Technical report
ULM A-010/2020

Accident on 13 July 2020 involving a DYNALI H3 'EASY FLYER' aircraft with registration EC- GS5, in Ontígola (Toledo)

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MINISTERIO DE TRANSPORTES, MOVILIDAD Y AGENDA URBANA

SUBSECRETARÍA

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

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In accordance with the provisions of Article 5.4.1 of Annex 13 of the International Civil Aviation Convention, Article 5.6 of Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010; Article 15 of Law 21/2003 on Air Safety; and Articles 1 and 21.2 of RD 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent their recurrence. The investigation is not intended to attribute any blame or liability, nor to prejudge any decisions that may be taken by the judicial authorities. Therefore, and according to the laws specified above, the investigation was carried out using procedures not necessarily subject to the guarantees and rights by which evidence should be governed in a judicial process.

Consequently, the use of this report for any purpose other than the prevention of future accidents may lead to erroneous conclusions or interpretations.

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ABBREVIATIONS

° ‘ “	Sexagesimal degrees, minutes and seconds
°C	Degrees Celsius
A	Amperes
AEMET	State Meteorological Agency
AESA	Spain’s National Aviation Safety Agency
ATO	Approved Training Organisation
BCAR	British Civil Airworthiness Requirements
CS	Certification Specifications
EASA	European Aviation Safety Agency
ECU	Engine control unit
EFIS	Electronic flight instrument system
ft	Feet
GPS	Global positioning system
h	Hours
H	Helicopter
LT	Local time
hp	Horsepower
HUL	Ultralight helicopters
kg	Kilograms
km	Kilometres
km/h	Kilometres per hour
kPa	Kilopascals
LAPL	Light Aircraft Pilot License
m	Metres
mAh	Milliampere hour
MAF	Multi-axis fixed-wing
MTOW	Maximum Take-Off Weight
No.	Number
N	North
W	West
OEW	Operational Empty Weight
ohm	Ohms
RD	Royal Decree
R/TC	Spanish-speaking radio telephonist
s	Seconds
SNS	Event notification system
T	Temperature
TULM	Ultralight Aircraft Pilot
EU	European Union
V	Volts

V/min	Volts per minute
VFR	Visual flight rules
VLR	Very Light Rotorcraft
W	Watts

SYNOPSIS

Owner and operator:	Helicópteros Deportivos de España S.L.
Aircraft:	Dynali H3 ‘Easy Flyer’, EC-GS5
Date and time of the accident:	13 July 2020: 12:50 LT [1]
Site of the accident:	Approximately 7 km north of Ocaña (Toledo).
Persons on board:	One, unharmed
Type of flight:	General aviation – Others - Test.
Phase of flight:	En route - cruising
Date of approval:	28 September 2022

Summary of accident:
On Monday, 13 July 2020, the pilot of the Dynali H3 'Easy Flyer' aircraft, registration EC-GS5, took off at 12:40 from Ocaña Aerodrome (Toledo), intending to carry out a test flight. Eight minutes after take-off, the aircraft suffered a loss of electrical power, causing the engine to stall. At that time, it was in cruise flight at an altitude of 1,100 m, approximately 10 km north of Ocaña Aerodrome and 6 km east of the municipality of Ontígola. Following the engine stoppage, the pilot performed the autorotation manoeuvre, but in the final part of the flare, the main rotor blades struck the tail mast which had been deformed by hitting the ground, causing severe damage to the helicopter's structure.

The pilot was unhurt, but the aircraft suffered significant damage.

The probable cause of the accident is thought to have been the incorrect execution of the autorotation manoeuvre due to an in-flight engine shutdown.

Two safety recommendations have been issued to the 'Dynali Helicopter Company'.

1. FACTUAL INFORMATION

1.1. Overview of the accident

On Monday, 13 July, at approximately 12:30 HL, the pilot of the Dynali H3 'Easy Flyer' aircraft was at Ocaña Aerodrome (Toledo), intending to carry out a test flight with the aircraft. He switched the aircraft on and off several times to perform different tests and waited for the oil to warm up. About 7 minutes after the last switch-on, he initiated a hover at a short distance from the ground. However, a few seconds before lift-off, the battery voltage dropped below 12 V, causing the onboard computer (ECU) warning light to come on. At that time, the pilot didn't notice the light or the low level on the battery voltage indicator. He commenced a taxi and then took off, climbing to an altitude of about 1,000 ft above the airfield, heading north. During the flight, the helicopter's alternator was unable to charge the battery, so the voltage continued to drop gradually. After about 8 minutes of flight, the Electronic Flight Instrument System (EFIS) alarm activated, and the pilot noticed a drop in engine revolutions. On checking the instrument panel, the pilot noticed that the battery level was low. He decided to shut down some systems to try to get the alternator to

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[1] Unless specified otherwise, all times referenced in this report are local.

charge the battery again, but to no avail. After a few seconds, the battery dropped below 7 V, and the engine stalled.

According to his statement, the pilot decided to go into autorotation, lowering the collective control and trying to descend at a constant speed. He stabilised the descent at about 100 km/h and searched for a field suitable for an emergency landing. He didn't have a precise reading of the rotor revolutions during the descent because this information was displayed on the EFIS, which, as the aircraft no longer had a power supply, was switched off. Finally, the pilot decided to land in a crop field, facing north and parallel to a road.

Shortly before touchdown, about 3 m above the ground, the pilot stated that he pulled the cyclic control back to initiate a flare at about 80 km/h, stabilising at about one-metre of altitude and 60 km/h of translational speed. At this point, he performed a rapid braking manoeuvre by pulling the cyclic full back to slow down the translational speed as much as possible. He then stabilised the helicopter by pushing the cyclic forward and raising the collective so that the rotor's inertia further slowed the fall, trying to land on the ground without translational speed.

At some point during this manoeuvre, the clockwise-turning main rotor blades struck the vertical stabiliser and the tail mast, causing the helicopter to yaw rapidly to the right. The pilot stated that he stepped on the left pedal to try to counteract the yaw, but to no avail. After yawing about 180º, the helicopter finally hit the ground.

1.2. Injuries to persons

Injuries	**Crew**	**Passengers**	**Total in the aircraft**	**Others**
Fatal				
Serious				
Minor / None	1		1	N/A
TOTAL	1		1	

1.3. Damage to the aircraft

The aircraft sustained major damage to its tail, main and anti-torque rotors, canopy and landing gear.

1.4. Other damages

N/A

1.5. Information about the personnel

Pilot of the aircraft:

- Age: 52 years
- License: Ultralight pilot license (TULM) - issued in 2011 by the Spanish Aviation Safety Agency (AESA)

- Ratings:
    - Multi-axis fixed wing (MAF), valid until November 2021
    - Helicopter (H), valid until October 2020
    - Radiotelephony Spanish (R/TC)
- Medical certificate: Class 2 (valid until May 2020) and LAPL, valid until May 2021.
- Total flight hours: 562 h
- Hours in type of aircraft: 541:37 h
- Flight hours in the last year: 30:03 h
- Flight hours in the last 3 months: 1:07:00 h
- Previous training: The pilot had previously performed numerous autorotation exercises (letting the engine idle and staying a few metres above the ground). He had also done four full autorotations to the ground, but all with the engine idling, as shutting it down completely is considered too high a risk.

1.6. Information about the aircraft

1.6.1. General information

The aircraft involved in the accident was an H3 'Easy Flyer' manufactured by the 'Dynali Helicopter Company', with an MTOW of 450 kg and an OEW of 278 kg. It was built in 2014. At the time of the accident, the aircraft's hour meter read 227 hours.

It is an ultralight helicopter with carbon fibre fairing and skids, powered by a 110 hp Rotax 912 ULS engine with an electronic fuel injection system designed by Dynali. The main rotor blades rotate clockwise, and it is designed for the pilot to sit on the left if travelling alone. It was designed according to French certification specifications for ultralight helicopters. The Type Certificate for Spain was subsequently obtained in 2016, following national regulations.

The aircraft had a valid Restricted Airworthiness Certificate issued by AESA. Its serial number is H3-22-1443.

Image 1: Dynali H3 “Easy Flyer” EC-GS5 aircraft (extracted from AviationCorner.net)

1.6.2. Relevant service bulletins

Initially, the helicopter was designed with two parallel vertical stabilisers of lower height, but it was decided to change to a single, taller stabiliser to improve the helicopter's cruise stability (see Illustration 2). However, this reduced the efficiency of the tail rotor, as the stabiliser interfered with its airflow, so another service bulletin was issued requiring the vertical stabiliser to be moved forward by 20 cm.

Illustration 2: Previous designs of the vertical and horizontal stabilisers

1.6.3. Aircraft's engine and electrical circuit

The engine fitted to the aircraft is a Rotax 912 ULS (110 hp) with electronic fuel injection, the latter having been developed by Dynali. The original Rotax 912 ULS engine is rated at 100 hp, but Dynali's electronic injection increases the power to 110 hp. According to the engine logbook, the engine had 346:16 h at the time of the accident.

According to point 3.5 of the Rotax 912 Maintenance Manual, the ULS version is not certified, but separate certification is not required for ultralight use, as the aircraft and engine must be certified together. However, it adds that this engine type has been manufactured using the same standards as the certified and tested versions.

In the versions of the Rotax 912 installation and maintenance manuals in force at the time of the accident, the following safety warning appears:

- "This engine has exclusively been developed and tested for fixed wing, gyrocopter, pusher and tractor applications. In case of any other usage, the aircraft manufacturer is responsible for testing and the correct function of the engine."

Due to the fact that the Rotax 912 was designed for use in fixed-wing aircraft that can harness airflow for cooling, it can require additional cooling mechanisms when installed in a helicopter, which is able to maintain flight at a fixed point. For this reason, the H3's engine has two electric fans installed underneath. These fans activate automatically when the T of the engine oil is high (the first fan when the T exceeds 97°C and the second when the T exceeds 103°C, according to EFIS data). These fans rely on the battery voltage for power. The system ensures the engine can be cooled even when maintaining flight at a standstill.

The aircraft's electrical circuit is powered by the standard Rotax 912 ULS alternator (250W power at 5,800 rpm) and an 'Aliant Type X3' 13.2 V nominal, 6,900 mAh capacity battery that can last up to 7,000 charge/discharge cycles at over 70% capacity, according to its manual. The electrical system powers various other systems, such as the fans, the helicopter's lights, the communications system, the fuel pump, the onboard computer (ECU), and so on...

The 912 ULS engine has, as standard, two separate electrical circuits to power the engine's spark plugs, so the failure of one alone would not cause the engine to shut down.

The manufacturer was asked whether the electrical system can operate with a flat battery, i.e., with the alternator only. The answer was that, in theory, it can as the battery is connected to the electrical circuit in parallel, so the alternator could supply power to the electrical system, as long as the electrical demand does not exceed its capacity (250W). However, flying like this is not recommended, as the battery is needed to help stabilise the current after the alternator rectifier and to supply the system's peak electrical demand. In addition, the ECU needs a flow of stable current to function properly, and as fuel injection system is controlled by the ECU, the engine needs an electrical supply to operate.

At the time of the accident, the manufacturer was offering buyers of the H3 model an optional safety upgrade consisting of an additional electrical circuit, with a second 500 W alternator and an additional battery. This extra option increased the weight of the aircraft by 3 kg. It was included as standard on the higher-end models and cost 1,313 euros for the other models. Since the accident, this option has been included as standard on all models sold by Dynali.

1.6.4. Control panel

Illustration 3: Control panel on the Dynali H3

The control panel has analogue instruments, such as an anemometer and variometer, and a digital display that shows the engine and main rotor revolutions, among other data, to complete the information.

The instrument panel has different coloured warning lights for easy identification by the pilot. The main group of lights is at the top, just below the instrument panel surround, which shields them from direct sunlight. They include the red generator warning light ('GEN'), which illuminates if it stops supplying power to the electrical components. According to the flight manual, you must land immediately if this light comes on.

In addition, there are 3 more warning lights on the lower part of the panel, including the red ECU warning light that warns of low oil temperature or low battery voltage, among other things, and is located at the bottom right of the panel. The flight manual stipulates that you have to wait for it to switch off before take-off (indicating that the oil has warmed up) and that if it comes on in-flight, the helicopter should be landed immediately.

In this area, it's easier for direct sunlight to affect the light (see Illustration 4). In current versions of the helicopter, however, this warning light is located on the main digital display (EFIS).

Illustration 4: impact of the sun on low battery warning light (and others)

1.6.5. Flight manual

Relevant parts of the aircraft flight manual are set out below:

Regarding operating limits, the flight manual stipulates the following:

- The engine must not be started at an ambient T of more than 40°
- Negative load values must not be obtained at any time.

With regard to this limit, the manual provides the following warning:

"Negative load values are strictly forbidden. Avoid forward cyclic command over-control after a reverse cyclic pitch control or collective pitch increment has been performed. All manoeuvres must be conducted smoothly and with minimal adjustments, especially those that may put the helicopter at negative load values."

Furthermore, in the emergency procedures section, it states the following:

"3.1 GENERAL ENGINE FAILURE
- EVERY PILOT MUST BE TRAINED FOR AUTOROTATION.
- A loss of power may be caused by a failure of engine or transmission.
- A change in the noise level, a yawing movement or a loss of revolutions (RPM) may indicate an engine failure.
- An unusual noise, vibrations or serious yawing may indicate a transmission failure. In all events, perform a precautionary autorotation landing.
- If you hear a suspicious noise or shock, pay attention, lower the collective and take action.

3.2 ENGINE FAILURE ABOVE 500FT
- Lower the collective completely and immediately initiate autorotation.
- Cut the throttle and push the left pedal down to maintain the heading.
- Keep the translational speed above 100km/h
- Use collective to maintain rotor RPM.

- Select landing point facing into wind.
- Approaching the ground, act on the cyclic stick to flare and reduce rate of descent WITHOUT RISING THE COLLECTIVE.
- At around 3 m, push the cyclic forward to bring the helicopter to horizontal and raise the collective to halt the descent.
- Preferably land into the wind."

1.6.6. Maintenance

The aircraft's maintenance programme had been properly complied with, and the last maintenance task performed was the 250 h overhaul carried out at Dynali's facilities in France. The accident was the second flight after the aircraft overhaul. The 250 h overhaul had checked, among other things, that the battery had an acceptable level of charge, and the decision was taken not to change it. Although the Spanish maintenance programme specifies that the battery must be replaced, the original maintenance programme specifies only that it must be checked.

Tests on the aircraft's alternator do not appear in the list of tasks performed during the overhaul, nor do they form part of the aircraft's scheduled maintenance. The scheduled maintenance programme for Rotax 912 ULS engines specifies that the alternator should be checked during the 'Overhaul', which, in the case of this engine, would be performed at 2,000 hours.

1.7. Meteorological information

The State Meteorological Agency (AEMET) weather station in Ocaña, located 6 km south of the accident site, recorded the following data at 12:00 and 13:00 HL:

- Wind:
  - Direction: North.
  - Average speed 7 km/h
- Visibility: good on the ground.
- Cloud cover: clear.
- Temperature: around 31°C.
- Altitude (of the meteorological station): 733 m
- Relative humidity: around 37%.
- There was no rainfall or warnings of adverse phenomena.

In addition, the aircraft ECU recorded T parameters of 32°C at the airfield and approximately 26°C at cruise level. The pilot stated that the wind during the flight was about 9 km/h from a northerly direction.

1.8. Aids to navigation

N/A.

1.9. Communications

No communications were made from the aircraft in the minutes before the accident, and the pilot also disconnected the radio to try to reduce power consumption in the last seconds before the engine shutdown.

1.10. Information about the aerodrome

N/A.

1.11. Flight recorders

The aircraft was not equipped with a conventional flight data recorder or a cockpit voice recorder, as it is not a requirement for this type of aircraft. It also did not have an active GPS during the flight. However, this aircraft is fitted as standard with an electronic engine control unit (ECU), model 'Motec 400', which controls the engine's operation and records certain flight parameters. The most significant parameters of the accident flight can be seen in Illustration 5 below (the 'Aux 3 Duty' and 'Aux 4 Duty' parameters indicate the activation of the two fans fitted to the engine for cooling).

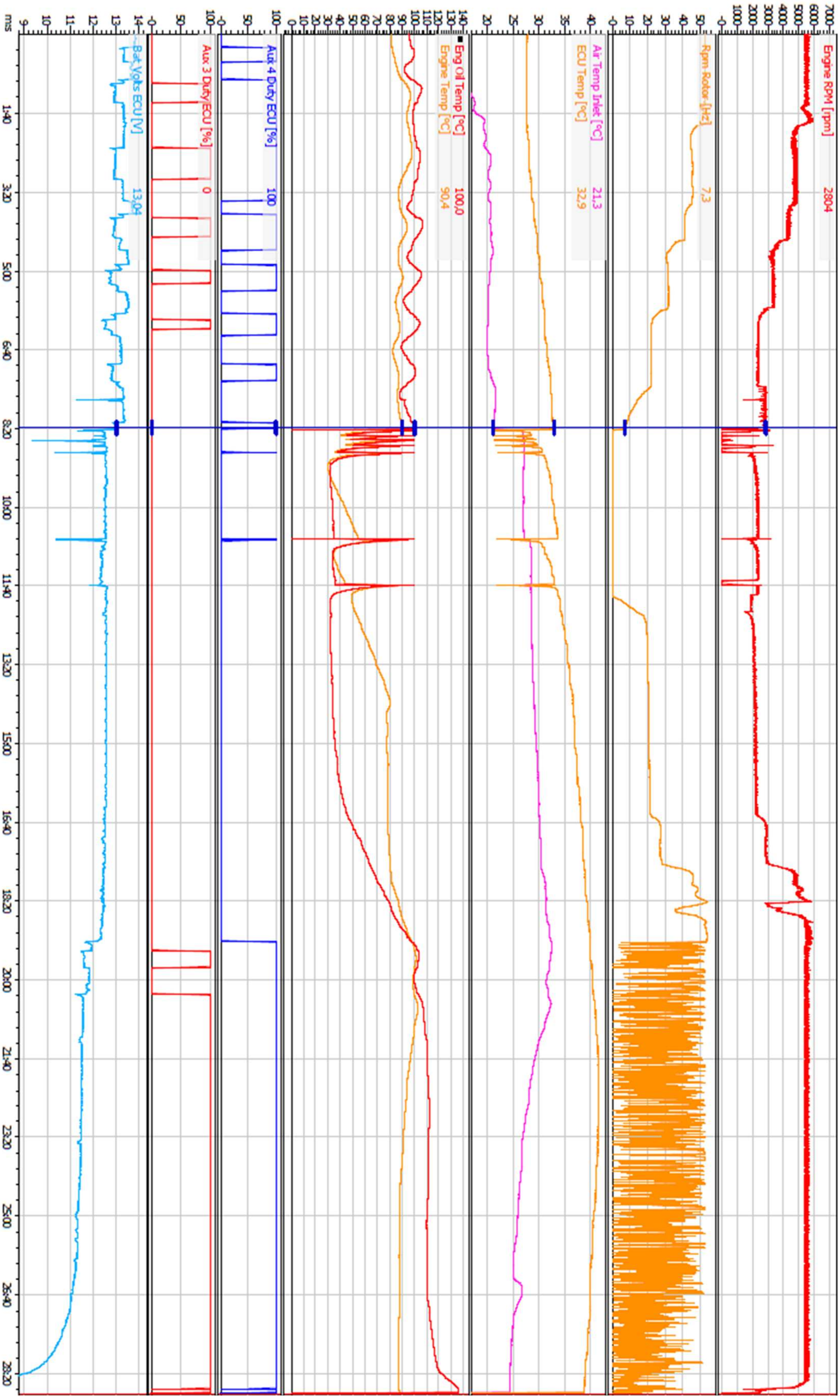

Illustration 5: Graphic showing the most relevant data recorded by the ECU for the accident flight

Data from that flight and other test flights made with the same helicopter a few months earlier were obtained. After a study of the parameters recorded, the following conclusions were drawn:

- The last recording lasts for 1,725 s (28 m and 45 s). Of that, the first 502 s (8:20) are from a flight prior to the accident (denoted by a different atmospheric pressure after landing).
- The first recording from the day of the flight includes five different engine ignitions and shutdowns between seconds 502 and 530. These are followed by two more, with a larger interval between them, at seconds 641 and 699, respectively). You can see that some time passed between the sixth switch-off and ignition, as there is a drop in the oil T and a rise in the intake T. The pilot said he carried out multiple engine ignitions to run different tests. The battery voltage level after the ignitions was 12.5 V.
- At second 1,150 (19:10), the following things happen:
  - The battery voltage drops below 12 V
  - The ECU alert activates again (it had deactivated when the oil T rose above 50°).
  - The main rotor RPM measurement starts to give meaningless values.
  - One of the 2 fans activates (10 s later, the second fan activates). Both of them ran without interruption until the battery failure.

  According to the manufacturer's statement, insufficient voltage can cause some measurements to display meaningless values (such as the main rotor revolutions). In addition, the fans started to run at lower power, reducing their efficiency.
- The helicopter lifted off the ground at second 1,163 (19:23), denoted by a significant increase in fuel consumption and intake pressure.
- Barometric pressure is 93.1 kPa at the airfield (at an elevation of 773 m). The pressure starts to drop at second 1,248 (20:48), which indicates that this was when the aircraft began to gain altitude.
- When the engine shut down, the barometric pressure was at 90 kPa, so the altitude was about 1,100 m.
- With regard to the battery voltage measurement:
  - Every time either of the two fans activated, there was a drop in voltage of about 0.3 V.
  - During the accident flight, and the other flights recorded, the battery was slowly losing charge, even at cruising power. Regardless of abrupt drops at the start, the battery voltage declines steadily, little by little, dropping 0.3 V in 16 minutes on the first flight (0.018 V/min) and 0.43 V in 16 minutes on the second flight (0.025 V/min). During the accident flight, comparing the area where the voltage drops linearly (before the final non-linear deterioration), the drop is 0.1 V in 221 seconds (0.027 V/min).
  - The battery values declared by the pilot (at lift-off and when the RPM drop occurred) do not match those recorded by the ECU. The pilot stated that before take-off, it was between 14 and 15 V, but the recording has it at around 12.5 V, and the warning light was triggered when it dropped below 12 V. A few seconds before the stall, the pilot stated that he saw the instrument reading 12

V and falling, but what was recorded seconds before the engine RPM drop was a voltage of about 8 V, with the engine stalling as it dropped below 7 V.

- With regard to the fans:
  - The graphs show one fan switching on when the oil T exceeds 97°C and the second when it exceeds 103°C.
  - In both the previous flight and the accident flight, the oil T tends to rise beyond the above-mentioned values and does so repeatedly, showing that the fans were working intermittently in cruise flight.
- For much of the flight, the T of the engine oil and coolant remained stable (around 110 and 90°C, respectively). However, when the battery voltage dropped below 11 V (at sec 1,600 - 26:39), the engine oil T began to increase, initially linearly and then parabolically until the engine failure.
- At second 1,709 (28:28), a decrease in engine RPM begins, with the engine finally stalling at second 1,724 (28:44)

1.12. Aircraft wreckage and impact information

Illustration 6: Final position of the aircraft after the accident

The impact site was located about 9 km to the north of Olocau Aerodrome. Its coordinates are 40° 01' 11" N, 3° 30' 15 W. The aircraft came to rest facing south, 10 m east of a road. The terrain where it crash-landed was a stubble field. The ground was hard and covered with the remains of a harvested cereal crop, making it difficult to detect any possible markings left by the aircraft.

Illustration 7 shows the relative positions in which the helicopter and the parts that came off in the accident were found. No impact or drag marks were found except for those where the aircraft was already located.

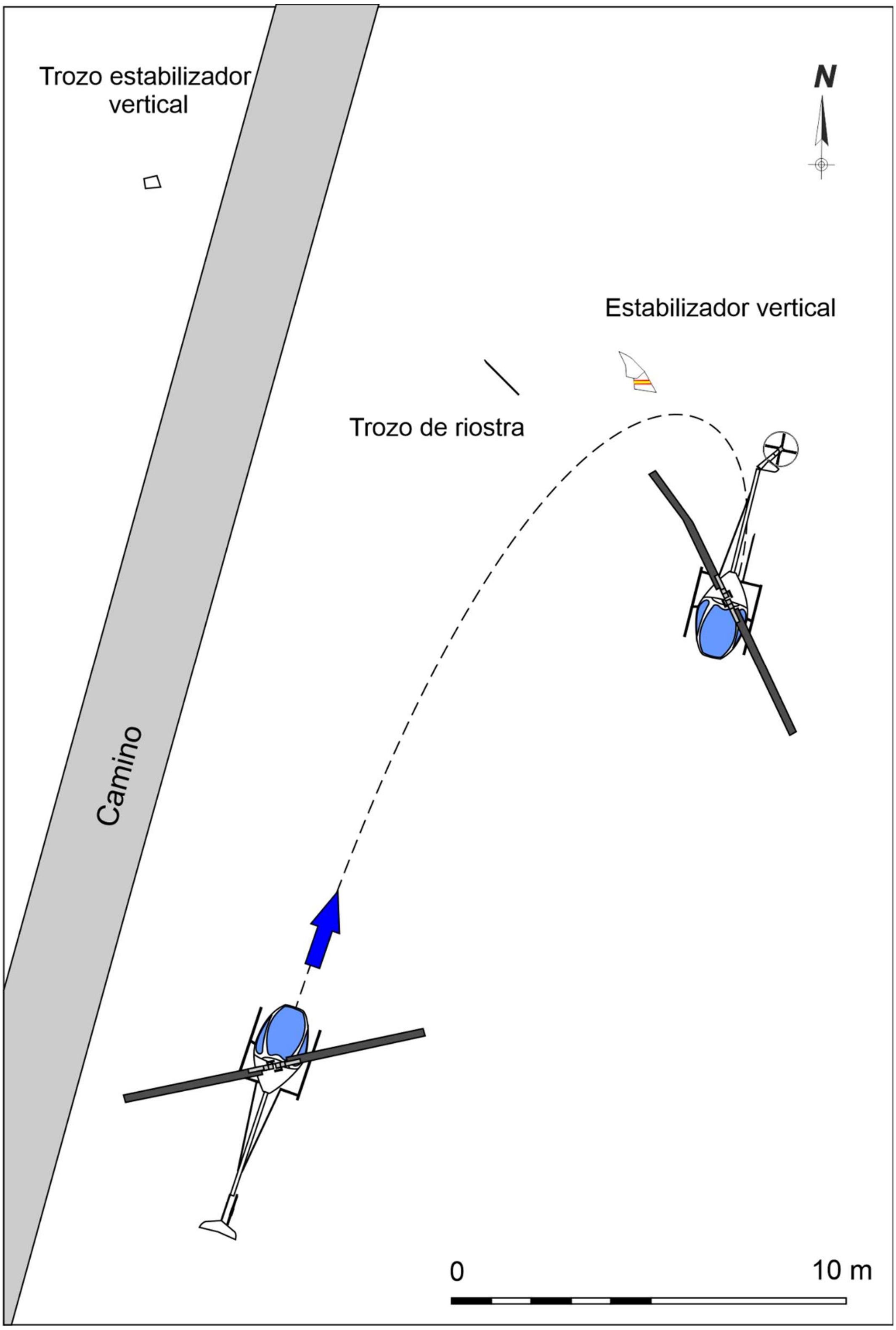

Illustration 7: Sketch of the positions of the aircraft wreckage

Image 8: Dynali H3 at the accident site

The mast had a large crack in its final third, where it had been bent and torn to the point of almost detaching. This gash was about 30 cm long. There were marks and scratches covering an area of the same length on the tip of one of the main rotor blades.

Image 9: Damage to the tail mast and anti-torque rotor

The left tail mast bracing strut (carbon fibre) was broken at two different points.

Image 10: Damaged left strut

The bulk of the 'Shark Fin' (horizontal and vertical stabilisers) had detached, leaving only the bit closest to the tail mast attached. There was a small notch in the lower third of the leading edge of the vertical stabiliser (about 2x2 cm).

The protective ring around the anti-torque rotor was broken and bore marks from striking the ground (traces of dirt). One of the two metal rods supporting it was bent and separated at the joint. There were marks and scratches on the anti-torque rotor blades (carbon fibre), but they remained intact (see Illustration 11).

Illustration 11: Damage to the 'Shark Fin' and the anti-torque rotor

The aluminium main rotor blades were scratched and had traces of white and red paint on the leading edge. Both were also bent downwards at their attachment point. In addition, the blue blade was bent sharply backwards from the middle and had rotated 180° on its longitudinal axis, bending the pitch change rod in the process (see Illustration 12). The main rotor shaft displayed marks where it had come into contact with the blade attachment sockets. The lower ring of the swashplate was severed in one place.

Illustration 12: Main rotor blades and shaft

The carbon fibre canopy was partially cracked from the left lower mounting to the window. The upper couplings to the aircraft cabin were completely detached. However, a safety restraint strap (made of fabric) at the top prevented the canopy from moving by more than a few centimetres, the displacement being forward and to the left.

The skids had been deformed by crushing, pulling away from the fuselage. The left skid was notably more deformed than the right.

Image 13: Damage to the tail, mast struts and skids.

1.13. Medical and pathological information

The pilot of the aircraft was unhurt and able to evacuate the helicopter without assistance.

There is no evidence that physiological factors or disabilities affected the pilot's performance.

1.14. Fire

N/A.

1.15. Survival aspects

The upper canopy attachments broke off, and the canopy was partially split from the lower left canopy attachment. However, thanks to a safety mechanism consisting of a fabric strap, it was only displaced by a few centimetres on impact. As a result, the canopy did not hit the pilot.

The pilot’s seat and restraint system functioned as designed, preventing him from sustaining injuries.

The pilot was able to exit the aircraft unassisted.

1.16. Tests and research

1.16.1. Engine inspection

Inspection of the battery

No defects were found in the battery, which was able to be recharged and reused after the helicopter accident.

Alternator inspection

- The alternator coils were statically checked. The resistance between the alternator output wires was 27 ohm, and the maximum acceptable value, according to the Rotax 912 engine advanced maintenance manual, is 0.8 ohm.
- The resistance between each of the alternator output cables and ground was 21/24 ohm when according to the manufacturer, it should be infinite.
- The engine was started, and at approx. 4,000 RPM with the alternator cables disconnected, the voltage between them was only about 15 V when it should be between 15 and 20 V at idle, or between 30 and 45 V at high revs, according to the technical expert consulted.

From the above tests, it was concluded that some of the alternator coils were defective and that, therefore, the alternator must have been delivering electrical power below its rated value (which is 250W at 5,800 rpm). However, at no time during the accident flight did the alternator warning light come on, which means the deterioration wasn't significant enough to trigger the alternator alarm.

Inspection of the battery voltage indicator

Taking into account that the voltage values declared by the pilot did not coincide with those recorded by the EFIS (neither at the start of the flight nor at the time of engine shutdown), we proceeded to check the cockpit indicator to see when the low battery light illuminated. It came on when the voltage fell below 12 V, which is consistent with what was recorded by the ECU, and shows that the cabin voltage indicator was working correctly and that the accident flight started with a voltage below 12 V.

Electrical consumption of the different systems

The power consumed by the helicopter's various systems was also measured by applying an ammeter to the main electrical circuit. Some of the electrical systems couldn't be switched on due to the damage, but we were able to measure a maximum power consumption of 8 A with the engine off (lights on, communications by pressing the 'Push to Talk' button, fuel pump and ECU). With the engine and both fans on (but with lights and communications switched off), the power consumption was around 18 A.

The manufacturer also provided the power consumption of the aircraft's most important systems:

- 2 SPAL VA08-AP10/C-23° fans:	6.5 A each

Electric fuel pump	3 A
Lambda sensor	about 3 A
Lights:	3 A each
Internal plug:	Depends on what's plugged in

As can be seen, with both fans and the other systems on, the consumption is higher than the generator can provide (250W, which at 12 V results in 20.8 A).
The manufacturer stated that the fans should only be on at the same time continuously in exceptional circumstances, such as a stationary flight on a hot day. In such cases, the battery should provide the extra power needed.

1.17. Organisational and management information

The company 'Helicópteros Deportivos de España' was in charge of certifying the helicopter in Spain in compliance with the Order of 14 November 1988. To this end, certification specifications from different countries were used as a reference, such as the British BCAR-CAP750-VLH for structural strength tests and the French CS-27 VLR and HUL for flight systems (using the most restrictive standards in the event of discrepancies). The Spanish Type Certificate was obtained in 2016. The company intended to sell the model in Spain but abandoned the plan after the accident, and as of the date of approval of this report, the only Dynali helicopter registered in Spain is the one that was involved in the accident.

In 2020, the company had also obtained ATO approval as an ultralight helicopter flight school from AESA, where the pilot involved in the accident would be the school's instructor. However, it had yet to start its operations at the time of the accident.

For its part, the company that designed the helicopter, the Dynali Helicopter Company, used French HUL (Ultralight Helicopters) standards and certification specifications to develop it.

1.18. Additional information

1.18.1. Other certification specifications for ultralight helicopters

Having consulted the regulations and certification specifications (CS) for electrical circuits on ultralight aircraft, the following point was found in EASA's CS VLR (for very light rotorcraft) (also present in the English CS, BCAR VLR):

'CS VLR 1165 Engine ignition systems

- *(a) Each battery ignition system must be supplemented by an alternator that is automatically available as an alternate source of electrical energy to allow continued engine operation if any battery becomes depleted.*
- *(b) The capacity of batteries and generators must be large enough to meet the simultaneous demands of the engine ignition system and the greatest demands of any electrical system components that draw from the same source.*
- *(c) The design of the engine ignition system must account for:*
    1. *The condition of an inoperative alternator*
    2. *The condition of a completely depleted battery with the alternator running at its normal operating speed; and*

   3. *The condition of a completely depleted battery with the alternator operating at idling speed if there is only one battery.*

(d) There must be means to warn the pilot if malfunctioning of any part of the electrical system is causing the continuous discharge of any battery used for engine ignition.'

It should be noted that this point does not appear in the French specifications for ultralight helicopters, which were used to design the helicopter.

1.18.2. History of similar events

The manufacturer stated that they had no knowledge of any engine shutdowns due to an in-flight loss of power supply on other H3 models flying in other countries, mainly France. At the time of the accident, the manufacturer stated that there were 22 other H3 models with the same characteristics as the one involved in the accident in service.

As for the number of autorotations performed in Spain, a search was carried out in the Eccairs database, which stores data provided by the Incident Reporting System (SNS). We searched for events involving an autorotation reported in the last 15 years in Spain. Eleven were found. Nine of these incidents resulted in major damage to the aircraft, with the aircraft remaining intact or escaping with minor damage in only two. According to this data, more than 80% of the reported autorotations involved major damage to the aircraft. While this data does not reflect the successful autorotations that were not reported, it does indicate that the chances of performing an autorotation without engine power and avoiding damage to the aircraft are slim.

1.19. Special investigation techniques

N/A.

2. ANALYSIS

2.1. Engine shutdown

The fuel injection system, designed by Dynali, relies on an electrical supply to work. In addition, the manufacturer stated that for the electrical circuit to function correctly, the battery can't be depleted as it helps to stabilise the current and cope with excess electrical demand. With a depleted battery, the engine will stall if the electrical demand exceeds the alternator's capacity. The data recorded by the EFIS showed that the battery was completely depleted seconds before the engine stalled at a time of high electrical demand from the systems, leading to the stoppage. In this section, we'll look at how the battery might have drained in cruise flight.

A possible battery failure has been ruled out as the inspection of the aircraft found no evidence of a malfunction, and the manufacturer stated that the battery was tested at the 250 h-inspection, found to be functioning correctly, and, as a result, was not replaced (as permitted by the manufacturer's original maintenance programme).

However, the post-accident inspection found that the alternator was defective and, according to the data log, the battery had been slowly draining in cruise flight (both during the accident flight and the earlier flights recorded by the ECU). Therefore, the capacity of the alternator was less than its rated capacity. The alternator had not been checked during the last overhaul of the aircraft. According to the Rotax maintenance manual, the alternator should be checked at overhaul, which, in this case, would be at 2,000 hours of engine operation (the engine had only 346 hours at the time of the accident).

As explained in section 1.16, the aircraft's power consumption with both fans on simultaneously (in addition to other commonly used systems such as communications or lighting) results in a power demand that exceeds the capacity of the alternator. The manufacturer stated that the fans should only be on simultaneously and continuously in exceptional cases, such as when hovering on a hot day, and that in these exceptional cases, the battery could cover the excess power requirement. However, these conditions may be present throughout large parts of the flight in hot places such as the centre of the Iberian Peninsula.

Running the alternator at full power continuously can have two effects:

1. The extra energy needed by the systems has to come from the battery, and consequently, the battery is not only not able to be recharged by the alternator but also continues to drain in flight.
2. According to the technical expert consulted, demanding more power from the alternator than its maximum capacity for a prolonged period of time can lead to overheating and, eventually, to a deterioration of the coating that separates the different winding coils, reducing their power and worsening the problem. This probably explains why the helicopter's alternator was found to be in poor condition during the inspection.

Additionally, at the start of the flight, the battery was already at a low charge level (12.5 V, according to the data logger). The pilot started the engine as many as five different times, draining it still further. Lastly, the ECU alarm activated on take-off when the battery voltage dropped below 12 V, but the pilot didn't notice and proceeded with the air taxi and subsequent flight. With a low battery level, the power of the fans, and thus their ability to cool the engine, was reduced. This meant they were on for longer, further depleting the battery. After take-off, both fans were on almost continuously until the engine shut down.

In conclusion, the engine shutdown occurred because the flight was initiated with a critically low battery level, which was further compounded by a defective alternator that was then unable to charge it in flight, probably because it had been operating at full capacity for a prolonged period beforehand.

2.2. Aspects relating to the low voltage warning

The pilot stated that, shortly before take-off, the voltage indicator showed between 14 and 15 V and that when the low-revs alarm sounded, the voltage was approximately 12 V. However, subsequent inspection revealed that the EFIS recording matched the cockpit instrument measurement, which was about 12.5 V before take-off and less than 10 V in the final stages of the flight. We have therefore concluded that the pilot must have made a mistake when looking at the battery level, and a possible malfunction of the battery reading instrument has been ruled out.

As for not noticing the activation of the ECU warning light, the following factors probably played a role:

- The inspection of the aircraft found that direct sunlight makes it hard to see the activated warning light and that it is positioned in a place where direct sunlight can easily fall on it (see Illustration 4).
- The warning light is at the bottom of the control panel, out of the pilot's line of sight. In addition, the cyclic control can obscure the pilot's view of it.
- The time of the alarm activation coincided with the take-off of the aircraft, so the pilot was probably focused on other tasks.

We have concluded that the ergonomics of this alarm are less than ideal, especially given the significance attached to its activation in mid-flight (pilots must land immediately if it comes on). However, the manufacturer has stated that its newer aircraft are manufactured differently. In the newer models, the alarm is activated on the digital display with the primary flight indicators, making it much more unlikely that it would go unnoticed.

2.3. Aspects relating to the design of the electrical system

The investigation revealed that due to the design of the electronic injection system and the electrical system, if the power consumption is high, a battery failure can lead to an engine shutdown, because in these circumstances the alternator cannot provide the necessary power to the ECU. This is especially critical in regions with hotter climates, such as the centre of the Iberian Peninsula, where aircraft are often flown in high temperatures. Under these circumstances, it's highly likely that the alternator has to run at maximum capacity for prolonged periods, being unable to recharge the battery and more prone to deteriorating, possibly causing the engine to stall if the battery becomes completely depleted. This situation is considered, given the results, to be unsafe.

While it's true that, in this accident, despite the low battery warning functioning correctly and well in advance of the engine shutdown, the pilot didn't notice it and continued the flight, batteries can also fail suddenly in mid-flight, so having an engine that depends entirely on a single battery and an alternator that doesn't always meet the electrical demands of the aircraft is deemed an unsafe situation.

The French certification specifications (CS) do not contain any requirements in regard to this issue, so the aircraft was designed in accordance with the regulations. There would also be no non-compliance (if applicable) with point 1165 of the EASA CS VLR described in 1.18, as this specifically refers to the engine ignition system (spark plugs), and the Rotax 912 ULS engine has a duplicate magneto circuit.

The manufacturer was aware of the risks of using the aircraft in warmer climates and recommended the optional purchase of a duplicate electrical circuit, including a second alternator (500W) and battery. Adding a duplicate circuit increases the system's capacity and improves safety. This version was only 1,313 euros more expensive and weighed 3 kg more. Given the relatively low impact on the helicopter's purchase price and the battery's importance for flight safety, it was deemed advisable for all H3 helicopters to have this option as standard, even those flying in cooler climates. This was discussed with the manufacturer, and the decision was taken to include the second alternator and battery as standard on the new models. Therefore, we have concluded that this particular safety issue has now been remedied.

As for the models flying in other countries such as France, although the milder climate may make the situation less critical than in Spain, and despite the fact that no further incidents of loss of power supply have been reported, the investigation feels that the owners of these aircrafts should be made aware of the possible risks. Consequently, a recommendation will be issued in this regard to ensure they are informed.

Furthermore, in relation to the models with a single 250W alternator: The Rotax maintenance schedule stipulates that the alternator should be checked at the engine’s overhaul, and the manufacturer assumed the same period for its maintenance schedule. However, this engine was designed for use in fixed-wing aircraft and autogyros, and the interval was calculated without considering the peculiarities of helicopter engine use. Specifically, due to the electric fans it uses to cool the engine, a helicopter's electrical consumption and the demands placed on its alternator are much higher than in other aircraft types. It has already been established that operating the alternator at maximum capacity for a prolonged period can result in its premature degradation (as was probably the case in this accident). We have therefore concluded that, specifically for the Dynali H3 models with a single alternator, it would be appropriate for the manufacturer to carry out a study and, depending on the results, to modify the alternator overhaul period stipulated in its maintenance programme. A recommendation will therefore be made in this regard.

2.4. Actions after the engine shutdown

After the engine shutdown, the pilot immediately started the autorotation manoeuvre by lowering the collective control, acting appropriately to avoid losing the kinetic momentum of the main rotor. Unfortunately, he was unable to monitor and control the rotor revolutions (as stipulated in the flight manual) because the digital display that shows them was rendered inoperable by the lack of power supply. As a result, the pilot focused on maintaining an indicated speed of 100 km/h, as stated in the flight manual. In addition, he chose a flat, unobstructed area for the landing and faced into the wind for the touchdown (as also stipulated in the flight manual).

However, according to the pilot's own statement, the final part of the autorotation was performed more abruptly and at a lower altitude than described in the flight manual. The manual stipulates reducing the descent speed close to the ground by pulling the cyclic control, and on reaching 3 m above the ground, pushing the cyclic forward to bring the helicopter to horizontal and, lastly, raising the collective to halt the descent. By doing this the pilot can achieve a sliding landing on the ground. However, the pilot stated that he started braking using the cyclic at about 3 m above the ground, and stabilised at 1 m above the ground. At that point, with a horizontal speed of 60 km/h, he pulled the cyclic to the maximum to halt the translation and immediately afterwards pushed it forward to stabilise the helicopter horizontally. Lastly, after stabilising, he pulled the collective in an attempt to land without sliding.

Given that the pilot performed such an abrupt flare (raising the nose and lowering the tail) at such a short distance from the ground, it seems perfectly feasible that its tail, the back of its skids or both might have hit the ground. This scenario would explain the dirt marks on the tail rotor protection ring and its bent bracing strut and would also have made the helicopter's subsequent commanded pitching movement faster while the main rotor blades continued to rotate backwards due to inertia, causing them to hit the 'Shark Fin' and the mast. The type of terrain, which was hardpacked and covered with cut cereal crop remnants, would explain the absence of marks on the ground despite the helicopter hitting it. In addition, if performed abruptly, this manoeuvre could cause negative load factors, which are expressly prohibited by the flight manual.

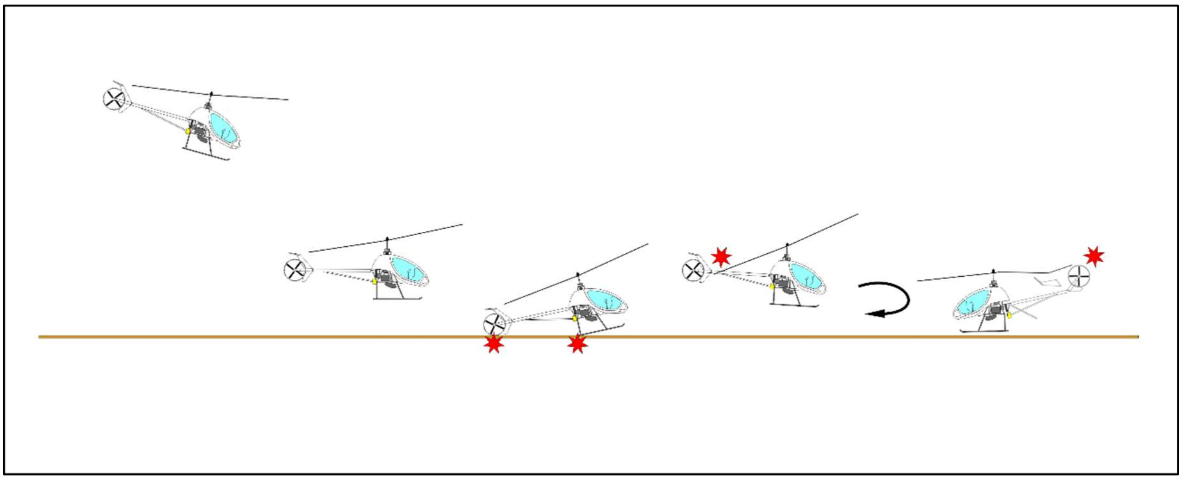

Image 14: Probable sequence of events in the final part of the autorotation

The blade strike resulted in the break and near separation of the last third of the tail mast and the compression fracture of the left mast brace. One of the blades flipped over on its longitudinal axis when it struck the mast. The impact and consequent transfer of kinetic momentum from the rotor to the fuselage also caused the helicopter to yaw to the right, causing the aircraft to turn 180° to the right and eventually hit the ground. Once the structural strength of the tail was compromised, the 'Shark Fin' eventually detached.

3. CONCLUSIONS

3.1. Findings

- Due to the design of the aircraft, the engine cannot operate without power supply.
- The 250W alternator could not meet the aircraft's electrical requirements at peak demand.
- The alternator failed the functionality tests, proving that it was unable to work at full capacity during the flight.
- It was a hot day (32°), which contributed to the electrical system being overloaded.
- The electric fans switched on one minute after take-off and remained on until the engine stalled, contributing to the aircraft's high electrical demand during the flight.
- The low battery voltage warning light came on when the battery voltage dropped below 12 V (roughly at the same time as the pilot took off from the ground). The warning light remained on for the remainder of the flight but wasn't noticed by the pilot until the low engine speed warning was also activated.
- After 9 minutes and 20 seconds of flight, the battery dropped below 7 V, at which point the engine cut out due to a lack of power supply to the aircraft ECU, which controls the injectors.
- According to his statement, the pilot performed the autorotation manoeuvre as per the procedure in the flight manual, except for the flare, which he carried out more abruptly and at a lower altitude than specified.

3.2. Causes/contributing factors

The probable cause of the accident is thought to have been the incorrect execution of the autorotation manoeuvre due to an in-flight engine shutdown.

4. OPERATIONAL SAFETY RECOMMENDATIONS

The investigation concluded that it is unsafe for an aircraft to suffer an engine shutdown due to battery failure when the alternator is at maximum capacity. Given that the helicopter manufacturer already offers additional equipment that doubles the number of alternators and batteries, resolving the unsafe situation, and given that the addition of this purchase option involves minimum extra weight and cost compared to the total cost of the helicopter, the manufacturer has agreed that, in the future, the second alternator and batteries will be included in all purchase options as standard. Consequently, going forward, all new Dynali H3 helicopters will be exempt from the safety issue that affected the one involved in this accident. Therefore, issuing a safety recommendation in this regard has been deemed unnecessary.

By contrast, we feel that pilots owning a Dynali H3 model with a single alternator and battery should be made aware of the potential risk involved in flying with a low battery level and running the alternator to its maximum capacity. The following recommendation is therefore issued:

REC 44/22. It is recommended that the 'Dynali Helicopter Company' distribute this report to owners of 'Dynali H3' helicopters with Rotax 912 ULS engines, the Dynali-designed fuel injection system, and only one alternator and battery installed.

Furthermore, given the potential for the alternators in these models to deteriorate prematurely due to the high power consumption, the following recommendation is issued:

REC 45/22. It is recommended that the 'Dynali Helicopter Company' conduct a study to adjust the interval for checking the Rotax 912 ULS alternator in its maintenance programme for single-alternator models, taking into account the particular pattern of use they are exposed to.