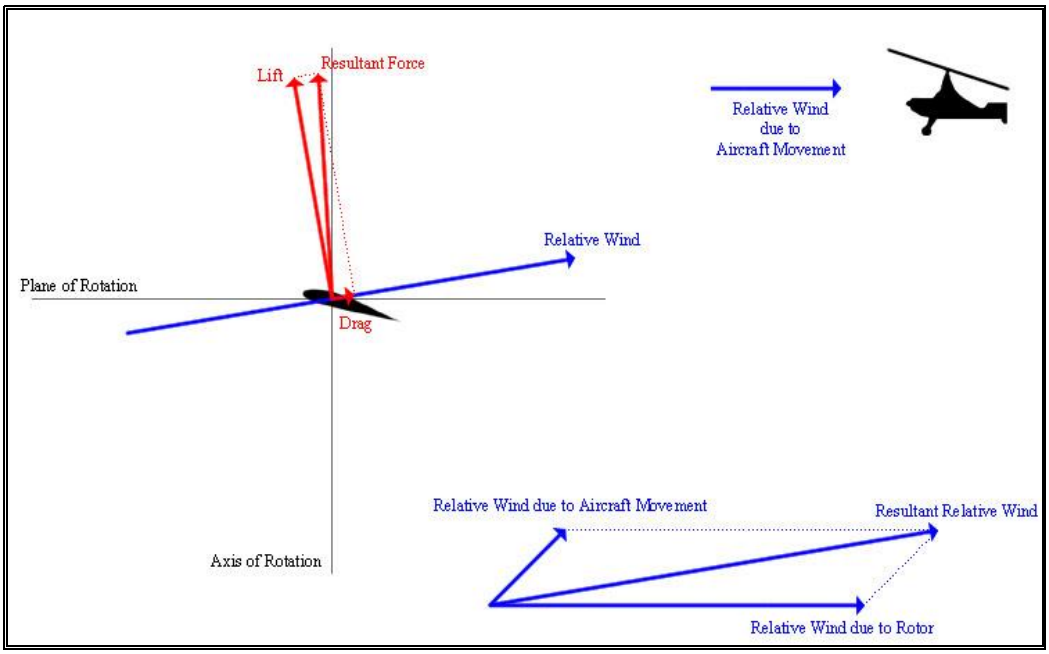

Figure 5: Autorotation illustrated

From the above theory it is clear that a gyro is continually in autorotation, i.e. the rotor is automatically rotating, very much like a windmill or a sycamore leaf, no matter what your airspeed is. Thus if you lose an engine, you lower the nose, just like a conventional fixed wing aircraft, to maintain your airspeed. A gyroplane, which is in a constant state of autorotation, simply settles to the ground if it loses an engine, regardless of the altitude and airspeed. What's more, gyroplanes should neither stall nor spin. If forward airspeed slows too much, below 15 mph in a typical design, the aircraft should descend gently.

Although the above theory is supported for straight and level flight in numerous articles, almost no information is available to consider what will happen in a banked turn at low speed with the engine inoperative. The Sycamore MK1 flight operator's handbook, emergency procedure, states that if there is insufficient runway ahead with an engine failure during take-off, keep to the safety speed (52 mph) and turn just enough to avoid obstacles. The emergency procedure in various gyroplane flight manuals, however, instructs a pilot to land immediately ahead (keep your heading) when an engine failure occurs during take-off. The flight manual for the Xenon R/RT/RST Autogyro and Magni M16 Tandem Training Gyro, similar gyroplanes, supports this instruction.

1.18.3. The Maximum All Up Weight (MAUW) was exceeded during the accident flight. A data plate on the instrument panel clearly shows the MAUW at 590 kg.

Figure 6: Shows a picture of the data plate on the instrument panel giving the MAUW as 590 kg

1.19 Useful or Effective Investigation Techniques

1.19.1 None

2. ANALYSIS

2.1 General

From the evidence available, the following analysis was made with respect to this accident. This shall not be construed as apportioning blame or liability to any particular organisation or individual.

2.2 Man

The pilot in command (PIC) was the holder of a national pilot's licence which was initially issued on 08 September 2009 and is valid until 09 August 2019. He is a grade A Gyro instructor, including class Y017 (Sycamore). He was in possession of a medical certificate without restrictions, which was issued on 03 September 2016 and is valid until 30 September 2020.

According to available information, the PIC flew the aircraft on previous occasions; however this was the first time that somebody accompanied him in this specific aircraft. This was a training flight conducted at the Klipriver Airfield in a modified Sycamore MK1 gyroplane. According to the PIC's statement, they were busy conducting circuits and landings at runway 02. He stated that on the 10th take-off when the aircraft was 80 ft AGL, the PF experienced a knock on the control stick. Although the PIC was of the opinion that delamination of the rotors caused the vibration on the control stick, this investigation found that the damage on the rotor blades are most probably the result of impact with the ground and tail of the aircraft during impact. According to a gyro plane expert vibrations caused by the rotor can be attributed to a number of factors. For example, the abnormal excessive forceful teeter action of the rotor due to dissymmetry of lift or retreating blade stall could have impacted significantly on vibration during initial climb.

The PIC took over control from the PF and requested the PF to switch off the engine. Before the PF

could switch off the engine, the engine suffered an uncommanded shutdown. This was followed by a rapid descent. The PIC stated that he turned the aircraft sharply to the right through 90° to avoid collision with the power lines situated 1 km from the threshold.

2.3 Machine

The aircraft is a Part 94 privately owned aircraft which was modified by the owner. The aircraft was subsequently inspected by an AP. The last maintenance inspection prior to the accident flight was certified on 26 October 2017 at 90 tacho hours, with expiry date of 28 January 2018 or at 115 tacho hours whichever comes first, where after a release to service was issued on 26 October 2017. Following the maintenance inspection, and prior to the last flight, the gyroplane had accrued a further 4.7 hours.

It was noted that the only historical logbook records available for the aircraft were between 03 March 1999 and 05 May 2004. It was furthermore noted that no serious incidents or accidents were recorded during this time. It was noted that on 26 October 2017 a new logbook was opened for the aircraft which pointed out that a Subaru EJ25 engine was installed from a damaged RAF 2000 aircraft. It was further noted that the owner used the engine mounting from the damaged gyroplane to do the modification. An engine static run was accomplished on 26 October 2017. The owner of the aircraft accomplished further modifications to the aircraft, which included a rotor mast modification. This modification was done to compensate for the weight and balance which was out of normal, because of the heavier engine.

The aircraft suffered substantial damage to the main rotors, landing gear and tail section during the impact sequence. The rotor blades were substantially damaged. The damage to the blades is consistent with damage expected from blades impacting the vertical fin and the ground at flight revolutions per minute (rpm). The damage to the landing gear is consistent with the damage expected after impact with the ground. The damage found on the right-hand vertical stabiliser gives the impression that the rotor blade impacted with the right-hand vertical fin after loss of control.

The aircraft's empty weight is 446 kg. The pilots combined weighed 159 kg. It was recorded that a minimum of 35 litres (around 27 kg) fuel was added to the aircraft prior to flight. This is a minimum total take-off weight of 632 kg. The aircraft is certified for a MAUW of 590 kg.

The witness, who is the owner of the aircraft, stated that when he arrived at the scene, there was no fuel inside the tank and there were no visible signs of damage to the tank and fuel lines after impact. However, according to the PIC, there were 20 litres of fuel on board the aircraft after the crash. The PIC further stated that they flew for approximately 54 min and the aircraft had 40 litres of fuel on board before take-off. The PF and owner who fuelled the aircraft stated that there was only 35 litres of fuel on board before the start of the flight. However, no record was found regarding the fuel uplift. The pilot report shows that the engine setting for take-off was 5300 rpm and for cruise 4700-4900 rpm. It was noted that the POH did not contain information relating to the fuel consumption of the modified Sycamore MK1 with the Subaru EJ25 engine and the 4-blade warp propeller taken from the RAF 2000. The Sycamore MK1 Flight Operator's Handbook document the fuel consumption with a Rotax 914 engine and three-bladed propellers as 2.5 hours per 55 litres (22 litres per hour) at a 75% power setting. According to the POH, the RAF 2000 with the Subaru EJ25 engine has a documented fuel consumption of 25 litres per hour (6.5 US gallons) at 80% or 4200 rpm. The Sycamore MK1 with

the Subaru EJ25 engine is documented to have a 2.5-hour range with a 55-litre fuel tank capacity. That is 22 litres per hour. According to available information, very little fuelling history was collected between the modification and the accident. It was noted in the flight folio that 45 litres of fuel was added for the duration of 3.4 hours (13.2 litres per hour) and a total of three flights were accomplished during that time. No passengers were accompanying the pilot during the previous flights. During the last flight, the aircraft was fuelled to 35 litres, and with this fuel the gyroplane accomplished 0.75 hours of flying with nine landings and 10 take-offs at varied power settings. There were two people on board the aircraft, and the MAUW was exceeded by 7%. According to the condition of the propeller there was no indication that the engine was running during impact. It was not confirmed by calculation that the aircraft ran out of fuel.

2.4 Management

2.4.1 The aircraft is a Part 94 privately owned aircraft which was modified by the owner. The aircraft was subsequently inspected by an AP. According to the CAR 44.01.10 relating to Modifications of Non-Type Certificated Aircraft, “in the case of a major modification an application for the approval of the modification and authority to fly, as prescribed in Document SA-CATS 44, must be submitted to the Director or the organisation designated for the purpose in terms of part 149, as the case may be, before the modification has been performed”.

2.4.2 The SA CATS 44.01.10 make reference of form XYZ, which must be completed when the application for approval of a modification is submitted to the Director for Non-Type Certificated Aircraft. The form does not exist yet. The AP claims that he assisted the owner to submit an application for approval of a modification the SACAA, which included the project status report, but no response was received back from the SACAA. The Airworthiness Division was consulted regarding this matter and the feedback that was received is that they don’t issue modification approvals for non-type certificated aircraft.

2.4.3 The SACAA technical guidance material for amateur-built aircraft states in par. 14 that “an amateur-built aircraft is not a design-approved product in terms of the CAA categorisation and as such all subsequent design changes are the responsibility of the amateur aircraft builder. Therefore, the amateur builder must carry out and certify modification and repairs on the aircraft and is fully responsible for the modification and repairs of such aircraft. This is supported by the feedback received from Airworthiness.

2.5 Conclusion

According to available information, the PIC flew the aircraft on previous occasions; however, this was the first time that somebody accompanied him in this specific aircraft. This was a training flight conducted at the Klipriver Airfield in a modified Sycamore MK1 gyroplane. According to the PIC’s statement, they were busy conducting circuits and landings at runway 02. He stated that on the 10th take-off, when the aircraft was 80 ft AGL, the PF experienced a knock on the control stick. The PIC took over control from the PF and requested the PF to switch off the engine. Before the PF could switch off the engine, the engine suffered an uncommanded shutdown. This was followed by a rapid descent. The PIC stated that he turned the aircraft sharply to the right through 90° to avoid collision with the power lines situated 1 km from the threshold. According to information presented to the Investigator regarding the height of the aircraft and the distance between the threshold and the power lines when the engine stopped, it was noted that these were deemed adequate to safely

perform an unscheduled landing. It couldn't be conclusively determined as to why the aircraft was turned through 90° because the power lines were 1 km away. A 90° turn when the engine is inoperative was likely to cause a major reduction in speed and subsequently loss of height. It was noted after the impact that there was no fuel inside the tanks; however, the PIC stated that there was 20 litres of fuel on board. It was likely that the engine suffered an uncommanded shutdown due to unknown circumstances. It was noted that the POH did not record the fuel consumption for the engine that was fitted on the aircraft as well as the new weight configuration due to modifications. According to available information, the modification made on the aircraft was not documented properly. It was further noted that the regulator issued the authority to fly with the release to service that was lapsing in three months after the issue date. At the time of the accident the aircraft did not have a certificate of release to service as required by the regulator. According to the weight and balance calculation the aircraft was operating with weight above MAUW. It is likely that the PF experienced rotor shake/vibrations on the cyclic stick when the rotor rpm dropped due to engine stoppage.

3 CONCLUSION

3.1 General

From the evidence available, the following findings, causes and contributing factors were made with respect to this accident. These shall not be construed as apportioning blame or liability to any particular organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusions heading:

- **Findings** – statements of all significant conditions, events or circumstances relevant to this accident. The findings are significant steps in the accident sequence, but they are not always causal or indicative of deficiencies.
- **Causes** – actions, omissions, events, conditions, or a combination thereof, which led to this accident.
- **Contributing factors** – actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident or incident occurring, or mitigated the severity of the consequences of the accident or incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.2 Findings

3.2.1 The pilot was a holder of a national pilot licence and the aircraft type was endorsed on the licence. The pilot licence was issued on 15 September 2016, with an expiry date of 30 September 2019, at the time of the accident.

3.2.2 The pilot was in possession of a valid aviation medical certificate with no restrictions, issued on 03 September 2016 with an expiry date of 30 September 2020.

3.2.3 The aircraft was in possession of a valid authority to fly certificate, which was issued on 01 December 2017 with an expiry date of 25 October 2018.

3.2.4 The last annual inspection was carried out on 26 October 2017 at 90 airframe hours whereupon a

certificate of release to service was issued with a lapsing date of 26 October 2018 or at 115 hours whichever occurs first. The aircraft only accrued 4.7 hours since last maintenance.

3.2.5 The aircraft was modified by the owner. There is no factory support for this type and no safety or maintenance oversight. No modification approval was issued by the SACAA for the major modifications done on the aircraft.

3.2.6 The AP issued the project status report to the owner highlighting the fact that the weight and balance of the aircraft is out of normal. No documented attempt was made by the owner to address the CG issues before flight, as suggested by the project status report that is attached in Annexure C on page 26 of this report.

3.2.7 The MAUW was exceeded by at least 7%.

3.2.8 An inflight upset caused rotor shake and subsequent vibration on the controls. The PIC selected to turn the aircraft through 90° when the engine was not running, shortly after take-off. The flight manuals of similar gyroplanes instruct the pilot to maintain heading when an engine failure occurs during take-off. The power lines were found to be 1 km away from the threshold.

3.2.9 The SACAA engineering technical guidance material (TGM) relating to modification of amateur-built aircraft is inconsistent with the CAR relating to Non-Type Certificated Aircraft. The TGM places the responsibility of modification solely on the owner.

3.2.10 The CAR states that in case of a major modification, an application for the approval of the modification and authority to fly, as prescribed in Document SA-CATS 44, must be submitted to the Director or the organisation designated for the purpose in terms of part 149, as the case may be, before the modification has been performed.

3.2.11 The SA CATS 44.01.10 reference form XYZ must be completed when the application for modification is submitted to the Director for Non-Type Certificated Aircraft. Footnote 1 confirms that this form is yet to be created.

3.2.12 The engine was tested on the aircraft after the accident. The engine ran normally without any malfunction. The cause of the inflight engine stoppage after take-off was undetermined.

3.3 Probable Cause/s

3.3.1 Engine stoppage in flight resulting unsuccessful forced landing after take-off due to undetermined reasons.

3.4 Contributory Factors

3.4.1 None

4 SAFETY RECOMMENDATIONS

4.1. General

The safety recommendations listed in this report are proposed in accordance with paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in section 3 of this report. The AIID expects that all safety issues identified by the Investigation will be addressed by the receiving States and organisations.

4.2 Safety Recommendation/s

4.2.1 None.

5 ANNEXURES

5.1. Annexure A: CARs of 2011 as amended

5.2. Annexure B: Guidance material for amateur-built aircraft

5.3. Annexure C: Wagtail Project Status Report

Source: Civil Aviation Regulations of 2011 as amended

Persons to carry out maintenance

44.01.4 (1) No person may carry out maintenance on an amateur built aircraft or a production-built non-type certificated aircraft, or any component thereof, unless such person—

(a) is appropriately rated or approved on type by the Director or the organisation designated for the purpose in terms of part 149, as the case may be, to carry out maintenance; or

(b) carries out the maintenance under the prescribed supervision of a person authorised by the Director or by the organisation referred to in paragraph (*a*). A dual check of the maintenance carried out must be performed by a person referred to in subparagraph (*a*); or

(c) **is the owner of the aircraft provided that an appropriately rated approved AMO, AME or Approved Person, rated in accordance with subpart 4 of part 66, performs a dual check on the maintenance which was carried out**; or

(*d*) is an appropriately rated approved AMO, AME or approved person, rated in accordance with subpart 4 of part 66.

(2) (*a*) Components and parts intended to be used on non-type certificated aircraft may be fabricated by a person or organisation not licensed in terms of part 66 or part 145.

(*b*) **The owner of the aircraft must provide the Director, or the organisation designated for the purpose in terms of part 149, as the case may be, with evidence that the components or parts meet the minimum specification for the component or part as specified by the Original Equipment Manufacturer.**

(*c*) An appropriately rated approved AMO, AME or approved person, rated in accordance with subpart 4 of part 66 shall sign off the component or part in the appropriate logbook.

Modifications

44.01.10 (1) If a person intends to carry out any modifications, including changes to equipment or the installation thereof, which affect, or are likely to affect, the serviceability of the aircraft, or the safety of its occupants or any other persons or property, in relation to an amateur built aircraft or a production built aircraft—

(a) in the case of a minor modification a notification of the modification must be submitted to the Director, or the organisation designated for the purpose in terms of part 149, as the case may be, within 30 days of the modification being performed. All subsequent modifications shall be an amendment to the build standard;

(*b*) **in the case of a major modification an application for the approval of the modification and authority to fly, as prescribed in Document SA-CATS 44, must be submitted to the Director or the organisation designated for the purpose in terms of part 149, as the case may be, before the modification has been performed.**

(2) The application referred to in subregulation (1) must be accompanied by the appropriate fee as described in part 187.

(3) All approved modifications shall be entered into the appropriate logbook(s).

(4) An appropriately rated approved AMO, AME or approved person, rated in accordance with subpart 4 of part 66 shall sign in the appropriate logbook(s) that all procedures, as stated in the application for modification, were adhered to and that he or she is satisfied with the quality of the work which was carried out.

Overhaul, repair and substitution of major components

44.01.16 (1) Overhaul of a Class I or Class II product and repairs to the primary structure of an aircraft, its engine(s) or propeller(s) shall be signed out by an appropriately rated approved AMO, AME or approved person, in terms of subpart 4 of part 66.

(2) **The procedure for the reissuing of a proving flight authority or authority to fly which is deemed to have been suspended when an aircraft is involved in an accident that renders one or more Class I products defective, is prescribed in Document SA-CATS 44.**

(3) Where the manufacturer's instruction or recommendation has not been complied with, such components or equipment must be overhauled as and when their condition shows that it is necessary to keep the aircraft serviceable.

(4) (*a*) In the case of an aircraft operated in terms of part 94, a component or part may be fitted to an aircraft for which traceable records are not available.

(*b*) It shall be the responsibility of the appropriately rated approved AMO, AME or approved person, in terms of subpart 4 of part 66, to ensure that the component or part is acceptable in fit, form and function.

(5) (*a*) Notwithstanding the provisions of subregulation (2), non-type certificated aircraft operated under part 96 or part 141 where the Director or the organisation designated for the purpose in terms of part 149, as the case may be, has approved a time between overhauls that differs from that recommended or specified by the manufacturer, such time between overhauls shall be specified in the aircraft's accepted maintenance schedule, referred to in regulation 44.03.1.

(*b*) Furthermore, where a manufacturer has not recommended or specified the overhaul of an item at certain times but where the Director or the organisation designated for the purpose in terms of part 149, as the case may be, considers its overhaul at certain intervals necessary in the interest of safety, he or she may prescribe a time between overhauls for such item in the aircraft's accepted maintenance schedule.

(*c*) The requirements for the substitution of products, components and parts with new or overhauled items are those prescribed in Document SA-CATS 24.

(*d*) **No part may be fitted to an aircraft for which traceable records are not available. The appropriately rated approved AMO, AME or approved person, in terms of subpart 4 of part 66, is responsible for ensuring that any part received comes from a reliable source and is serviceable, and that the storage limitations have not been exceeded. Substitutions must be certified by the holder of an appropriately rated licence or authorisation.**

Temporary and permanent repairs after accidents

44.01.17 (1) Any repair to an aircraft or aircraft component, which has been damaged after an accident, shall be carried out in accordance with the requirements as prescribed in Document SA-CATS 44.

(2) Following the permanent repair of an aircraft that has been involved in an accident, as defined in paragraph (*b*) of the definition of "accident" in part 1, the aircraft shall meet requirements for the initial authority to fly.

Annexure B

Source: Guidance material – amateur-built aircraft, Par 14.

14. MODIFICATION AND REPAIR REQUIREMENTS

An amateur-built aircraft is not a design approved product or configuration in terms of the CAA categorisation and as such all subsequent design changes are the responsibility of the amateur aircraft builder. However an amateur builder must ensure that those changes are properly recorded in the aircraft logbook. Therefore the amateur builder must to carry out and certify modification and repair on the aircraft and is fully responsible for modification and repair of such an aircraft. Amateur builders performing modification are advised to make themselves fully aware of their legal responsibility under the aviation legislation.

NOTE: In view of the amateur-built aircraft not intended to comply with any prevailing airworthiness design standard, the classification of major or minor modification is not necessarily applicable.

PROJECT STATUS REPORT

Documented and

Presented by J von Ludwig

To the Owner

Abstract

Project status in regard to the Modification application lodged in terms of CAR part 24

Release Date: 15 December 2017

L. Tollemache
16/12/2017

H.L. Currie
2017/12/16.

Table of Contents

L. TOUCHEMACHE
16/12/2017

H.L. Cave.
2017/12/16.

1. Status of Project

1.1 General

The aircraft as presented to me for inspection was already modified by the current owner. The work done by the owner was commented on in relation to Good Technical Practice standards. The Gyro ZU-BUA was not inspected against a specific Inspection list because no such list existed at the time. The gyro was not inspected for the suitability or inherent safety of the modification.

1.2 Powertrain

The aircraft is now equipped with Subaru EJ25 Normally aspirated engine recovered from a RAF gyroplane which the owner bought after a hanger door fell on the RAF gyro. A Static run was conducted and the following were monitored:

Engine rpm

Water temperature

Air / fuel ratio

No alarming values or unexpected behavior were observed. The prop balance was not performed at the time and still need to be done before the Test flight program starts. Prop blade pitch was also not checked and need to be confirmed before the actual flying.

1.3 Fuselage/Cabin

The composite fuselage is a stock standard original Sycamore MK1 fuselage. The only modification which could be observed at the time was in the engine mounting, wiring and instrumentation.

1.4 Rotor System

At the time of presentation, ZU-BUA was equipped with a rotor system which resembles a old early model Chayair Sycamore or a RAF rotor. According to the owner the hubbar and composite blades came with the Sycamore gyro when he bought it. The two composite blades were mass balance checked and a significant weight and CG imbalance was corrected. The hub bar was not inspected for suitability or cracks (condition)

The owner was verbally informed that the hubbar system is a very sensitive component and that further consultation with RAF and CAA Engineering would be wise because there has been structural failures documented on these systems in the past. There are specific issues around the main tension bolts and the backing washers for which I do not have SB or inspection criteria. The adjustments for pitch was not inspected or commented on during any report on the overall modification. No modification to the rotor blades hub bar or rotor head was presented to CAA.

1.5 Weight and Balance

During the W&B procedure it was noted that this gyro is exceptionally heavy for it's class. The hang angle is also completely out of the normal ranges we are used to seeing. The back-forward and side travel angles of the head was also out of traditional ranges. I advised the owner on some of the flight characteristics and dangers which are associated with the forces not being in balance. The way forward was suggested to involve more detail engineering calculations of the expected behavior and then followed by a very carefull Test flight program to explore the flight characteristics. The thrust line of

L. Tollemache
16/12/2017

H.L. Currie.
2017/12/16.

this gyro also appears very high and more detail measuring is needed to comment on the effects thereof.

2. Regulatory Category

This gyro is a Part 24 machine operated by the owner for Private pleasure. Historically the Sycamore type was removed from the Production build category and placed under the Amateur build category.

There is no further Factory support for the Type and no Safety or Maintenance oversight.

No airworthiness standard can be presented because the original Sycamore build standard is not sufficiently documented at CAA. I advised the owner to proceed with a formal Mod application to CAA and in this regard, I assisted the owner to prepare the application forms and I assisted the owner further to e-mail the documentation to CAA Engineering. The documents were later even hand delivered to CAA. To date no reply or response were received.

An application for Proving flight was also included in the e-mailed and delivered document pack.

With no response from CAA the owner requested an inspection for a RAASA AtF. RAASA process was followed and the gyro received an AtF from RAASA. I made it very clear to the owner that the RAASA AtF does not override the CAA Mod process and I strongly suggest that the CAA process stay a high priority until he have written response on file to indicate the closure of the CAA process.

The Pilot Operating handbook is completely out of status with the current configuration and the initial Project plan discussed with the owner instructed that the Pilot operating handbook as well as the Maintenance manuals be corrected and handed in after the Proving flight phase has been concluded AND before the application for first AtF from CAA was handed in. This might now fall through the cracks if not actively pursued by the owner.

3. First of type Autogyro

This gyro is a unique combination of a standard old model Sycamore and a standard RAF Subaru NA engine. The modification was performed by the owner. No comment, approval or endorsement is given on the suitability of this specific combination. It is strongly suggested that a person with a Sycamore type rating do not just fly this machine, rather get a person with suitable experience to investigate and explore this machine further.

For further information or any inquiries regarding the aircraft, please feel free to contact:

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2017/12/16.

4. Expected maximum and empty take-off weights

No structural changes were presented so the best estimate I can come up with is the typical original Sycamore Specs which applied at the time. Because of the heavier allowing can be expected:

Table 1 - Expected Weights

MTOW	600 kg
Empty Weight	448 kg
Useful Weight	150 kg

Applicability: Sycamore Modification status
Edition 1/ Rev 0
15 December 2017

L. Tocchiache
16/12/2017

H.L. Carré.
2017/12/16.