Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

Bureau Enquêtes Accidents pour la Sécurité de l'Aéronautique d'État

(State Aviation Safety Investigation Bureau - BEA-É)

Safety Investigation Report

A-2021-09-A

Event date	April 13th 2021
Place	Cavaillon (Bouches-du-Rhône)
Type of aircraft	Cirrus SR22
Organization	Armée de l'Air et de l'Espace (French Air and Space Force)

BEA-É

NOTICE

USING THE REPORT

In accordance with article L. 1621-3 of the French Transport Code ("Code des Transports"), the sole purpose of this safety report is to prevent accidents and serious incidents without apportioning blame or responsibilities.
The identification of causes does not imply the determination of administrative, civil or criminal liability.
Therefore, any use of the full or partial report for purposes other than its aim of improving safety is contrary to the international commitments of the French Republic and to the spirit of the relevant laws and regulations and is the sole responsibility of its user.

CONTENTS

The first chapter of the report presents the facts relevant to understanding the accident. The second chapter identifies and analyzes the causes of the incident. The third chapter summarizes the conclusions of this analysis and presents the identified causes.
In the fourth and last chapter, the BEA-É specifies its safety recommendations.

Unless otherwise specified, the times quoted in this report are expressed in French legal time.

CREDITS

	Airbus Flight Academy Europe	Cover page
Figure 1	Géoportail and BEA-É	8
Figure 2	BEA-É	9
Figure 3	La Provence credit J. REY	12
Figure 4	Photo Wikipedia credit Malost	12
Figure 5	Google Earth and BEA-É	13
Figure 6	BEA-É	13
Figure 7	France-Bleu	14
Figures 8 to 12	BEA-É	14 to 19
Figures 13 to 21	DGA and BEA-É	20 to 23
Figure 22	Google Earth and BEA-É	24
Figure 23	AAE	27
Figure 24	Cirrus Design	27
Figure 25	Géoportail and BEA-É	29
Figure 26	Géoportailet BEA-É	34

CONTENTS

GLOSSARY

AAE	*Armée de l'Air et de l'Espace* (French Air and Space Force)
AFAE	Airbus Flight Academy Europe
ATC	Air Traffic Control
BA	Air base
CAPS	Cirrus Airframe Parachute System
CEMPN	*Centre d'Expertise Médicale du Personnel Navigant* (Medical Centre for Aviation Personnel)
CFA	*Commandement des forces aériennes* (Air Force Command)
CFAMI	*Centre de Formation Aéronautique Militaire Initiale* (Centre for initial military aviation training)
DGA EP	*Direction Générale de l'Armement - Essais propulseurs* (French Defence Procurement Agency - Turboprop Tests)
DGA TA	*Direction Générale de l'Armement - Techniques aéronautiques* (French Defence Procurement Agency - Aeronautical Techniques)
EASA:	European Union Aviation Safety Agency,
EFPN	*Écoles de Formation du Personnel Navigant* (Air crew training schools)
ft	Feet (1 ft =30.46 cm)
IFR	Instrument Flight Rules
kt	knot (1 kt = 1.852 km/h)
MCE	*Mémento Complément Équipage* (\Crew's Supplementary Instructions)
NOSA	Navigateur Officier Systèmes d'Armes (Weapon systems officer - navigator)
PIC	Pilot in command
POH	Pilot's Operating Handbook
RESEDA	*Restitution des Enregistreurs d'Accidents* (Accident Recorder Analysis Department of DGA EP)

SUMMARY

Date and time of the accident: April 13th 2021 at 14:06 local time
Place of the event: Cavaillon (Bouches-du-Rhône)
Organization: Armée de l'Air et de l'Espace (French Air and Space Force - AAE)
Organizational command: Human Resources Department of the AAE
Unit*:* Centre for Initial Military Aviation Training – (CFAMI)
Aircraft: Cirrus SR22 – Registration No. F-HKCS
Nature of the flight: training flight
Number of persons on board: 3

Summary of the accident, according to the initial findings

On Tuesday, April 13th 2021, an IFR[1] training mission for a candidate Navigator/Weapon Systems Officer (NOSA) was ordered from the Centre for Initial Military Training (CFAMI), in Salon-de-Provence. A Cirrus SR22 aircraft took off from the Salon-de-Provence air base (BA) at 13:58 with a crew consisting of a NOSA instructor, who was also the designated pilot in command (PIC), a pilot instructor and a NOSA trainee.
At 14:06, at the start of the IFR climb, while passing 5000 ft[2] directly above Cavaillon and without any warning sign, the crew heard a loud bang. All the engine parameters dropped, while the propeller continued to be led by the relative wind. After applying the emergency procedure and switching off the automatic pilot, the pilot sent a distress message to the Marseille Provence control tower. The crew started to divert towards the Avignon Caumont airfield in glide mode, but they were forced to abandon this option due to the insufficient altitude and the headwind. The pilot then attempted an engine airstart, but without success. Then, the propeller stopped completely. Finally, the crew decided to use the airframe parachute, which was triggered at an altitude of 600 ft. After a moderate impact on the ground, the aircraft was overturned by strong gusts of the north-westerly "Mistral" wind, which inflated the parachute foil like a sail, dragging the aircraft two hundred metres along the ground. The wrecked aircraft finally came to a complete stop in a bunch of trees next to the motorway close to Cabannes village. The crew evacuated the aircraft during this phase.
The emergency services, which had been alerted by the pilot's distress message, quickly picked up the crew.
The aircraft was destroyed, and one member of the crew sustained minor injury.

Composition of the safety investigation group

- A BEA-É-appointed chief safety investigator (investigator in charge)
- A BEA-É-appointed deputy chief safety investigator
- A technical investigator (BEA-É)
- A Cirrus SR22-experienced pilot;
- An aviation medicine-licensed physician.

Other involved experts

- Direction Générale de l'Armement - Essais Propulseurs (French Defence Procurement Agency - Turboprop Tests) - DGA EP; Division Evaluation des Systèmes Aéropropulsifs (Fuel System Evaluation Division) - DESA;
- DGA EP/RESEDA (accident recorder analysis department) ;
- Météo – France (French national meteorological service).

[1] IFR : Instrument Flight Rules.
[2] ft :feet (1 ft = 30.46 cm).

INTENTIONALLY LEFT BLANK

1. BASIC INFORMATION

1.1. Flight details

1.1.1. Mission

Flight type: IFR[3]
Type of mission: IFR instruction mission
Last taking-off point: BA 701 Salon-de-Provence (LFMY)
Time of take-off: 13:58
Scheduled landing point: BA 701 Salon-de-Provence (LFMY)

1.1.2. Detailed account of the flight

1.1.2.1. Preparation for flight

All trainees and instructors met at 08:15 for the weather briefing of the unit. The forecast weather conditions on that date were fair, and the sky was clear. However, the “Mistral” (strong northwesterly wind) was blowing in the Salon-de-Provence sector, with wind speeds of thirty knots (kt) at ground level, but it was expected to decline slightly in the beginning of the afternoon. This wind would be causing moderate to severe turbulence in the morning. During this briefing, the NOSA instructor explained the afternoon mission to the trainee. This mission is included in flight school’s manual and is part of the initial training course for navigators-weapon systems officers. It consists of an IFR return flight to Grenoble Airfield with landing and take-off on the runway. The mission briefing was scheduled at 13:00.
Shortly after this initial morning briefing, the NOSA instructor cancelled a first training mission that he was expected to carry on in the morning with another trainee. The reason for cancelling this mission was that he considered the wind conditions did not fill the school’s criteria. There was a risk of severe turbulence.

During the morning, the NOSA trainee prepared the navigation tasks of the afternoon. This first IFR flight as a flight navigator gave the trainee an opportunity to show his first flight plan. For the presentation of the plan, he was assisted by the NOSA instructor at about 12:00. Meanwhile the pilot instructor took advantage of some flight cancellations to train solo in very low-altitude navigation and then circled the runway a few times before landing. He was flying between 09:25 and 10:25 in the same aircraft that would also be used for the training flight in the afternoon. This flight was carried out under nominal conditions.

As was scheduled, the briefing of the training mission started at 13:00 with the full crew of the Cirrus. At this meeting, the trainee presented the updated weather forecast. He confirmed the forecast and in particular the wind conditions. The wind in Grenoble was forecast to be less than 10 kt and about 30 kt in Salon, with moderate gusts.

1.1.2.2. Description of the flight and the factors that led to the accident

The briefing ended at about 13:30, and the crew went to the aircraft after signing the flying orders sheet. The Cirrus SR22 was waiting on the apron. It had been prepared by Airbus Flight Academy Europe (AFAE), which provides trainer aircraft to the CFAMI. The pre-flight refuelling and inspection had been carried out by the technical staff of the company between the two flights.
After having completed the aircraft inspection, the crew climbed on-board. The pilot instructor and the trainee sat on the left- and right-hand pilot seats, while the PIC sat in the left-hand back seat.
After the starting procedure, the pilot checked that he had started the voice recorder. On receiving clearance from air traffic control at Salon-de-Provence, the pilot took off at 13:58, taking the flight path, as it was planned by the trainee. The flight started with a climb to level 120. Passing 2 000 ft, the crew left the frequency of the Salon-de-Provence control tower and contacted the Marseille-Provence air traffic control (ATC).

1.1.2.3. Reconstitution of the significant part of the flight path

Whereas the aircraft was carrying on its initial climb, passing 5 000 ft, the crew heard a loud bang, and the pilot observed a sudden fall in engine speed, which dropped to zero with zero oil pressure. The propeller went into the windmill. The pilot noticed the absence of residual power. He then applied the emergency procedure.

[3] IFR: Instrument Flight Rules.

He set the transponder to 7 700 and sent a distress message. The pilot then announced to Marseille-Provence air traffic control that he would head to Avignon airport. Flying at a speed of 105 kt with flight path heading north-west, the aircraft rapidly lost altitude. Since the wind was now blowing from the north at 35 kt, the crew realized that they would not be able to land at Avignon airport. With no further option of landing to any accessible runway, the pilot attempted to restart the engine. The propeller then, came to a complete and permanent stop. Finally, the pilot steered the aircraft towards the Durance River. Since he had not identified a suitable terrain for an emergency landing, the pilot, with the approval of the PIC, positioned the aircraft above the bed of the Durance and got the aircraft ready for the use of the airframe parachute system. However, he sighted a high-voltage power line below the aircraft, between the Durance and the motorway. So, he deferred the parachute ejection procedure and had to release it at the limit of the operating range of the Cirrus Airframe Parachute System (CAPS). Finally, at an altitude of 600 ft, he raised the nose of the Cirrus to reduce the speed of less than 100 kt and actuated the CAPS. A short time after this operation, the aircraft hit the ground. The airframe was immediately overturned by the gusts that continued to fill the canopy of the parachute like a sail, and the aircraft was dragged upside down along on the ground for two hundred metres. The crew took advantage of a few seconds of calmer winds, during which the aircraft stopped moving, to evacuate the cabin in two stages. The aircraft finally came to a complete stop in a grove of trees close to the motorway. It was totally destroyed, and one member of the crew was slightly injured.

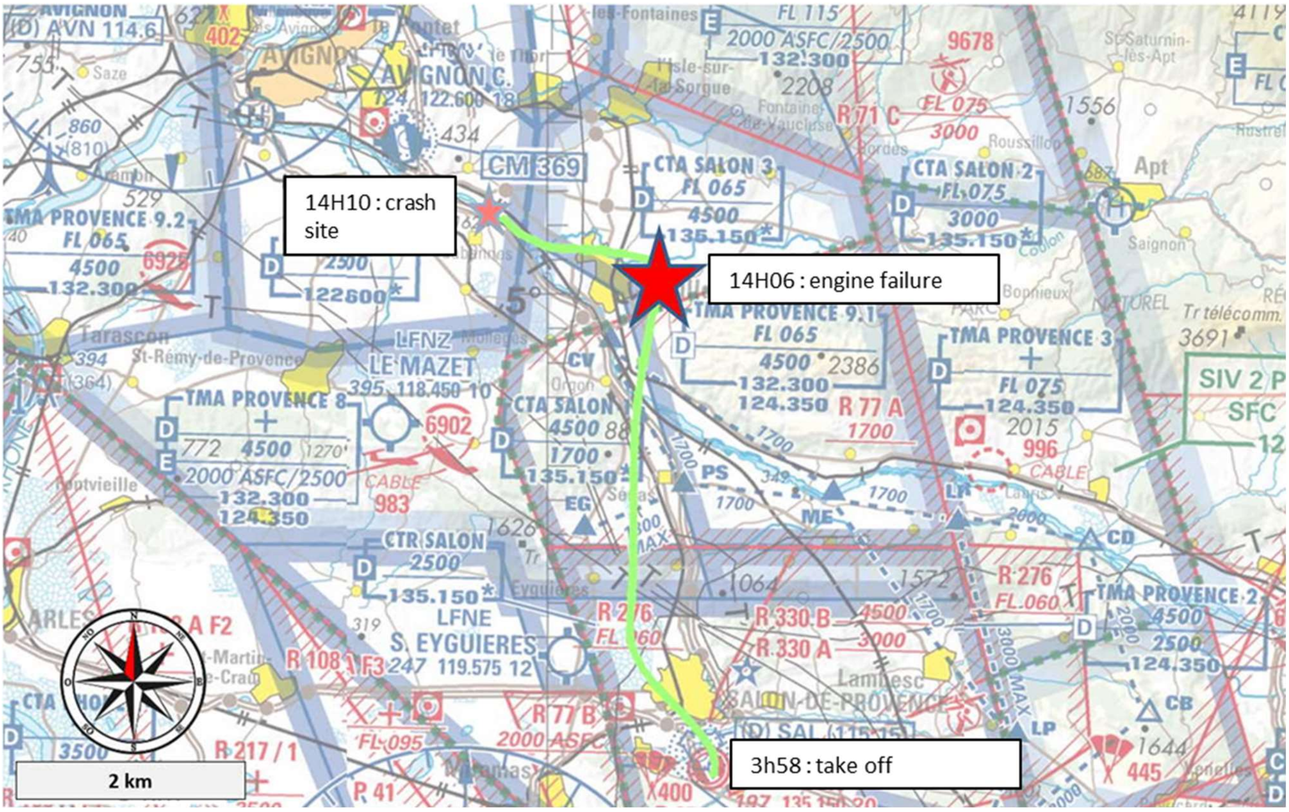

Figure 1: Aircraft's flight path

1.1.3. Location

- Place: above Cavaillon
  - Country: France
  - "Département" : Bouches-du-Rhône (13)
  - Municipality: Cavaillon
  - geographical coordinates :N 43° 49'27''/E 005° 04'19''
  - altitude of the event location: 5 000 ft
- Moment: daytime
- Closest aerodrome at the time of the event: Le Mazet de Romanin (LFNZ)

1.2. Personal injuries

Two members of the crew were unharmed, and one member was slightly injured.

1.3. Aircraft damage

The aircraft was destroyed.

Figure 2: wreck of the Cirrus SR22

1.4. Other damage

Not applicable.

1.5. Information concerning the crew

1.5.1. Captain/NOSA instructor

- Age: 41 years old
- Assigned unit: CFAMI
- Role in the unit: navigator instructor
- Training: NOSA, navigator instructor
    - qualification: chief navigator, NOSA certificate
    - specialization school: fighter aircraft school 2003
- Flight hours as NOSA

	Total		During the previous 6 months		During the previous 30 days	
	on all types	Cirrus SR22	on all types	including Cirrus SR22	on all types	including Cirrus SR22
Total (h)	3 005	250	90	90	24	24

- Date of previous flight on Cirrus SR22 April 2nd 2021

1.5.2. Pilot instructor

- Age: 35 years old
- Assigned unit: CFAMI squadron 2/93 Cévennes

– Role in the unit: squadron commander
– Training: Fighter pilot school
  - qualification: patrol commander, pilot instructor
  - specialization school : fighter aircraft school 2004
– Flight hours as pilot:

	Total		During the previous 6 months		During the previous 30 days	
	on all types	including Cirrus SR22	on all types	including Cirrus SR22	on all types	including Cirrus SR22
Total (h)	1 210	295	65	65	18	18

– Date of previous flight on Cirrus SR22: in the morning of the accident

1.5.3.NOSA trainee

– Age: 21 years old
– Assigned unit: CFAMI
– Role in the unit: NOSA trainee
– Training: NOSA training course in progress
– Flight hours as a NOSA trainee

	Total		During the previous 6 months		During the previous 30 days	
	on all types	including Cirrus SR22	on all types	including Cirrus SR22	on all types	including Cirrus SR22
Total (h)	64	62	45	45	10	10

– Date of previous flight on Cirrus SR22 April 9th 2021

1.6. Information concerning the aircraft

The aircraft belongs to the AFAE, which hires flight hours to the French Air and Space Force (AAE)
– AFAE organization
– Base airport: BA 701 Salon-de-Provence
– Assigned unit: CFAMI 05.312 "Élisabeth Boselli"
– Aircraft type: Cirrus SR22

	Type - Series	Number	Total flight hours	Flight hours since last maintenance
Airframe	Cirrus SR22	3 884	2 736	28[4]
Engine	Continental IO-550-N68B	103 2831	1 701	28[4]

Cylinders Nos. 2 and 4 of the engine were replaced after 1 134 engine flight hours during an aircraft inspection, type 100 to 2 200 airframe hours, on September 7th 2019

1.6.1.Maintenance

Examination of the technical documentation shows that maintenance had been conducted in accordance with the applicable maintenance schedule. The aircraft was airworthy.
The engine was a factory-rebuilt[5] engine that had been provided by the company Continental Aerospace Technologies. It had been mounted on the aircraft in October 2016

[4] Scheduled inspection, type 50 flight hours, performed on March 22nd 2021.
[5] *Factory rebuilt*: The definition of factory-rebuilt engines is provided in 1.18.

1.6.2. Performance

The aircraft was not subject to any operating restriction, and its performance was within the standard range.

1.6.3. Mass and centre of gravity

The mass and centre of gravity of the aircraft comply with the relevant standards.

1.6.4. Fuel

- Type of fuel used: 100 LL
- Quantity of fuel at take-off: 50 gallons
- Quantity of fuel at time of occurrence: 48 gallons

1.6.5. Other fluids

The engine oil was of type 15W50

1.7. Weather conditions

1.7.1. Forecast

The meteorological conditions were favourable to flight, with good weather, very clear visibility and the Mistral wind near Salon-de-Provence, with gusts of up to 35 kt, a cloud ceiling higher than 5 000 ft, visibility of more than 10 km and no particular aerological conditions (cumulonimbus).

1.7.2. Observations

The observed meteorological conditions were as forecast.

1.8. Navigation aids

The Cirrus SR22 has two GPS navigation systems and the equipment necessary for IFR flight.

1.9. Telecommunications

At the time of the occurrence, the aircraft was in radio contact with Marseille-Provence air traffic control,

1.10. Information concerning the airport

1.10.1. Avignon-Provence airport

Avignon-Provence airport is a French international airport located in Montfavet in the municipality of Avignon. The airport has a concrete runway 1 900 m long and oriented 17/35.

Figure 3: Avignon Provence airport

1.10.2. Le Mazet de Romanin airport

One of the closest aerodromes to the occurrence site is Le Mazet de Romanin (LFNZ), which is in the *département* (county) of Bouches-du-Rhône and located at Saint-Rémy-de-Provence at an altitude of 150 m above sea level. It consists of a 1 000 m long grass-covered runway pointing north-south, asphalted over its first hundred metres and with hangars. The south end of the runway faces away from the beginning of the Alpilles low mountain range, with a highest point at 350 m.

Figure 4: Le Mazet de Romanin

1.11. Flight recorders

The Cirrus SR22 is equipped with:

– a flight data recorder on SD card
– a voice recorder

– a Cirrus Aircraft hardened RDM100-2 data recorder located in the tail.

The sound recorder did not record what was said during the flight. A file corresponding to the date is present in the memory card of the device. It only contains white noise[6]. The other recordings were usable.

1.12. Observations of the accident zone and of the aircraft

1.12.1. Examination of the impact zone

The aircraft first hit the bed of the Durance north of a high-voltage line. It was then dragged southwards by parachute acting as a sail in the wind over a distance of two hundred metres. Many marks and grooves were observed on the ground, tracing the passage of the airframe. The ground was littered with debris and remains of equipment along this route. These marks along the ground confirm that the aircraft passed underneath the high-voltage line, which is confirmed by an eyewitness who was present at the bottom of the electricity pylon to the south-east of the initial point of impact.

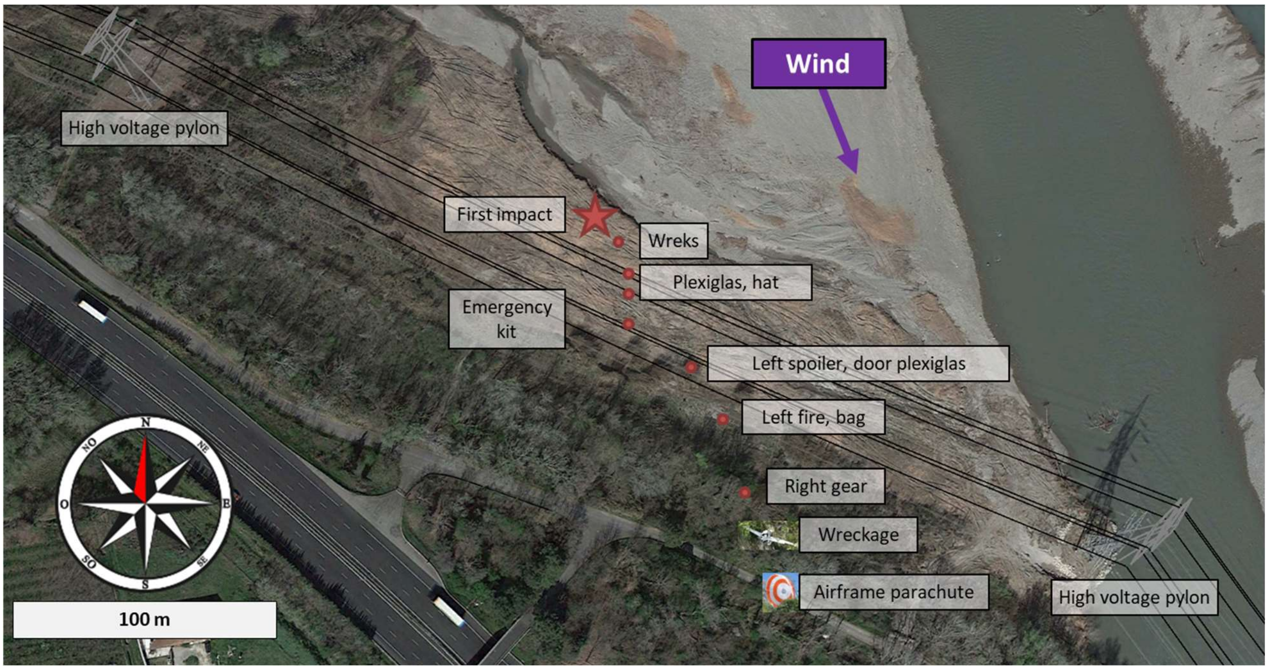

Figure 5: Identification of the wreckage

1.12.2. Examination of the aircraft

The aircraft was destroyed while being dragged along the ground by the parachute. It was stopped by the trees and ended almost hanging above a pond.

Figure 6: Wreck viewed from the front and above

6 White noise: sound composed of all audible frequencies, similar to audio hiss.

The aircraft was almost horizontal and on its underside. The upper part of the aircraft was crushed, and the rudder was completely twisted and broken.

Figure 7: airframe parachute still billowing in the wind on the arrival of the emergency services

Figure 8: instrument panel   Figure 9: Fuel selector

A significant amount of mud was found in the aircraft cockpit. All the windows were broken, and several pieces of plexiglass were strewn inside the aircraft. The fuel selector was in the “left tank” position.

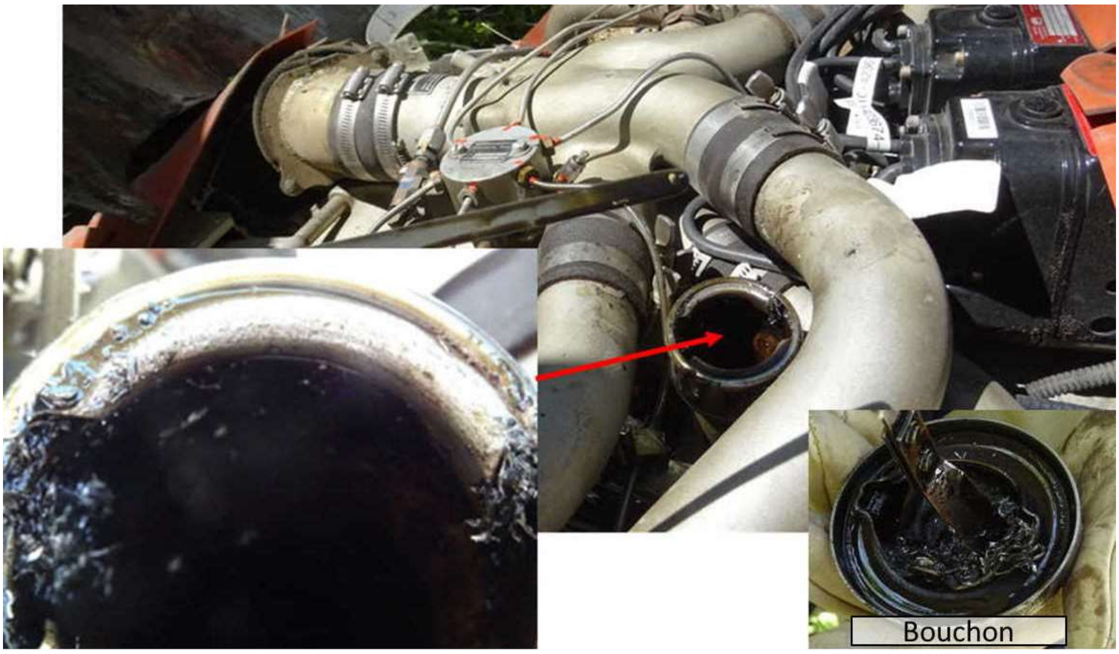

Figure 10: engine (large quantity of filings at the filler cap)

On-site examination of the Continental engine of the aircraft revealed a large quantity of metal filings in the area oil filler cap. Pistons Nos. 1 and 2 were jammed.

1.13. Medical information

1.13.1. Captain - NOSA instructor

- Last medical examination:
  - Type: examination at the CEMPN Medical Centre for Aviation Personnel[7] on January 5th 2021
  - result: eligible
- Biological examinations: conducted
- Injuries: minor

1.13.2. Pilot instructor

- Last medical examination:
  - Type: examination at the CEMPN on October 16th 2020
  - result: eligible
- Biological examinations: conducted
- Injuries: none

1.13.3. NOSA trainee

- Last medical examination:
  - Type: examination at the CEMPN on January 19th 2021
  - result: eligible
- Biological examinations: conducted
- Injuries: none

1.14. Fire

Not applicable.

1.15. Questions concerning the organization of the rescue services

1.15.1. Evacuation

The crew was able to evacuate the aircraft while it was being dragged along the ground. The aircraft was overturned by the gusts of the north-westerly Mistral immediately after impact, and the wind continued to fill the parachute like a sail. On its back, the Cirrus was dragged by its aft end for about two hundred metres. The NOSA trainee was the first to exit the wreckage, taking advantage of the immobilization of the aircraft He was immediately followed by the pilot. The navigator instructor was sitting in the rear cockpit and was the last to evacuate the cabin after the aircraft was again dragged for a further few metres. The crew was taken in charge by a local inhabitant while waiting for the emergency services.

1.15.2. Organization of emergency services

Following the display of transponder code 77 00, the local emergency service alert was activated by ATC. The helicopter of the Gendarmerie Nationale, a “SMUR of SAMU 13”[8] helicopter and a Fennec helicopter from Orange Airbase rapidly arrived on the scene. The crew was evacuated to Cavaillon hospital for medical examination.

1.16. Tests and investigations

The data from the aircraft’s flight recorders were reviewed by RESEDA.
The fluids and engine were reviewed by DGA EP.
An analysis of the organizational and human factors was conducted by BEA-É.

---

[7] Reference: French Ministerial Instruction No. 4000/DRHAA/SDEPRH-HP/BPECA of 20 April 2017 concerning the medical fitness standards applicable to military personnel of the French Air Force and the definition of minimum medical fitness standards required for aviation personnel.

[8] SMUR of SAMU 13: mobile emergency and intensive care unit of the Emergency Medical Service(SAMU) of Bouches-du-Rhone.

1.17. Information concerning the organizations

1.17.1. Air base 701

The Salon-de-Provence air base of the French Air and Space Force (AAE) is located in both municipalities of Salon-de-Provence and Lançon-Provence.
It is the main initial training centre for the pilots of the AAE and houses the following organizations:

- The French Air and Space Force Academy (École de l'air et de l'espace);
- the Flight School officer training course;
- the Flight School special course;
- the Centre for advanced military education – (Centre d'Enseignement Militaire Supérieur Air) ;
- the demonstration teams of the AAE, including the Patrouille de France and the stunt team;
- The initial military air and space force training centre (CFAMI).

1.17.2. *Centre de formation aéronautique militaire initiale* (Centre for initial military aviation training)

The CFAMI is an air and space force unit of the EFPN. It is stationed at Salon-de-Provence air base (BA 701). It is headed by the air base two-star commanding officer and general director of the French Air and Space Force Academy. The CFAMI provides initial theoretical and practical training for AAE air crew personnel and some specific training courses for trainees from other specialized units.

1.17.3. Airbus Flight Academy Europe

The AFAE company is a subsidiary of Airbus. It carries on operations from six military sites in France: Cognac, Angoulême, Avord, Lann-Bihoué, Lanvéoc and Salon-de-Provence. It provides training services for French airborne military activities. AFAE is the owner of all the SR22 aircraft fleet used by the French air force in Salon-de-Provence. It is responsible for the maintenance and airworthiness of these aircraft. The company has the requisite PART M/G[9] and 145[10] approval for the maintenance of these aircraft.

1.17.4. Cirrus Aircraft

Cirrus Aircraft is of American origin. It has manufactured light aircraft for both business and leisure. It was founded in 1984 and is based in Duluth (Minnesota) in the United States. In 2011, the company was purchased by China Aviation Industry, General Aircraft.
The Cirrus aircraft family is distinguished by its ballistic CAPS airframe parachute system. It enables the aircraft to be brought down to ground safely if normal landing is impossible or too risky.

1.17.5. Continental Aerospace Technologies

Continental Aerospace Technologies is a manufacturer of aircraft piston engines. It is located in the city of Mobile (Alabama), in the United States. It is owned by the Chinese company Aviation Industry Corporation of China, a state-owned company based in Beijing. It supplies the Cirrus SR22 aircraft with the Continental O-550-N68B engines. The engine of the Cirrus involved in the accident was supplied by Continental as a "factory rebuilt" engine.

---

[9] PART M/G is the general approval allowing an organization to carry out maintenance work on European aircraft. Subpart G allows the organization to ensure the continuing airworthiness (or the management and monitoring of airworthiness) of the aircraft under its authority.

[10] PART 145 authorizes the holder to manage the maintenance of aircraft operated in commercial air transport and of the components of its own aircraft and of any other aircraft operated in aerial work or general aviation.

1.18. Additional information

1.18.1. Factory Rebuilt

Factory Rebuilt is a term used by the American regulator [11] to describe an engine leaving the factory in a intermediate condition between a brand new engine and an overhauled engine. This definition is given in the FARs[12], which are the FAA-issued regulations and directly implemented in the CFR[13]. CFR Title 43.2(a) specifies that an overhauled engine must have been disassembled, cleaned, inspected, repaired as much as necessary, reassembled; and tested in accordance with approved standards. A factory rebuilt engine must whereas, have been tested to the same tolerances and limits as a new item. In a factory rebuilt engine, all the cycle counters (service life expectancy) have been reset to zero. The Continental company is the sole provider that has been authorized to sell factory rebuilt engines. The crankshaft is one of the overhauled components in both the overhaul and rebuild processes.

Brand New engine	"Factory Rebuilt"	Overhauled
Warranty - 24 months or to the next overhaul	Warranty - 18 months or to the next overhaul	No manufacturer warranty
New cylinders	New cylinders	Cylinders tested and replaced if necessary
Complete engine balancing	Complete engine balancing	No engine balancing
Cycle counters set to zero	Cycle counters reset to zero	Cycle counters updated
100% new parts	Significant proportion of new parts	Significant proportion of retained or repaired parts
Application of 100% of the service bulletins and airworthiness directives	Application of 100% of the service bulletins and airworthiness directives	Application of the service bulletins and airworthiness directives applicable in the factory
Updated to the applicable configuration	Updated to the applicable configuration	Configuration applied: only the imperative modifications

Figure 11: Comparative table between new, factory rebuilt and overhauled engines

1.18.2. The General Aviation Revitalization Act

The General Aviation Revitalization Act (GARA) is an Act of Congress on Senate Bill S. 1458, amending the Federal Aviation Act of 1958. It was adopted by the US Congress in 1994, in order to defend the American aviation industry. It is shielding manufacturers from any criminal or civil liability for most accidents, even fatal ones, and even in case of negligence. This measure concerns the manufacturers of aircraft and components for aircraft carrying fewer than 20 passengers if the products concerned are more than 18 years old.
The Cirrus SR22 was put on the market in 2001, and its Continental IO-550 engine dates back to 1996. Therefore, these products are covered by the scope of GARA.

1.18.3. Emergency landing

Following the accident of the Cirrus SR22 AFAE issued a safety incident report on the official form of an incident detected during maintenance or during airworthiness maintenance management ("CRESMANA").
The CRESMANA SR22 2021 03 C1 Report dated 21 July 2021 classifies the occurrence as acceptable from the point of view of airworthiness. This is because the European regulator, EASA[14], considers that, generally, engine failure by itself is not an "issue"[15] that should cause a fatal outcome as the glide ratio of general aviation aircraft is generally good and should enable pilots to find a suitable landing area, given their preflight

[11] FAA: Federal Aviation Administration.
[12] FARs: Federal Aviation Regulations.
[13] CFR: Code of Federal Regulation.
[14] European Union Aviation Safety Agency:
[15] repeated in tin numerous documents of the Agency, in *particular the* Annual Safety Review of 2020.

preparation and sufficient altitude at the time of the failure. According to EASA, flight management after the failure has strong links to another safety issue called: "handling of technical failures”.
Emergency landing on improvised terrain or in a field is one of the options for pilots of non-commercial light aircraft. However, this remains a sensitive operation requiring rigorous training. However, few statistics are available. Many successful emergency landings are not listed by the regulators or safety investigation agencies). Moreover, this practice is extremely common on aircraft carriers. According to the EASA Annual Safety Review 2020, four emergency landings of light aircraft had fatal consequences during the 2015-2019 period.
The Aircraft Owners and Pilots Association (AOPA) is an American non-profit organization that fosters the interests of general aviation in the United States. One of its objectives is to improve air safety, which it promotes via its Air Safety Institute. It classifies off-airport landing into 3 different classes - precautionary landing, forced landing and “ditching” (forced landing in water). Precautionary landings are landings that were carried out with a significant degree of residual engine power. Forced landings are carried out with a total lack of propulsion. Ditching is a forced landing in water.
The AOPA Air Safety Institute reports statistics on the three types of landing with their associated fatality rates. The fatality rate of precautionary landings is 0.06%. By contrast, the fatality rate for forced landings is 10%, and the rate for ditching is 20%.

1.18.4. Airframe Parachute System (CAPS)

At the moment of the accident, the CAPS was the only airframe parachute system standard-fitted to aircraft. It is fitted to the Cirrus SR20, SR22 and SF50. The Cirrus Owners and Pilots Association has recorded the cases when this system has been used anywhere in the world. The data may be read on the following website: https://www.cirruspilots.org. Up to August 11th 2021, CAPS have been pulled 126 times. Out of these 126 attempts, 13 resulted in deadly accidents. 12 of these failures were linked to human error, with a non-relevant use of the CAPS outside its scope of application (a plane that was flying too low or too fast). In the latest case, the aircraft was on fire before pulling the parachute. The manufacturer stipulates that the CAPS must be used at an altitude of more than 500 feet to ensure that the parachute can fully open and at a speed of less than 100 kt to prevent the parachute from tearing.
If one would focus on engine failures and loss of power during flight, the CAPS has been used 32 times, and the figures show:
– 2 fatal accidents (3 persons fatally injured and 3 seriously injured);
– 3 accidents with serious injuries (4 persons seriously injured) ;
– 4 accidents with minor injuries (8 persons) ;
– 23 accidents with all occupants unharmed.

2. ANALYSIS

2.1. Expert technical investigations

2.1.1.Fluids analysis

The chromatographic analyses of the aircraft fuel did not reveal any organic contamination, and the gum content values comply to specifications. The fuel does not have any anomaly.
The analysed oil also showed a high rate of metal particles. Chromatographic analysis revealed very significant lead content, a high content of iron, copper and aluminium and also nickel.

The fuel does not have any anomaly. On the other hand, oil is significantly contaminated with high concentrations showing significant internal degradation of the engine.

2.1.2.Analysis of the Continental engine

The Continental IO-550 engine is a large family of fuel injected six cylinder, horizontally opposed, air-cooled aircraft engines that were developed for use in light aircraft by Teledyne Continental Motors.
The first inspections at the crash site noted that some pistons had seized.

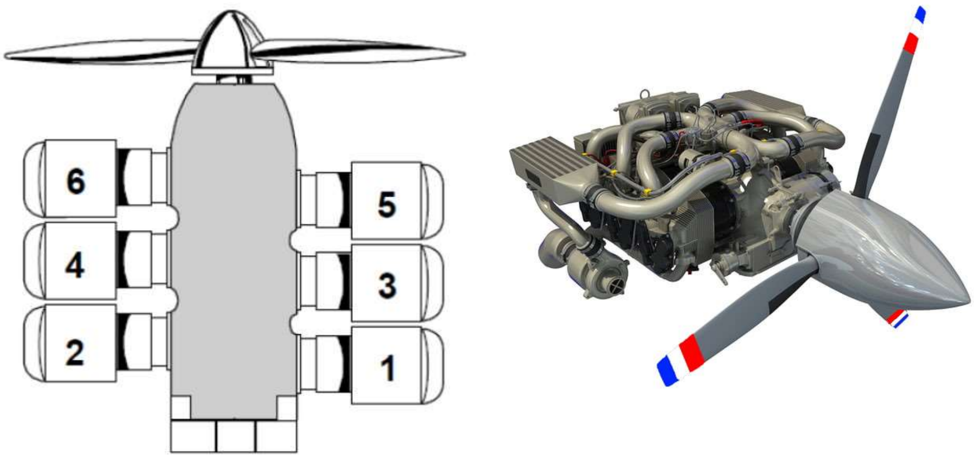

Figure 12: flat six-engine

While dismantling and inspecting the engine in the workshop, the following principal damage was identified:
- broken crankshaft at web No. 3;
- overheating traces on the surface of journal No. 2;
- destruction of bearing shell No. 2;
- significant wear of bearing No.1.

No damage prior to rupture and possibly linked to the latter-mentioned rupture could be identified on the other parts, in particular the cylinders, pistons and connecting rods at the back end of the engine.

2.1.2.1. Crankshaft

On dismantling the crankcase, the rupture of web No. 3 of the crankshaft was clearly visible. This break is located in the fillet of the web close to journal No. 2. The limited damage in the surrounding areas of the engine seems to indicate that the crankshaft was subject to moderate load at the moment of failure. It is a sign that the engine was operating normally.

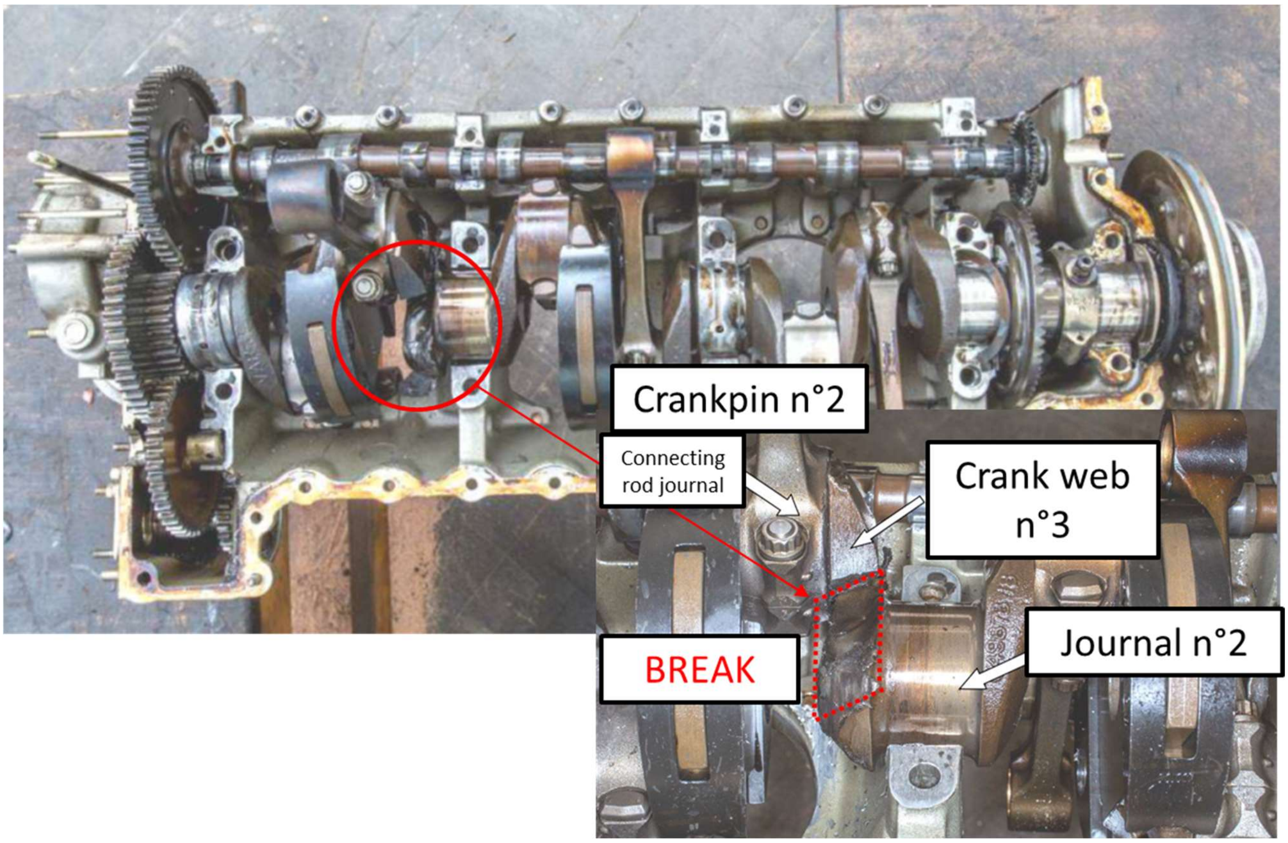

Figure 13: Engine open after removing the casing

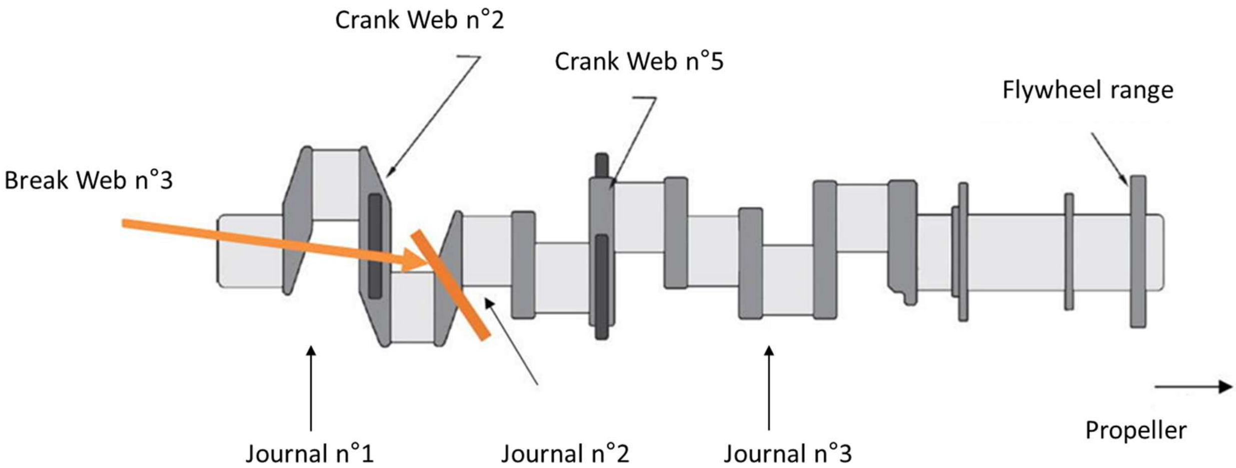

Figure 14: Diagram of the crankshaft

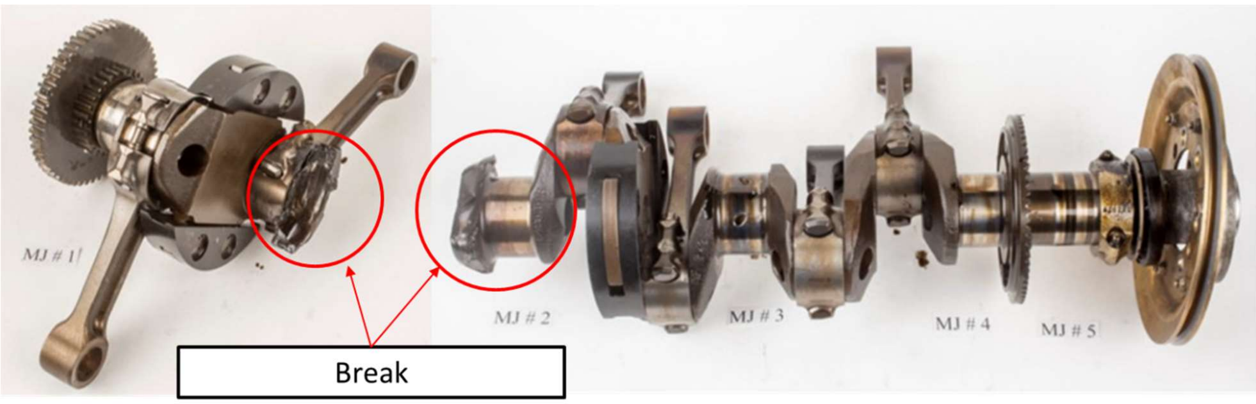

Figure 15: Crankshaft broken

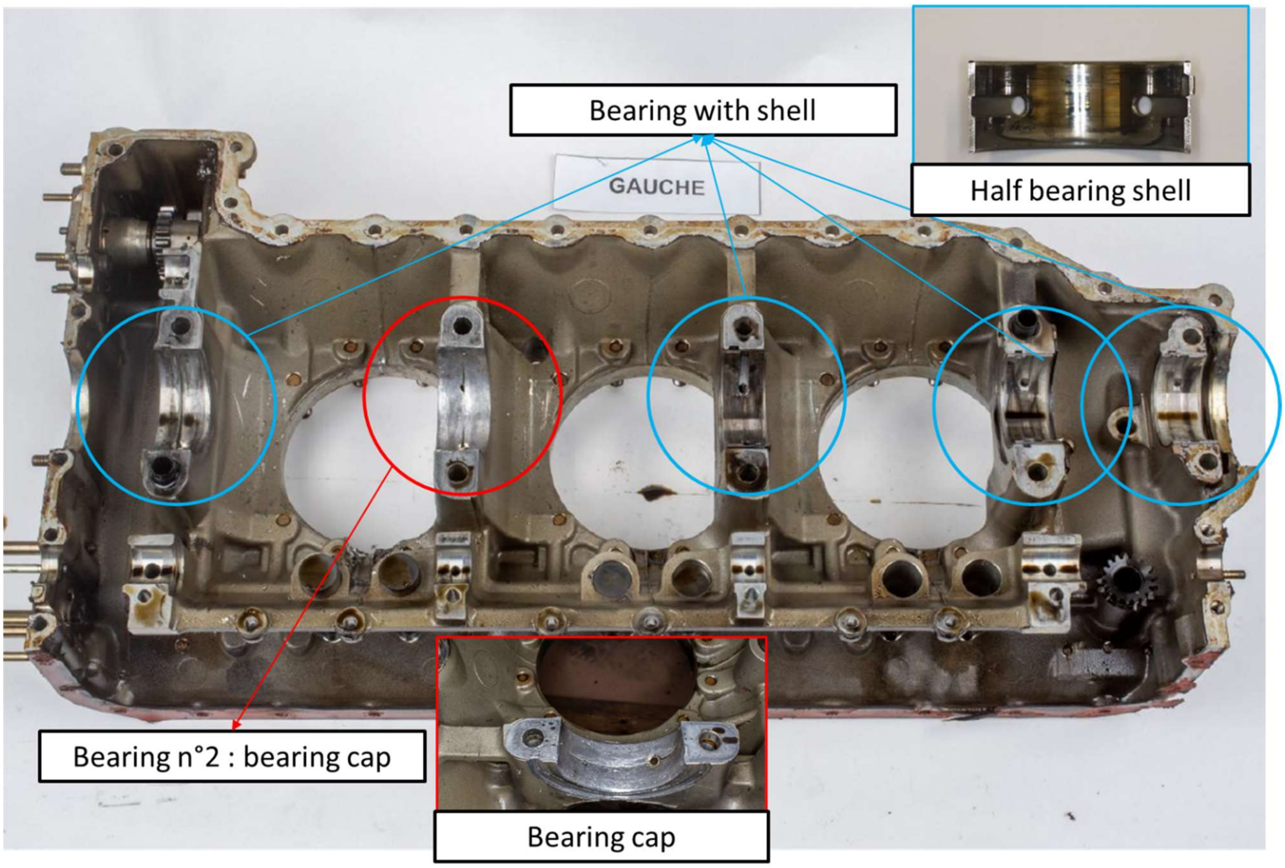

Figure 16: Left half of crankcase open

The broken areas were examined under binocular microscope. Some strips were cut off and analysed by scanning electron microscope.
The binocular observations showed incipient cracking at the fillet of journal No. 2 and web No. 3, which propagated the fatigue crack until the final failure.
Several concentric propagation fronts towards the initial area indicate final failure due to propagation of a fatigue crack. Blue colouration, a sign of local overheating, is visible only in the area of the failure.

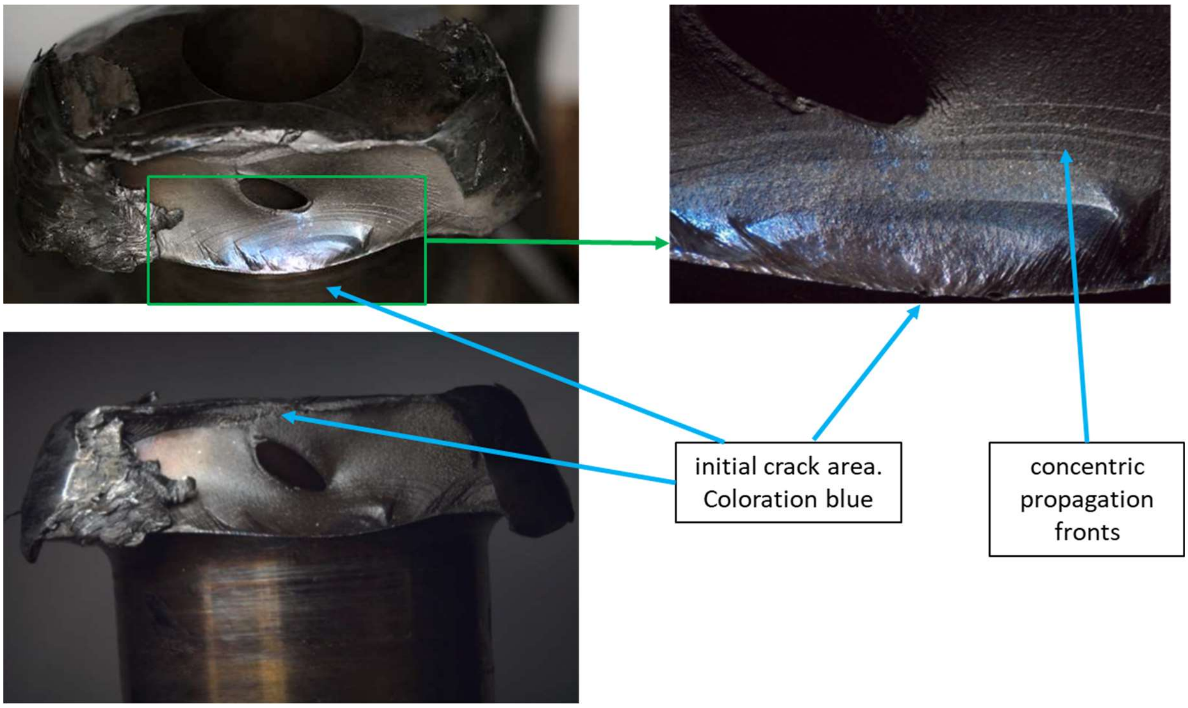

Figure 17: Trace of overheating at journal No. 2

Blue colourations are distinctive indicators of a significant increase in temperature. This colouration is only visible over a part of journal No. 2 and not over the entire area.

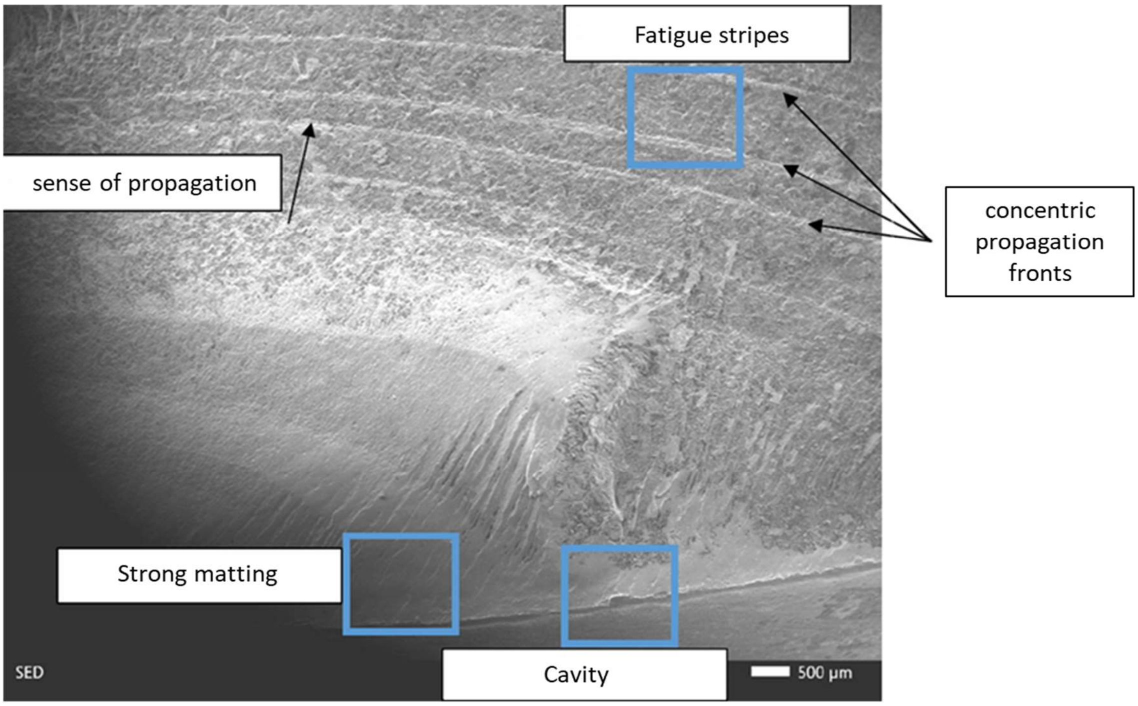

Figure 18: View of the break under scanning microscope

Observation by scanning electron microscope revealed darkening of the initial crack area. The original appearance is therefore no longer observable. The crankshaft rupture was probably due to local overheating that started fatigue cracking of the fillet of web No. 3 and journal No. 2.

The stalling of the engine was a direct consequence of the rupture of web No. 3 of the crankshaft, following fatigue cracking that was probably caused by local overheating.

2.1.2.2. Bearing shells (in action)

Bearing shells are smooth bearings which are in direct contact with rotating shafts. Smooth running is ensured by the materials chosen and by a film of oil. On this engine, the bearings consist of two steel half-shells housed in their respective caps (Figure No. 16). Their bearing surface is coated with different layers of lead/tin/copper alloy. Their surface also has small grooves that - due to the speed of rotation - enable oil to be retained.

Figure 19: Fragments of the shells of bearing n° 2

The shells of bearing No. 2 were totally destroyed by the accident. Fourteen fragments of bearing No. 2 were found at the bottom of the crankcase, and the crankcase support is significantly hollowed. Only some fragments were analysed. The shells of bearings Nos. 1, 3, 4 and 5 were also analysed.

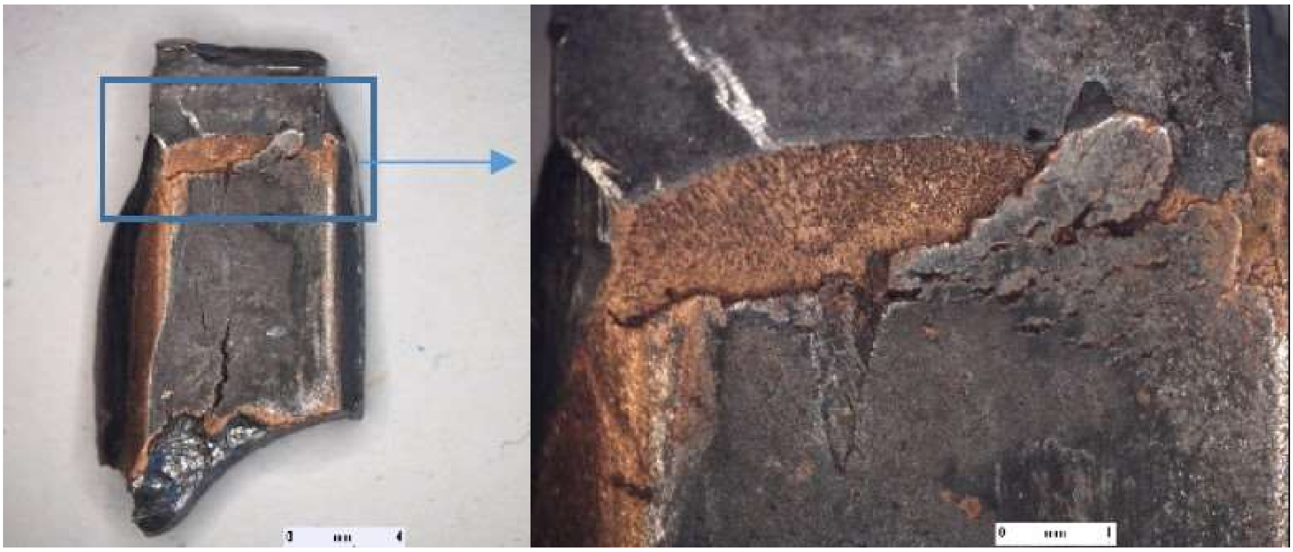

Figure 20: Fragments of shell of bearing No. 2 under binocular microscope

Binocular observation of a fragment of bearing No.2 shows the presence of several layers. A grey upper layer is on top of a copper-coloured layer. However, the anti-friction coating has almost disappeared in the fragments of bearing No. 2. The fracture surfaces of the fragments of bearing No. 2 were unusable for further detailed analysis.

Figure 21: Shells of bearing No. 1

Traces of operating friction can be seen on the anti-friction coating of bearings Nos. 1, 3, 4 and 5. Bearing No. 3 is the bearing of the most severe marking. It is considerably worn. In the figure above, it can be seen that the copper colour of the anti-friction coating is separated by a greyish band in the centre. The anti-friction layer seems to have been gummed.

The engine stalled immediately on rupture of the crankshaft. On comparing the condition of bearing No. 2 with the other bearings, the destruction of the shells of No.2 and the hollowing out of their supper cannot be exclusively the result of the engine failure. Bearing No. 1, which was exposed to stresses close to its breaking point, remained almost intact, with a slight wearing of the anti-friction coat without any major loss of material. In conclusion, the deterioration of the shells of bearing No. 2 had occurred before the crankshaft broke.

Bearing No. 2 was damaged before the accident occurred.

2.1.3.flight data analysis

The sequence of the accident could have been replayed with the data of the flight data recorder, the testimony of the crew and with the audio recording of the Provence air traffic control.

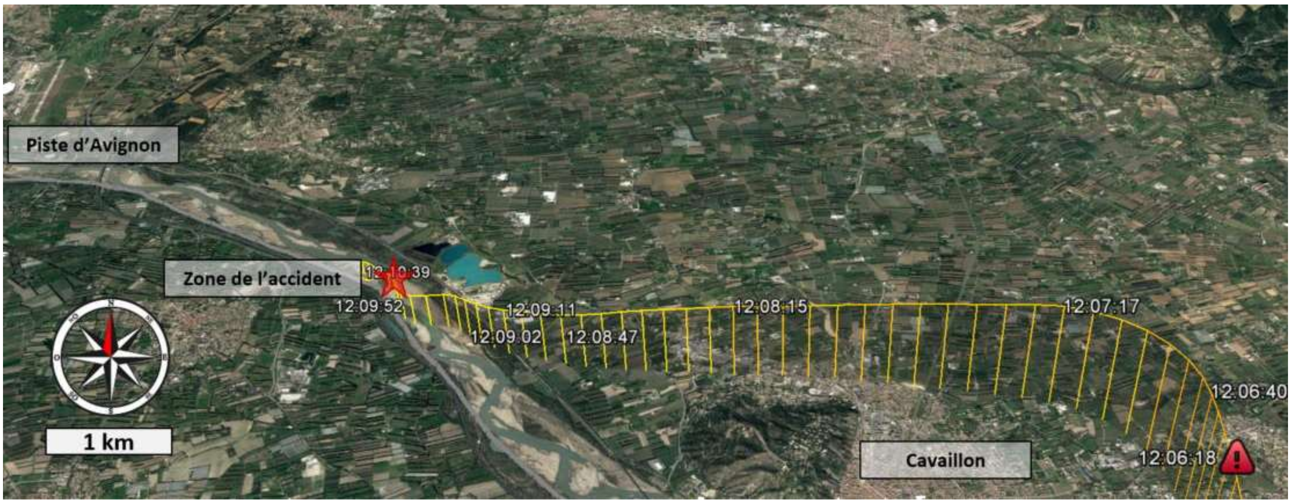

Figure 22: End of the flight path

Time	Altitude	indicated speed	Bearing in °	Description and transcriptions of audio exchanges
12:05	4 987	125	7	Clearance obtained for flight level `20 with Provence
12:06	5 087	125	5	Sudden drop in engine speed Application of the engine failure procedure
12:06	4 760	106	2	Start of a turn towards Avignon
12:07	3 995	100	288	End of turn Avignon airfield in view Alert message and transponder set to 7700
12:08	2 894	99	289	Cirrus: "62 21. We are at 3000 feet. We are heading to Avignon with no certainty that we can reach the airfield."
12:08	2 721	100	291	Cirrus: "62 21. I confirm that we have an aircraft equipped with an airframe parachute. So, it is probable that if we cannot reach the airfield, we will deploy the parachute where we are."
12:08	2 609	95	296	Attempt to restart the engine
12:09	1 993	103	301	End of attempted restart propeller stuck.
12:09	1 944	97	303	ATC: "62 21 confirm the number of people on-board,"
12:09	1 896	96	307	Cirrus : "62 21 there are 3 people on board, 3"
12:09	1 870	96	310	Start in the search for an emergency landing area or a field
12:09	1 346	88	282	Turning to look for favourable areas
12:09	1 313	87	293	Cirrus: "62 21: I inform you that we will not go to Avignon. We are directly above the Durance and we are preparing to deploy the parachute."
12:09	1 264	94	317	ATC: "Received 62 21, we have alerted everyone."
12:09	1 134	98	338	Cirrus: "Roger"
12:09	990	101	339	Cirrus: At the moment, we are flying above the highway, heading 340."
12:10	896	99	339	Air traffic control: "Roger."
12:10	646	101	316	Air traffic control: "62 21 can you see any field in view?"
12:10	552	97	309	Cirrus: "Well, we're directly above the Durance at right now we'll deploy the airframe parachute."
12:10	671	67	326	Deployment of the airframe parachute
12:10	61	0	348	Impact with the ground

The sequence analysis shows that the engine failure in flight was sudden and that the crew could not have anticipated it. During a two-minute glide, the crew attempted to reach Avignon airfield, without success, and then tried to restart the engine. The airframe parachute was deployed at 600 feet (about 180 metres).

2.1.4. Mistakes in applying procedures

Reconstitution of the sequence shows that the crew, which was facing a real engine failure, committed several mistakes in applying the check-lists. They did not adopt the best glide speed. During the event, the indicated speed was between 100 and 105 kt. The pilot had speed under control with some precision. He wanted to maintain this speed within the range of values that he considered to be reassuring. The best glide speed of the Cirrus SR22 is specified as 95 kt by the relevant authority and as 88 kt by the manufacturer's manual. Also, the pilot did not put the aircraft in "nose up" attitude as was written in the check-list after an engine failure. When the engine failed, the pilot let go, losing altitude more rapidly. Both these actions reduced the available time in flight.

Additionally, the pilot interrupted the check-list for engine failure in flight before it was completed. Since the last action consisted in testing the magnetos to attempt an engine airstart, the ultimate aim of this procedure was not attained. Finally, he forgot one action on the check-list during the attempted engine airstart: he did not cut off the alternator and did not activate the emergency radio-beacon. It should, however, be reminded that, given the engine condition, even the correct airstart procedure would not have worked.

Several mistakes have been identified in applying the check-lists.

2.2. Accident timeline

The engine inspection showed that bearing No. 2 was already damaged at the time of failure. The deterioration of bearing No. 2 was progressive, having two cumulative effects.

- abnormal alternate bending stresses on the crankshaft due to the loss of retention of the journal in the bearing;
- friction on the surface of journal No. 2, causing local heating and a loss of fatigue resistance characteristics of the materials.

This led to cracking of the crankshaft in the journal fillet, which is a high-stress-exposed area. This fatigue crack was propagated up to web No. 2, which failed and caused the complete stalling of the engine while in flight. The pilot rapidly deployed the emergency procedure, he made some mistakes. Then, the crew agreed on an emergency diversion towards Avignon. Between 12:06:40 and 12:08:47, the crew carried on flying towards Avignon airfield. It finally decided to pull the airframe parachute at the limits of it operating range above a high-voltage line and above the Durance River. Fifteen seconds after the parachute was triggered, the aircraft hit the ground without major damage but was immediately overturned on the ground by the gusts of north-westerly wind and was dragged less than two hundred metres. This caused the destruction of the aircraft. The crew managed to evacuate the aircraft during a brief wind lull.

The following safety incidents were analysed while researching the possible causes of this accident: the progressive degradation of bearing No.2, the aerological context, flight management by the crew (emergency period, choice of terrain, late change of plan), including the use of the airframe parachute.

2.3. Investigation of the causes of the accident

The causes were investigated in the technical domain, in the environmental factors and in the domain of human and organizational factors.

2.3.1.Engine failure

2.3.1.1. Bearing No. 2

The destruction of the shell of bearing No. 2 and the few available clues are not sufficient to be able to identify the initial causes. The damage was progressive. Both hypotheses of a lubrication fault or of excessive load on this bearing were discounted. The reasons for ruling out these possibilities are that the engine does not show any sign of flagrant lubrication deficiency at the other parts and that the damage exclusively concerns bearing No. 2.

Possible causes that have not been ruled out are the following ones:
- structural failure of the shell of bearing No. 2;
- nonconformity at the level of the shell or a problem of compatibility between the shell and its bearing;
- nonconforming assembly;
- local lubrication fault;
- design of the bearing-shell-journal assembly.

All of these possible causes are technical ones.

The total failure of the engine in flight was due to progressive damage to bearing No.2, which is the probable cause of the fatigue cracking that led to rupture of web No.3 of the crankshaft.
The reason why this damage occurred could not be determined. It could probably have been caused by a "quality" problem, although expert inspection was unable to identify a precise cause.

2.3.1.2. Engine overhaul

AFAE, as the owner of the Cirrus SR20 and SR22 fleet, was also responsible for the maintenance of both these aircraft. A significant difference in the reliability of the Cirrus SR20 and SR22 engines is revealed in their maintenance tracking tables. The engine of the Cirrus SR22 is a 350-horsepower Continental IO-550 one, whereas the engine of the SR20 is a 215-horsepower Continental IO-390 one.
For six years of maintenance, no engine from the Cirrus SR22 fleet has ever attained its operating limit of 2 200 hours before it has had to be dismounted for overhaul. All these engines have had to be returned before this deadline, because of stress fractures, of corrosion and of other abnormal wear. On average, the operating time before returning for overhaul is 1 370 hours.
By contrast, the engines of the Cirrus SR20 on average attain their operating limit. To be precise, this is the case of 13 engines out of 19. On average, the operating time of these engines before being sent for overhaul is 1 900 hours for the same operating limit.

No Cirrus SR22 engine has ever reached its operating limit before removal for overhaul.

2.3.2. Significant aerological context

2.3.2.1. Missions in Salon-de-Provence

This mission was the first IFR flight for the NOSA trainee. Due to the severe meteorological conditions, this mission had already been postponed once. The aerological limits for a training flight at CFAMI are a wind speed of 35 kt or gusts stronger than 40 kt. The Salon-de-Provence region is well-known for regularly having strong winds, and this problem is a significant parameter in the management of instruction flights. Having severe turbulence is also often a limiting factor whenever one has to plan such missions.
The weather conditions on the morning of the event had not improved compared to the previous day. The NOSA instructor, who had two flights scheduled for that day, cancelled his first instruction flight, in order to preserve the specified training conditions for his trainee. This decision was not unanimously adopted by other instructors, who maintained their flight schedules.
His second flight was originally scheduled for the end of the afternoon. However, the improvement in weather conditions at the beginning of the afternoon leads the PIC to bring forward the take-off time.

At the beginning of the afternoon, the forecast still indicated a significant wind intensity. For example, the forecast wind speed for the time of the take-off was 24 kt with gusts of 33 kt. In view of the temporary nature of the severe turbulence, the PIC decided to maintain the flight. So, the weather conditions were very close to the limits that were imposed by the CFAMI for an instruction flight but were considered to be acceptable by the crew.

The time constraints for training the student probably motivated the decision to carry out this flight under aerological conditions that were close to the normal limits applied by the CFAMI. Cancellation and postponement of instruction flights resulted in time constraints for the training of the students.

2.3.2.2. Destruction of the aircraft

The accounts of the crew were categorically clear: the overturning of the aircraft and its destruction were caused by the strong gusts of the "Mistral" wind. The observed damage, the tracks on the ground and the debris along the way confirm the hypothesis that the aircraft was dragged along the ground by its parachute. Moreover, the manufacturer is aware of this risk and recommends avoiding the use of the airframe parachute in the event of strong gusts of wind at ground level.

The aircraft was dragged along the ground by the wind, which filled the airframe parachute like a sail and dragged the aircraft for about two hundred metres.

2.3.3. Management of the engine failure in flight

2.3.3.1. Emergency procedures

2.3.3.1.1. Emergency procedure for engine failure in flight

The emergency procedure for an engine failure in flight is described in the Cirrus manufacturer's manual, the *Pilot's Operating Handbook* (POH). This procedure is partly repeated in the Crew's Supplementary Instructions (MCE) issued by the CFAMI The actions that were listed in the POH and in the MCE differ, both with regard to the best glide speed, which is 88 kt in the POH and 96 kt in the MCE, and in the order in which the actions should be taken. Some supplementary actions have been added in the MCE.

ENGINE FAILURE IN FLIGHT

Climb .... 10° OF PITCH
Mixture .... AS REQUIRED
Throttle .... FORWARD
Fuel Pump .... BOOST
Fuel Selector .... SWITCH TANKS
Alternate induction Air .... ON
Ignition switch .... BOTH
Best glide speed (Vg 95kts) .... ESTABLISH
Air conditioner .... OFF

If engine does not start on the top of climb

Crash area .... CHOSEN

Above 2000ft AGL

Perform ENGINE AIRSTART or CAPS DEPLOYMENT or FORCED LANDING

Below 2000ft AGL

Perform CAPS DEPLOYMENT or FORCED LANDING

Below 500ft AGL

Perform FORCED LANDING

Figure 23: Extract of MCE

Section 3
Emergency Procedures

Cirrus Design
SR22

Engine Failure In Flight

1. Best Glide Speed .... ESTABLISH
2. Mixture .... AS REQUIRED
3. Fuel Selector .... SWITCH TANKS
4. Fuel Pump .... BOOST
5. Alternate Induction Air .... ON
6. Air Conditioner (if installed) .... OFF
7. Ignition Switch .... CHECK, BOTH
8. If engine does not start, proceed to Engine Airstart or Forced Landing checklist, as required.

Amplification

• WARNING •

If engine failure is accompanied by fuel fumes in the cockpit, or if internal engine damage is suspected, move Mixture Control to CUTOFF and do not attempt a restart.

If the engine fails at altitude, pitch as necessary to establish best glide speed. While gliding toward a suitable landing area, attempt to identify the cause of the failure and correct it. If altitude or terrain does not permit a safe landing, CAPS deployment may be required. Refer to Section 10, Safety Information, for CAPS deployment scenarios and landing considerations.

Figure 24: Extract of POH

The CFAMI explained the reason for the differences between the MCE and the POH as being the desire to harmonize standard procedures for the Cirrus SR22 and SR20, which are the two aircraft used by the instructors. The aim is to prevent confusion of the procedures of theses aircrafts by CFAMI students. Also, the Cirrus SR20 and SR22 are designed mainly for navigation at medium altitude, whereas at Salon-de-Provence they are mainly used at low altitude. So, the MCE procedures were adapted to respond to the risks of engine failure in flight at low altitude and are not fully suitable in the case of an engine failure at medium altitude, which was the case in this accident.

The procedures described in the MCE issued by the flight school at Salon-de-Provence and in the POH issued by the manufacturer are not the same. The procedure for engine failure specified in the MCE is suitable for engine failures of the Cirrus SR22 at low altitude.

2.3.3.1.2. Implementation of the emergency procedure

When the engine failure occurred, the pilot rapidly announced that he was taking the reflex actions specified in the check-list for an engine failure in flight. This check-list is perfectly known by pilots, without having to look it up and read it. It is one of the "reflex" procedures for which monthly training and written examination is mandatory. Authorization to fly is conditional on passing these tests. During the monthly test, all pilots are required to visualize and mentalise the actions at the same time as they are writing them.

The divergences in the instructions described in the MCE and POH may lead to errors, but they are also subject to adjustment by crews wishing to adapt the procedure to the exact situation encountered, especially in the case of an emergency procedure that is not suitable for medium altitude, as in this case. This divergence can therefore explain the errors observed in applying the check-lists designed to establish reflex actions.

The difference in procedures between the MCE and POH and the unsuitability of the MCE's procedure for engine failure at medium altitude contributed to the occurrence of errors, omissions or incorrect adaptation of the procedures observed during the accident.
The adoption of a higher speed reduced the glide time and restricted the time available to the crew.

2.3.3.1.3. Time pressure

When the engine failure occurred, the aircraft was still in its initial climb, and the automatic pilot was activated. At this moment, the level of attention of the crew was reduced. Surprised by the engine failure, the crew experienced a high level of stress. The rapid loss of altitude, at a rate faster than 1 100 ft/min, generated a sense of time pressure for the crew. Under this pressure of time, cognitive abilities are reduced, and errors can occur in the application of procedures, especially in the case of procedures based entirely on memory, such as the procedures for engine failure in flight.

The sense of stress and pressure of time felt by the crew contributed to the errors observed in the application of the reflex procedures.

2.3.3.1.4. Lack of a simulator for engine failure

The CFAMI has a flight simulator for the Cirrus SR22, with cockpit and flight quality. This flight simulator was being upgrades at the time of the accident. It does not allow training crew in engine failure procedures. SR22 crew was not prepared to carry out and thereby physically memorize the actual emergency procedures under realistic conditions.
Learning such procedures relies solely on mental memorization of the items on the check-list, in the absence of the acquisition of physical reflexes, which is far more efficient. Also, the crew was unable to train their situational analysis and decision-making immediately after an engine failure.

The lack of emergency training for aircraft failures in a simulator was a significant contributing factor to the errors of analysis and to the execution of the emergency procedures.

2.3.3.2. Inappropriate diversion decision

2.3.3.2.1. Choice to fly to Avignon

The choice of Avignon airfield seemed obvious to the crew, and the pilot persisted with this decision for two minutes. The engine failure occurred while the crew was at an altitude of 5 400 ft above Cavaillon.

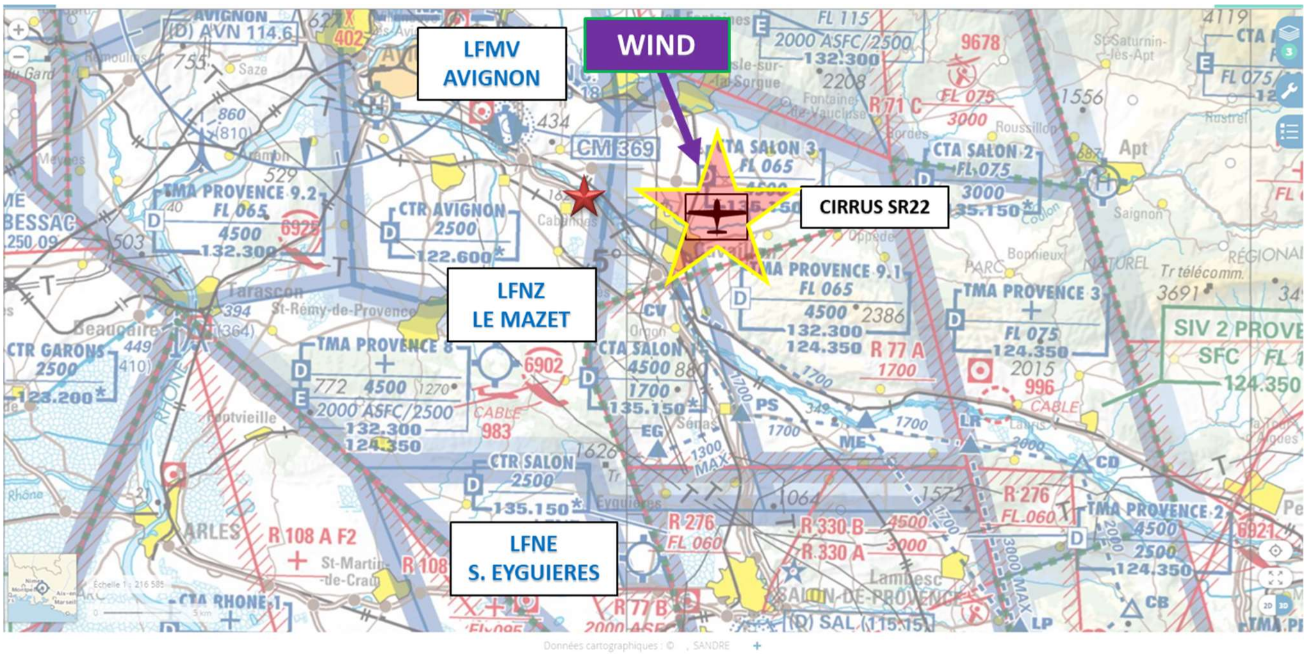

Figure 25: Context at the time of engine failure

25 seconds after the engine failure occurred, the time taken to analyse the situation and carry out the first reflex actions, the pilot decided to divert the aircraft to Avignon airport, and aircraft descended below 5 000 ft. The weather conditions at that moment were not favourable to reaching Avignon. A wind was blowing from 340° with a speed of 26 kt and gusts of up to 40 kt at 5 000 ft. Avignon airfield (LFMV) was located at a distance of 8 Nm with a heading of 300°. In the opposite direction, Eyguieres airfield(LFNE) was 11 Nm away with a heading of 195°. However, the presence of the Alpilles low mountain range on this flight path mode this runway inaccessible by gliding. Finally, even the airfield of Mazet de Romanin (LFNZ) at 8.5 Nm, with a route perpendicular to the wind, was also inaccessible for a glide approach. Moreover, this airfield is not asphalted, and the personnel at CFAMI never considered it to be a possible solution because of its proximity to the Alpilles. However, the configuration of the area is favourable to an off-airport emergency landing, with the availability of several clear fields.

At the time of the engine failure, Avignon airfield was already out of the range to a glide approach by the Cirrus SR22. Although Mazet airfield was also inaccessible, other areas adjacent to this airfield were more possible to an emergency landing.

2.3.3.2.2. Preparation of the mission

The flight was prepared by the NOSA trainee. He identified the main diversion airfields, which he presented at the briefing. As a reminder, this flight was a training mission in the early stages of the trainee's instruction, with the particularity that it was his first IFR flight. The expectations and demands for this flight were therefore relatively low on the part of the instructor. The trainee was not expected to have analysed the emergency terrains at each stage of the flight in case of engine failure.

Moreover, neither the pilot instructor nor the PIC - who was also the NOSA instructor – had the habit of anticipating the emergency landing areas all along the flight path. This point seems to be agreed among all the instructors at the CFAMI. Therefore, they had not anticipated the emergency landing areas at each stage of the flight.

The lack of preparation concerning the suitable emergency landing areas at each point of the flight path is a cause to a non-relevant decision when the engine failure occurred.

2.3.3.2.3. Partial analysis of the situation

Following the engine failure, the crew focused its attention on obtaining visual information on the ground: this information is rapidly obtained but imprecise. Since they had not anticipated the possible emergency landing areas during the flight preparation or during the flight, the assessment of the aircraft's distance from Avignon airfield by the crew was purely subjective. In addition, focused on the search of a suitable area for ground landing, the crew forgot about the significant aerological conditions in their analysis of the situation. It did not realize that Avignon was not accessible.

The decision to head towards Avignon airfield was taken on the ground of a partial analysis of the situation.

2.3.3.2.4. Ergonomics of the cabin at the rear

The Cirrus SR22 is a single-pilot aircraft in which the rear seats have been designed for carrying passengers. The CFAMI uses this aircraft in its initial flight training of the trainee pilots and NOSAs of the French Air and Space Force. The rear seats are exclusively used by the NOSA instructors for navigator training flights.
Visibility of the exterior environment and instruments is extremely limited. The instrument panel is raised, and large pillars on either side limit the crew's field of view, especially in the case of the NOSA instructor in the rear seat. The NOSA instructor only has small, tinted windows to see outside the aircraft. Flying instruments are masked by the front seats.

Since the information available via personal perception is limited, the situational awareness of the PIC could only be partial and dependent on information that he managed to perceive.

The PIC for training missions on the Cirrus SR22 is the NOSA instructor. The design of the aircraft from the rear seat blocks the PIC's view of the onboard instruments and his perception of the exterior environment, which are necessary for acquiring an accurate situational awareness.

2.3.3.3. Crew characteristics

2.3.3.3.1. Passive posture of the trainee

The low level of experience of the trainee at the time of the occurrence caused him to rapidly adopt a passive attitude with regard to the decisions and actions of the instructors in managing the engine failure. This considerable difference in experience between instructor and trainee is common. It is specific to training crews.
This difference in experience prompts the trainee to adopt a passive attitude in the event of a real failure due to an objective lack of knowledge but also due to a subjective sense of lack of legitimacy.

The difference in rank is also a factor that led to a more passive posture by the trainee. It is commonly accepted that a difference of at least two pay grades causes the person of lower rank to adopt a passive role. Among this crew, the trainee was a candidate officer, while the instructors were respectively captain and major. Moreover, the pilot was also the squadron's commanding officer.

The crew's seemingly serene and very calm of the event reinforced the sense that the instructors were in control of the situation. The trainee did not feel he had to take initiatives.

The very low level of experience of the trainee, which is characteristic of training crews, prompted him to adopt a passive posture with regard to the decisions of the instructors, who were of higher rank, and their conduct appeared to him to be professional and appropriate.

2.3.3.3.2. Lack of assertion[16]

The account of the crew, corroborated by the radio exchanges with Marseille-Provence control tower, showed that the PIC was lacking assertion. At the time of the occurrence, communication between the two members of the crew remained limited. The PIC also adopted a relatively passive posture, assuming responsibility for the radio, while leaving the pilot to manage the flight path.

Among the squadron, the instructors have varied career paths corresponding to the different profiles of the aircrews of the AAE. Pilot instructors mainly come from the fighter pilot and transport pilot branches. These professional cultures are sometimes very different. The members of the aircrews have not all developed the same working habits. Also, the cultural mix in an instructor team and the habits specific to certain types of aircraft can be a risk factor due to differences in practice. Both the pilot flying and the PIC come from the world of fighter jets, and both were Mirage 2000D qualified and experienced pilots.

The Cirrus SR22 is a single-pilot aircraft with a single reciprocating engine. The PIC of the Cirrus acted as navigator for instruction missions. So, the PIC in fact appeared to be mainly responsible for training and for the mission rather than for the flight itself. Also, there is no operating manual for managing the use of this aircraft by a training crew, especially in the event of an engine failure in flight. In the absence of an operating manual, no procedure sets out in detail what is expected of each member of the crew, in particular with regard to mutual cross-checking of each other's actions. Both instructors know and appreciate each other. Because of their shared professional culture, they enjoy a strong mutual trust. At the time of the occurrence, communication between both these crew members was limited. The PIC adopted a relatively passive attitude, leading to a lack of leadership among the crew despite his role as pilot in command. Repeatedly, in particular during the exchanges with Provence, he expressed doubts on the ability of the aircraft to reach Avignon, but he left the evaluation and validation of the pilot's proposals to the pilot himself.

Based on their considerable common experience of two-seater fighter aircraft and their acquired working habits as fighter pilots, both instructors established a serene and mutually respectful distribution of tasks. While the pilot instructor took responsibility for the short-term piloting of the aircraft, the NOSA instructor / PIC took responsibility for communications and sought to assist in the longer-term decision-making. However, despite the doubts expressed by the PIC regarding the possibility of reaching Avignon, this choice of diversion was not questioned until the aircraft was below 2 000 ft (after the attempt to restart the engine), and the division of tasks remained strict.

Shared experience of two-seater fighter jets enabled the crew members to establish a serene and respectful division of responsibilities among the crew. The PIC is a navigator and seemed to be responsible mainly for the training or for the mission. However, despite his expressed doubts regarding the ability to reach Avignon, this choice was not challenged until the last moment, and the division of tasks remained strict.

[16] Assertion, or assertiveness/assertive conduct, is a concept designating the capability to express and defend one's rights without obtruding on the rights of other.

2.3.3.4. Decision to use the airframe parachute

2.3.3.4.1. Excess confidence

In the event of an engine failure in flight without any possibility of restarting the engine, the procedure prescribes the choice between a forced landing and the use of the airframe parachute. During the event, the crew rapidly decided on the latter option. They took it for granted to do. While the aircraft was still at more than 3,000 ft, the PIC notified the Marseille-Provence control tower that they would probably use the parachute if they could not reach Avignon. The decision to use the airframe parachute was then, rapidly taken by the crew without discussing any possibility of landing out of any airfield. The airframe parachute was considered to be the most reassuring solution, unlike an off-airport emergency landing, which was considered difficult and having a high risk of failure. This last solution was therefore, rapidly ruled out by the crew.

> Over confidence in the effectiveness of the airframe parachute, as opposed to an off-airport landing, which was perceived as risky by the crew led to the latter hypothesis being ruled out very quickly to adopt the parachute as a solution.

2.3.3.4.2. Practices in fighter aviation

In fighter aviation, in the case of single-engine aircraft with engine failure and no possibility of restarting in flight ("airstart"), the emergency procedure is obvious - ejection. Off-airport landing is impossible on these aircraft, which have a stall speed in excess of 110 kt. Therefore, the main experience of the crew in the event of engine failure involved a parachute rather than emergency landing in a field.
At the CFAMI, the use of the airframe parachute in the event of an engine failure is also strongly preferred by the organization as the "default" solution.
Opinion surveys conducted in the squadron in 2016, 2019 and 2021 (after the accident) showed an increasingly marked tendency to choose the airframe parachute over an off-airport landing. The result of 2021 seems to have been influenced by the initial feedback from this accident.
Confidence in emergency landings is very limited, and the consequences of accidents are overestimated is in spite of a lack of knowledge. As the crew, the squadron personnel are mainly from the fighter aviation, where the use of a parachute is considered the only possible decision.

> The practices in fighter aviation and the organization of the squadron lead to the preference for the airframe parachute over an off-airport emergency landing.

2.3.3.4.3. Limited experience of off-airport landing

The crew of fighter aircraft never conduct training for forced landings. This procedure is unsuitable for such aircraft. In this event, the crew of the aircraft mainly had aviation experience of fighter aircraft, which cannot carry out off-airport emergency landings. The pilot instructor and NOSA instructor joined the squadron in 2019 with less than 300 flight hours on the Cirrus aircraft. Training in emergency landing is rare. These landings have been exercised during qualification for the aircraft type and subsequently on average twice a year. Given this lack of experience, this procedure is felt by the instructors to be difficult and rarely executed satisfactorily.

> The experience of the squadron crews in off-airport landings is very limited. This procedure is felt by all to be particularly complex and likely completed satisfactorily.

2.3.3.4.4. Overestimate of the risk of off-airport landing

For the personnel of the CFAMI, a SR22 is poorly adapted to off-airport landings. This aircraft has small wheels on a non-retractable landing gear, and its stall speed is relatively high for such an aircraft. The recommendations issued by the safety officers at Salon-de-Provence stipulate forced landing as a solution only when engine power is still available. The lack of annual training in off-airport landing reinforces the lack of confidence in this procedure. It is, therefore, commonly accepted that off-airport landing is dangerous.

However, from the point of view of airworthiness and the rules of the civil aviation regulators, emergency landing is a sensitive procedure but is considered relatively safe. The landing gear of the Cirrus is designed to be easily broken off and detached in an off-airport landing on rough terrain. The statistics recorded in 1.18.3 and 1.18.4 permit a comparison between the risks of emergency landings and the use of the airframe parachute. This shows that, as recommended by the safety officers, emergency landing with the engine power still functional is relatively safe, with a survival rate of 99.94%. The survival rates from emergency landings without engine power and with the use of the airframe parachute are close to 90% in both cases. The unsuccessful emergency landings are due to human factors in managing the engine failure.

CFAMI personnel overestimate the danger of off-airport forced landings. The survival rates from emergency landings without engine power and from the use of the airframe parachute are nevertheless, comparable.

2.3.3.4.5. Ignorance of the risks of using the airframe parachute

According to the manufacturer's documentation, the use of the airframe parachute is not recommended in winds exceeding 30 kt at ground level. Under these conditions, the airframe risks being dragged along the ground by the parachute, making evacuation of the crew difficult or dangerous. However, this limitation on the use of the parachute is not mentioned in both POH and MCE. The POH simply reminds users of the risk that gusts of wind may drag the aircraft along the ground, especially on even terrain.
Then, crew is unaware of the risk associated with the use of an airframe parachute in strong winds. The use of the Cirrus SR22 for training flights is limited to maximum average wind speeds of 36 kt, with gusts of 40 kt. This limitation therefore, does not take into account the manufacturer's recommendations.

Crews are unaware of the risks associated with the use of airframe parachute in conditions of strong wind. The procedures do not mention any limitation or risk if the wind speed is above 30 kt.

2.3.3.5. Use of the airframe parachute under pressure of time

2.3.3.5.1. Late renunciation of the diversion

One minute and thirty-five seconds after deciding to glide to Avignon airfield, when the aircraft was still at an altitude of about 3 000 ft, the crew expressed doubts to the control tower on the possibility of reaching Avignon due to the partial headwind. The crew announced that it would probably deploy the parachute if it could not reach Avignon. Refusing to give up this option, the crew then attempted an engine airstart at 2 600 ft. Only when the aircraft had dropped below 2 000 ft did the crew start to look for an area where they could land.
At that point, the aircraft had already reached the altitude at which the decision had to be taken regarding which emergency procedure to adopt, emergency landing or airframe parachute.

Having decided to head for Avignon rapidly after already deciding on the airframe parachute, the crew then found it difficult to give up this initial plan of action, due to the associated cognitive cost. The crew continued its flight path until the aircraft dropped to the altitude where a decision had to be taken, at about 2 000 ft. On passing 1 900 ft, the pilot started looking for an emergency landing area. By delaying this change of plan, the crew totally reduced its analysis time, and the aircraft was now flying over an area ill-suited to either an emergency landing or the use of the parachute. The area included a motorway, a railway line and the river Durance. Moreover, most of the fields in this area are small and used for wine-growing or tree-growing and they were perpendicular to the wind.
With an emergency landing now entirely out of the question, the pilot prepared to deploy the airframe parachute. However, a short time earlier, focusing on the search for a suitable terrain, the crew had forgotten the presence of a high-voltage line, which was now directly below the aircraft.

Figure 26: Last few minutes of glide path

> The crew's decision to change its initial plan was late. For two minutes, they continued trying to land at Avignon. They decided to give up this attempt when the aircraft had just reached the minimum deployment limit of the CAPS and was flying over an area that was unsuitable for emergency landing or for the deployment of the airframe parachute.

2.3.3.5.2. Procedure for using the airframe parachute not completed

The pilot instructor did not notice the high-voltage power line until very late when he was preparing to deploy the airframe parachute. So, he delayed his action in order to distance the aircraft from the power line. Once the airframe parachute was deployed and the parachute canopy had stabilized, the aircraft hit the ground a few seconds later. This is because, initially, the aircraft had adopted a sharp nose down attitude, which was maintained for about fifteen seconds before the parachute was correctly deployed. In this nose down position, no action could be taken in the cockpit. On re-establishing the horizontal position of the aircraft, the crew only had five seconds before the aircraft hit the ground. This period of time was insufficient for the crew to carry out every action of the procedure. The fuel tank selector remained in the "open" position; the distress beacon was not activated, and the electric fuel pump was still switched on, at the moment of impact with the ground.

> A late perception of the high-voltage power line by the pilot instructor forced him to delay activating the airframe parachute. Due to a lack of time, the crew was not able to apply the complete procedure, causing a risk of fire while hitting the ground.

3. CONCLUSION

The accident was an engine failure in flight during the initial climb of a Cirrus SR22 aircraft, leading to the total destruction of the aircraft on landing after deploying the airframe parachute system.
#SCF-PP[17]
#EVAC

3.1. Identified factors useful to understanding the accident

On Tuesday April 13th 2021, a training mission was planned and ordered by the *Centre de Formation Aéronautique Militaire Initiale* (CFAMI - Centre for initial military aviation training) in *Salon-de-Provence*. A Cirrus SR22 aircraft took off from Salon-de-Provence air base at 13:58 with a crew consisting of a pilot in command/navigator, a pilot and a NOSA trainee.
At 14:06, at the beginning of the climb, on passing 5 000 ft directly above Cavaillon, without any warning, a failure of the aircraft's power plant occurred in flight The engine came to a complete stop immediately following the rupture of its crankshaft. The pilot than applied the "reflex" procedures associated with this type of failure and opted to stabilize the aircraft by maintaining a speed of 105 kt instead of seeking to achieve the best glide speed. The aircraft dropped below 4 500 ft from the ground, and the crew implemented a change of course towards the airfield of Avignon-Caumont, with which it had visual contact. However, the altitude and meteorological conditions (headwind) prevented the aircraft from reaching the runway. At the same time, the pilot emitted a distress message and reported the situation to Marseille-Provence. After gliding for 2 minutes against the wind, the pilot gave up the attempt to reach Avignon and attempted a final engine airstart without success at about 2 000 ft. The aircraft was at this moment at 1 700 ft, and the available options were limited. The aircraft was flying over the Durance River bed, and no suitable area for a forced landing was available. The presence of a high-voltage power line directly below the aircraft delayed the decision to activate the CAPS at the limit of its operating range, and it was finally activated at an altitude of 600 ft. This altitude was only just enough to deploy the parachute and did not allow the pilot time to complete the emergency procedure. A few seconds after deploying the parachute, the aircraft touched ground on the bed of the Durance and was immediately overturned by the gusts of wind and then dragged in stops and starts by these gusts over a distance of two hundred metres. The crew managed to evacuate the aircraft in two stages, taking advantage of rare lulls in the wind. The aircraft ended up totally destroyed in a grove of trees close to the motorway. The emergency services, which had been contacted at the time of the distress message, arrived rapidly at the site. One member of the crew was slightly injured.

3.2. Causes of the accident

3.2.1.Technical cause

The cause of the accident was an engine failure in flight due to a problem at crankshaft bearing No. 2, which had been damaged progressively over the course of several flights. The cause of this problem was probably a quality defect.
Problems of reliability have been recorded with the Continental engines of the Cirrus SR22 aircraft that have been operated within French state's fleet.

3.2.2.Organizational and human factors and environmental causes

The aircraft was destroyed by strong gusts of wind on the ground.
The decision to use the airframe parachute was motivated by:

- a culture at the CFAMI that favours the use of the airframe parachute over emergency landing;
- limited experience of the crews of the CFAMI squadron in emergency landings;
- overestimate of the risks of emergency landings by CFAMI personnel;
- a delayed decision by the crew to give up the attempt to reach Avignon, thereby reducing their options;
- ignorance of the risk of using the airframe parachute when there are strong gusts of wind at ground level;

[17] System/Component Failure or Malfunction (Powerplant) conforming to the Taxonomy of the air Accident/incident Data Reporting system (ADREP) of the ICAO:https://www.icao.int/safety/airnavigation/aig/pages/adrep-taxonomies.aspx.

- lack of an operating manual defining the limits of use of the airframe parachute;
- insufficient precision of the Cirrus manufacturer's manual regarding the risks of using the airframe parachute in gusts of wind.

The delay in deciding to give up the attempt to reach Avignon prevented the use of the airframe parachute under optimal conditions. This delay in the decision was due to:

- A lack of assertiveness by the PIC. Despite his expressed doubts about the ability to reach Avignon, this choice was not called into question until the last moment, and the distribution of responsibilities remained strict without mutual cross-checking;
- a significant cognitive cost associated with this decision in a situation of intense stress;
- extremely limited experience of the trainee, characteristic of training crews, causing him to remain passive during the accident;
- a lack of an operating manual specifying the role of the PIC-NOSA, in particular during an engine failure in flight.

4. SAFETY RECOMMENDATIONS

4.1. Preventive measures directly related to the accident

4.1.1.Continental Engine

The investigation highlighted the fact that the reliability of the IO-550 engines of the Cirrus SR22 aircraft is perfectible. The complete product returns to the workshop for technical reasons concern all these engines, giving an average operating life of 1 350 hours, compared to the operating limit of 2 200 hours, as was specified by the manufacturer.

Consequently, BEA-É recommends:

> to AFAE to adjust the overhaul interval of the Cirrus SR22 engine to its observed operating reliability.
>
> R1 – [A-2021-09-A] *Addressed to: AFAE*

4.1.2.Emergency landing

Confidence in emergency landing at CFAMI is low. The culture at the centre, marked by the considerable experience of fighter jet aviation for the majority of the personnel, results in a preference for the use of the airframe parachute. The safety regulations consider emergency landing to be a procedure of limited risk. The pilot is a Mirage 2000 veteran, and his training in emergency landing is therefore, limited. His mandatory training on piston engine aircraft after his transfer to the training centre in Salon included one single emergency landing exercise only:

Consequently, BEA-É recommends:

> to the French Air and Space Force to formalize the rules of use of the airframe parachute by associating it with the forced landing, in particular in aerological conditions of important winds and gusts on the ground and to enrich the training of the pilots on Cirrus aircraft with these complements.
>
> R2 – [A-2021-09-A] *Addressed to: CEMAAE*

4.1.3.Conditions of use of the airframe parachute

The use of the Cirrus SR22's airframe parachute during strong ground wind gusts contributed to the destruction of the aircraft. This rescue device does not have a release system to reduce the wind load after the aircraft touches down. In addition, the conditions of use of the airframe parachute in the presence of strong gusts on the ground are not clearly defined in the manufacturer's manual.

Consequently, BEA-É recommends:

> to NTSB to have Cirrus Aircraft study an airframe parachute system that incorporates a partial or total canopy release mechanism.
>
> R3 – [A-2021-09-A] *Addressed to: NTSB*

> To NTSB to have Cirrus Aircraft specify the conditions of use of the airframe parachute in the presence of strong gusts on the ground.
>
> R4 – [A-2021-09-A] *Addressed to: NTSB*

4.1.4.Operating Manual

On the Cirrus SR22, the PIC is officially the NOSA instructor. The investigation revealed a lack of assertions in the management of the accident. The late decision to give up the attempt to reach Avignon prevented the use of the airframe parachute under its optimal operating conditions and limited the alternatives for a forced landing. Despite the doubts expressed by the PIC, this choice challenged until the last moment, and the distribution of tasks remained strict. No operating manual has been drawn up to regulate the use of this aircraft by a training crew. Moreover, the investigation revealed a documentary dispersion that is detrimental to firm knowledge of the standards operational procedures by the crews.

Consequently, BEA-É recommends:

> to the French Air and Space Force to provide the CFAMI crews with a document, such as an operating manual, describing operation of the Cirrus SR22 by training crews, specifying the distribution of responsibilities between the pilot flying and the navigator.
>
> R5 – [A-2021-09-A] *Addressed to: CEMAAE*

4.1.5. Emergency procedure

The emergency procedures in the event of an engine failure described in the MCE issued by the CFAMI do not exactly align with check-list items in the Cirrus POH. They have been adapted for trainee pilots, and a uniform best glide speed has been specified for both the SR20 and SR22 aircraft. These new speed recommendations do not maximize the distance travelled or the flight time in the event of an engine failure.

Consequently, BEA-É recommends:

> to the French Air and Space Force to bring the MCE into consistency with the POH, in particular by adopting the best glide speed values defined by the manufacturer.
>
> R6 – [A-2021-09-A] *Addressed to: CEMAAE*

4.1.6. Simulator training

Reconstitution of the accident highlighted the deviations in execution of the emergency procedures compared to the procedures specified in the MCE. The lack of a simulator with the capability to conduct training in emergency procedures, combined with the exercises on the aircraft, which, for safety reasons, do not include all the items of the check-list, do not favour the acquisition of automatic physical reflex actions and their application in flight, in particular in situations of intense stress.

Consequently, BEA-É recommends:

> to the French Air and Space Force to upgrade the Cirrus simulator and have it updated with training functionalities for the procedures to adopt in the event of technical failures.
>
> R7 – [A-2021-09-A] *Addressed to: CEMAAE*

4.2. Measures not directly linked to the accident

4.2.1. Voice recorder

The voice recorder of the aircraft involved in the accident was found relatively undamaged after the accident. However, the recording of the most recent flights had not worked. This equipment was never checked by the AFAE.

Consequently, BEA-É recommends:

to AFAE to establish a plan for maintaining the audio recording equipment in operational condition.

R8 – [A-2021-09-A] *Addressed to: AFAE*

to DMAé to specify a clause in its light aircraft supply contracts that would require the mandatory use of hardened flight recorders, in accordance with the ED-155 standard of the European Organisation for Civil Aviation Equipment (EUROCAE).

R9 – [A-2021-09-A] *Addressed to: DMAé*

4.2.2. Maintenance tracking

The DMAé, which is responsible for the contract concerning the provision of aircraft for pilot training at Salon-de-Provence, does not have access to all the technical information on the problems affecting the early returns for an overhaul of the Continental engines of the Cirrus SR22 aircraft even though said problems may relate to air safety.

Consequently, BEA-É recommends:

to DMAé to add in its contracts a clause or clauses defining the tracking indicators for technical incidents affecting safety.

R10 – [A-2021-09-A] *Addressed to: DMAé*

4.2.3. Distress radio beacon

The distress radio beacon was not activated during the accident, and the pilot was unable to complete the emergency procedure for the deployment of the airframe parachute, which requires activation of the radio beacon.

Consequently, BEA-É recommends:

to NTSB to have Cirrus Aircraft study a mechanism to automatically activate the emergency locator transmitter when the airframe parachute is triggered.

R11 – [A-2021-09-A] *Addressed to: NTSB*

INTENTIONALLY LEFT BLANK