RÉPUBLIQUE FRANÇAISE
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BEA-É

FRENCH STATE FLIGHT SAFETY
INVESTIGATION BOARD

INVESTIGATION REPORT

A-2024-02-I

Event date	February 12th 2025
Place	Salon-de-Provence (France)
Type of aircraft	Extra 330 SC
Organization	French Air and Space Force

NOTICE

USE OF THE REPORT

In accordance with article L. 1621-3 of the French Transport Code ("Code des Transports"), the sole purpose of this safety investigation 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 draws 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 France local time (UTC + 1 hour).
The figures are oriented according to the geographic north.

This is a courtesy translation of the safety investigation report. As accurate as the translation may be, the original text in French is the work of reference.

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GLOSSARY

FAI	International Aeronautical Federation – *Fédération Aéronautique Internationale*
FASF	French Air and Space Force
BAAC	Air Fighter Aircraft Brigade - *Brigade aérienne de l'aviation de chasse*
CIVA	International aerobatic commission – *Commission internationale de la voltige aérienne*
NDT	Non-destructive testing
DGA EP	General Directorate of Armament Aero-engine Testing – *Direction générale de l'armement Essais propulseurs*
DGA TA	General Directorate of Armament Aerospace Systems – *Direction générale de l'armement Techniques aérospatiales*
EASA	European Union Aviation Safety Agency
EQPAAE	French Air and Space Force presentation teams – *Équipes de présentation de l'armée de l'Air et de l'Espace*
EVAAE	French Air and Space Force aerobatic team – *Équipe de voltige de l'armée de l'Air et de l'Espace*
ft	Feet. 1 ft equal 30,48 cm
kt	Knot. 1 kt equal 1,852 km/h
NIDA	Honeycomb – *Nid d'abeille*
POH	Pilot's Operating Handbook
RESEDA	Accident Recorder Analysis Department – *Restitution des enregistreurs d'accidents*
IV	Intermediate visit
DI	Daily inspection
V_A	Design manoeuvring speed (kt)
V_{NE}	Never exceed speed (kt)

SUMMARY

Date and time of the event : February 12th 2024 at 12:20 (11:20 UTC)
Place of the event : Salon-de-Provence Airbase 701, France
Organization : French Air and Space Force (FASF) – *Armée de l'Air et de l'Espace (AAE)*
Organizational command : Air Fighter Aircraft Brigade - *Brigade aérienne de l'aviation de chasse (BAAC)*
Unit : French Air and Space Force aerobatic team – *Équipe de voltige de l'armée de l'Air et de l'Espace* (EVAAE)
Aicraft: Extra 330 SC registration F-TGCI
Nature of the flight : aerobatic flight training
Number of persons on board : 1

Summary of the event

On February 12th, 2024, the Extra 330 SC number 04[1] performed its second flight of the morning at the Salon-de-Provence Airbase 701. After an aerobatic training session, the pilot in command lands and returns to the parking area. During the post-flight inspection[2], the aircraft engineer notices a significant crack on the rudder, the aircraft is declared out of service.
The aircraft is damaged and the pilot is unharmed.

Composition of the safety investigation group

- A BEA-É-appointed chief safety investigator (investigator in charge - IIC) ;
- A BEA-É-appointed assistant to the IIC ;
- An on-scene investigator ;
- A Extra 330 SC-experienced pilot ;
- A Extra 330 SC-experienced engineer ;
- An expert in organizational and human factors ;
- An aviation medicine-licensed physician ;
- An accredited representative from *Bundesstelle für Flugunfalluntersuchung* (BFU, Germany).

Autres experts consultés

- *Direction générale de l'armement Essais propulseurs (DGA EP) / Restitution des enregistreurs d'accidents (RESEDA)*, General Directorate of Armament Aero-engine testing / Accident Recorder Analysis Department ;
- *Direction générale de l'armement – Techniques aérospatiales (DGA TA)*, General Directorate of Armament Aerospace systems.

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1 Named SC04 in the following report.

2 The post-flight inspection includes a complete tour of the aircraft and preparation supplements if necessary (refueling, adjustments, etc.).

NO TEXT

1. FACTUAL INFORMATION

1.1. History of the flight

1.1.1. Mission

Flight type : military air traffic – visual flight rules (VFR)
Type of mission : aerobatic flight training
Takeoff point : Airbase 701, located in Salon-de-Provence aerodrome (LFMY)
Takeoff time : 11:45
Landing point : Airbase 701, located in Salon-de-Provence aerodrome (LFMY)

1.1.2. Detailed account of the flight

1.1.2.1. Context

The EVAAE is organizing a training session from February 12 to 16, 2024, under the direction of the coach of the French aerobatic team, in preparation for competitions and the opening of the 2024 season.
The EVAAE training flights, which take place from and above the Salon-de-Provence base, have an average duration of 25 minutes. The maneuvering area for aerobatics takes the form of a cube called a box, with a volume of 1 km^3, whose base is marked on the ground by white markings. The instructor positions himself at the central point, near the maneuvering area to observe the program.

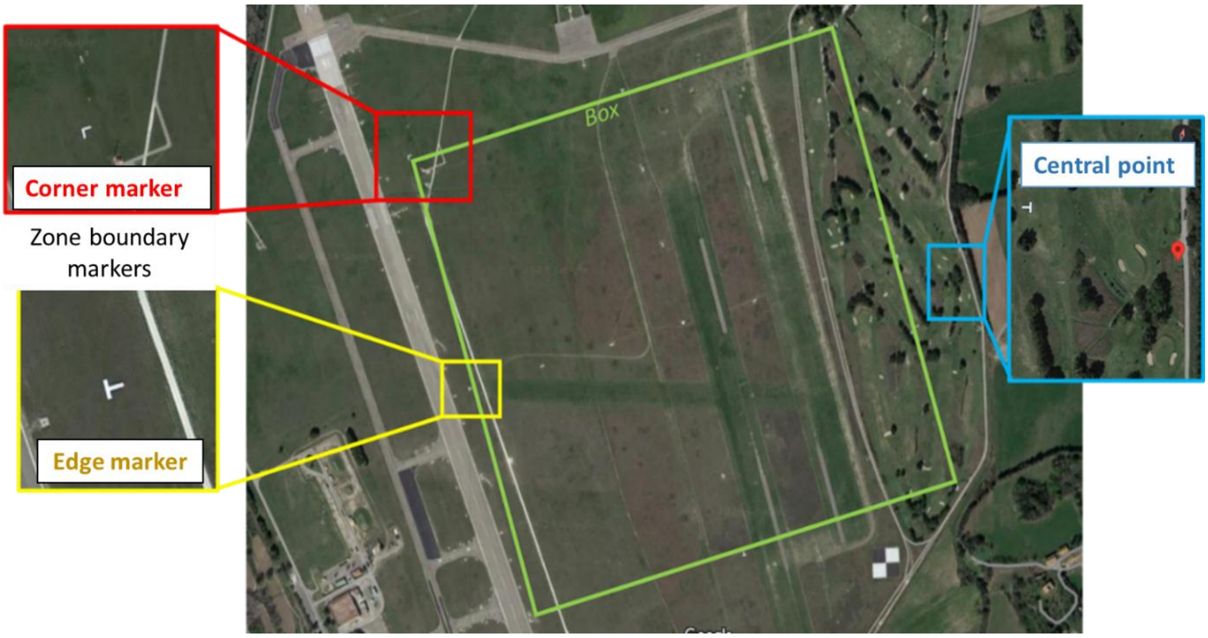

Figure 1 : maneuvring box for EVAAE at Salon-de Provence airfield

A typical day includes eight flights, four per half-day split between the two single-seater Extra 330 SC aircrafts of EVAAE. Engineers perform a daily inspection (DI) on each aircraft. Each flight is preceded by an inspection called pre-flight inspection (« PRE ») carried out jointly by an engineer and the aircraft pilot, followed by a post-flight inspection (« POST »), performed by an engineer only. The visits surrounding the flights allow for a return to service consisting of a top-up of fuel or an adjustment of the cabin preparation, depending on the need.

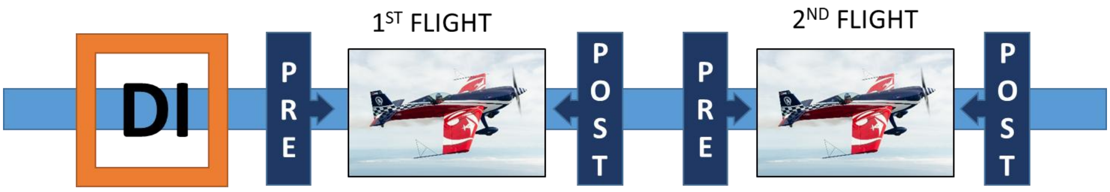

Figure 2 : typical schedule of a morning flight by aircraft

1.1.2.2. Flight preparation

On February 12th, 2024, upon arriving at the unit, the pilot in command (PIC) checks the weather. He is training that day on his "known-free" program of the Unlimited[3] category. He confirms fuel quantity, given the duration of the flight and the planned training. He flies after a first pilot who also conducts training under the direction of the coach. During the first flight, the pre-flight inspection as well as the flight and the post-flight inspection proceed nominally. During the second rotation, the PIC performs the pre-flight inspection with a unit's engineer. This one proceeds in a standard manner.

1.1.2.3. Description of the flight and the factors that led to the event

Runway 34 is in service. Due to light winds, the PIC requests and is authorized to take off from runway 16 to reduce taxi time. The aircraft takes off at 11:45 and directly enters the box after its activation by Salon-de-Provence control. The PIC switches to the auto-information frequency dedicated to the flight zone and informs of the activation of the box. After a reconnaissance of the axis, he checks the wind's orientation and speed to adjust his positioning in the volume, then performs the radio tests with the coach. He performs his aerobatic program, then, following the debriefing with his coach, decides to perform the tail-slide[4] figure several times to improve. He then completes his flight with a freestyle[5] sequence. He releases the box after 22 minutes of occupation and directly integrates the downwind leg to land. He clears the runway, rolls to the EVAAE parking area and shuts down the engine. An engineer performs the post-flight inspection and then discovers a significant crack on the rudder. The head of engineering deparment is informed of the anomaly and declares the aircraft unavailable.

1.1.3. Location

- Place :
  - country : France
  - municipality : Salon-de-Provence
  - geographical coordinates : N 43°37'08" / E 005°07'05"
  - height of the event location: around 3,200 ft
- Moment : daytime
- On Salon-de-Provence aerodrome (LFMY)

1.2. Injuries to persons

The PIC was unharmed.

1.3. Damage to aircraft

The aircraft was damaged.

1.4. Other damage

Not applicable.

1.5. Personnel information on the PIC

- Age : 35 years old
- Assignment unit : French Air and Space Force presentation teams (EQPAAE) / French Air and Space Force aerobatic team (EVAAE)
- Training :
  - qualification : transport pilot in 2013, aerobatic pilot in 2009 (integration into the French aerobatic team in 2018)
  - specialization school : French Transport Aviation School (*École de l'Aviation de Transport, EAT*), 2013.
- Flight hours as pilot :

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[3] Highest category of aerobatics for single-seat aircraft.

[4] The tail-slide figure is an aerobatic maneuver consisting of transitioning from a level flight path to a vertical climb phase until the aircraft comes to a halt, followed by a vertical backward flight phase that ends with a swing, either forward or backward, similar to the movement of a bell's clapper. The aircraft then resumes a diving trajectory.

[5] Sequence of free figures, chosen and sometimes created by pilots, not necessarily listed in the catalog of aerobatic figures.

	Total		During the previous 6 months		During the previous 30 days	
	on all types	Extra 330 SC	on all types	Extra 330 SC	on all types	Extra 330 SC
Total (h)	2,830	809	46	37	8	8

- Date of previous flight : February, 1st 2024

1.6. Aircraft information

- Organization : FASF
- Organizational command : BAAC
- Based aerodrome : Airbase 701 Salon-de-Provence, France
- Assignment unit : EVAAE
- Aircraft type : Extra 330 SC single-seater from family *Extra Flugzeugbau Extra 300* Extra Aircraft

	Type- series	Number	Total flight hours (h)	Flight hours (h) since
Airframe	Extra 330 SC	89	477	IV 50 : 10 IV 100 : 35
Engine	Lycoming AEIO-580-B1A	L-278-79 E	37	-
Propeller	MTV 9 BC/C198-25	190435	847	-
Rudder	-	3C101.020-VF	3,600	IV 100 : 35 IV 1000 : 778

The aircraft's airframe was entirely rebuilt in 2022 by the manufacturer following the discovery of a crack in the metal framework[6]. The new fuselage bears the number 89. However, the EVAAE has kept the designation 04 for visibility at airshows and in competitions.
The Extra 330 SC is a German-made aerobatic aircraft. Its wingspan is 7.5 m and the fuselage length is 6.7 m. Part of its structure is made of carbon fiber composite, including the wings and the rudder. The composite material of the rudder is in a sandwich[7] structure.

1.6.1. Maintenance and airworthiness

Examination of the technical documentation showed that maintenance was conducted in accordance with the applicable maintenance schedule. The aircraft was airworthy.

1.6.2. Performance

The calculated performance for the aircraft configuration in the day's weather conditions was compatible with the mission.

The values of the characteristic speeds and the aircraft's limit load factors are indicated in the airworthiness certificate[8] of the Extra 300 aircraft. In particular.:
- Never exceed speed V_{NE} is 219 kt ;
- Maneuvering speed V_A[9] , for aerobatic category, is 154 kt ;
- The limit load factors in the aerobatic category are ± 10 g for a weight up to the maximum takeoff weight of 780 kg.

6 Main structural framework of the aircraft consisting of longitudinal, vertical, and diagonal metal bars forming a rigid triangulated structure.
7 Material resulting from the assembly of two thin but rigid outer skins to a light but thick central core.
8 Type-Certificate Data Sheet (TCDS) EASA.A.362
9 The maneuvering speed is the maximum speed at which full deflection of the flight controls (in roll, pitch, and yaw) will not create an overload on the aircraft.

1.6.3. Mass and center of gravity

Its takeoff weight is 755 kg, with a maximum weight of 780 kg. It is 716 kg upon landing. The center of gravity is within the required limits throughout the flight.

1.6.4. Fuel

- Type of fuel : AVGAS - 100 LL[10]
- Quantity of fuel at take-off : 60 litres
- Quantity of fuel at landing : 22 litres

1.6.5. Other fluids

- Engine oil : AeroShell (Piston Engine Oil 100)
- Smoke : paraffin oil (FC05 white mineral oil based on petroleum).

1.7. Meteorological information

1.7.1. Forecast

The weather forecast prepared by the meteorological center of Airbase 701 indicates visibility greater than 10 kilometers, a ceiling above 5,000 ft, and calm winds with a temperature of 11° C. A change is expected with a ceiling of 8,600 ft starting at 12:00.

1.7.2. Observations

The weather conditions are in line with the forecast and favorable for aerobatic training flight. The wind is variable at 2 kt.

1.8. Aids to navigation

Not applicable.

1.9. Communications

The aircraft is equipped with two VHF radio stations. The PIC is in contact with the control tower of Salon-de Provence for takeoff and landing phases, then during aerobatics with the coach of the French team and on standby on the self-information frequency dedicated to the flight area.

1.10. Aerodrome information

The Salon-de-Provence airfield (LFMY) is located on Airbase 701, which is situated in the municipalities of Salon-de-Provence and Lançon-de-Provence. The main runway 16/34 is a paved runway 2,001 meters long. There are three other unpaved runways used for gliding.

No NOTAM[11] is published for February 12, 2024, and no operational restrictions are in effect.

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[10] AVGAS, a shortened form of "aviation gasoline" & LL for "low lead", low lead content.

[11] Notice to Airmen – Aeronautical messages to airmen: published messages containing essential information for flight operations on or around aeronautical infrastructures.

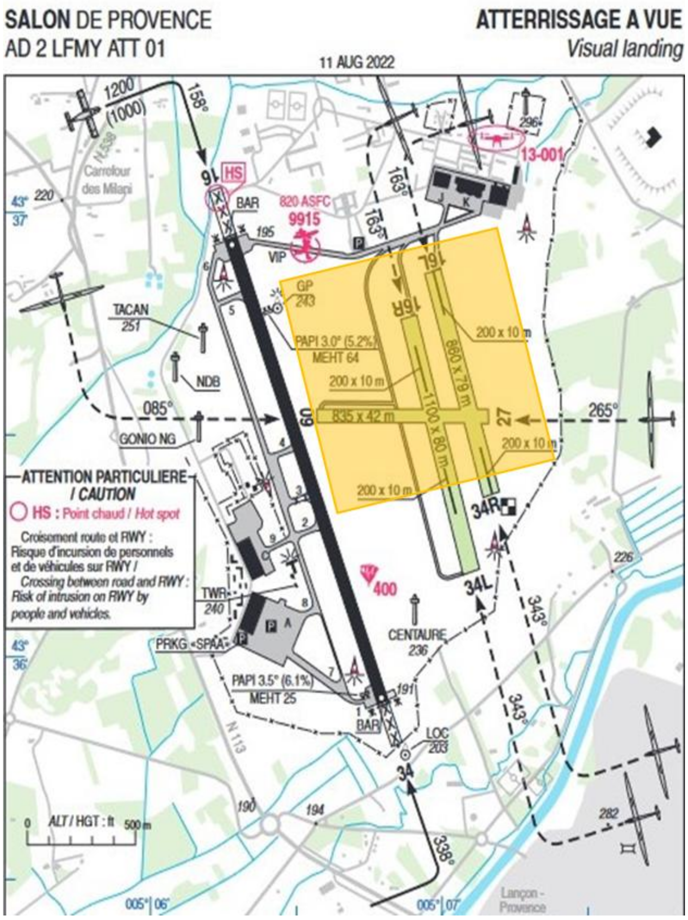

Figure 3 : visual approach chart of Salon-de-Provence airfield with the representation of the aerobatics box

1.11. Flight recorders

The aircraft is equipped with a flight data and voice recording APIBOX system, which memorizes the trajectory, radio and onboard telephone conversations, and some flight and engine parameters. In addition to being stored in the hardened recorder, this data is exported to a removable SD (secure digital) memory card.

The aircraft is also equipped with an internal memory accelerometer, model TL-3424[12], which records positive and negative accelerations along the vertical axis of the aircraft.

Training flights for aerobatics are filmed from the central point for debriefing purposes. The flight video has been retrieved.

All the data could have been exploited. However, during the expertise, it turned out that the rudder position sensor was defective over a large part of its operating range, providing erratic and unreliable position data compared to the physical position of the rudder.

1.12. Observations of the aircraft

The rudder has a crack on the left side measuring 60 cm.

12 The SC04 integrates an accelerometer TL-3424_EXT, a modified version of the TL-3424 type accelerometer, specifically designed for the EVAAE. Among the modifications made, there is the addition of an indicator functionality that allows the pilot to position themselves on the scale of load factor values (the alarm frequency gradually increases as the load factor increases).

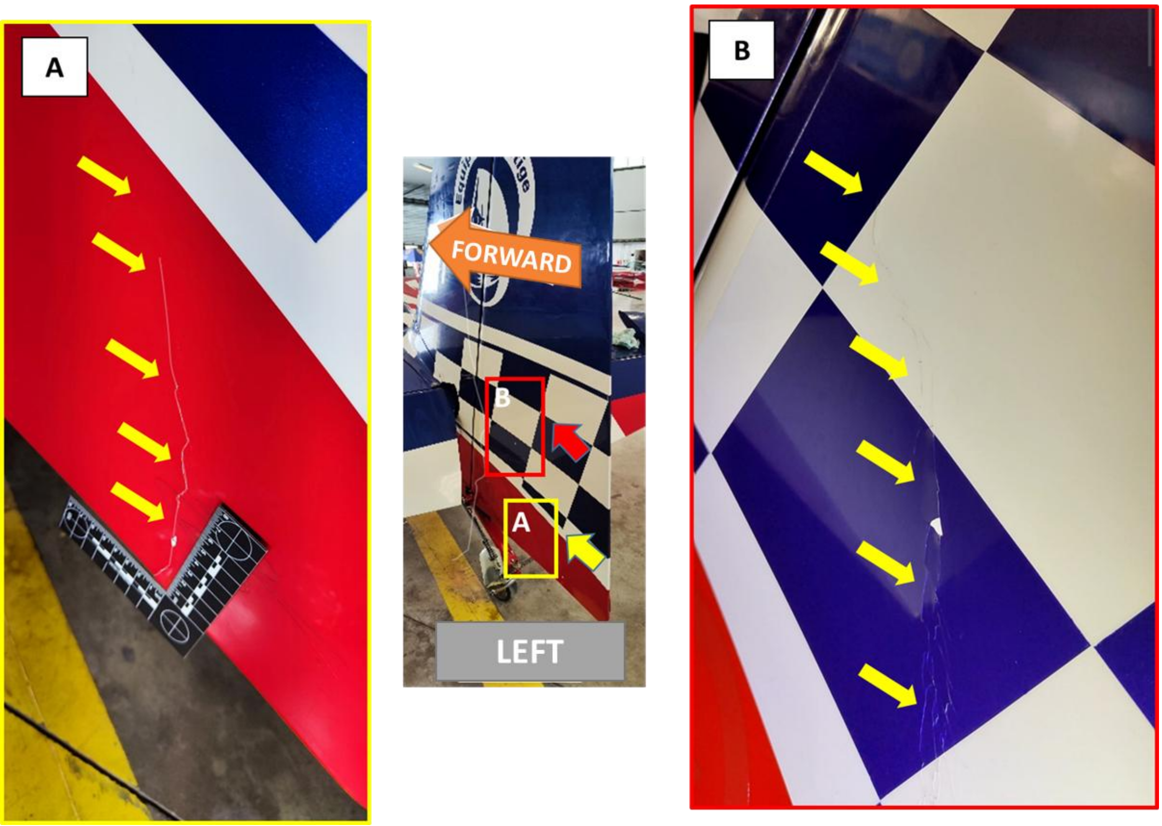

Figure 4 : crack on the left side of the rudder

The crack is visible over 10 cm under the rudder.

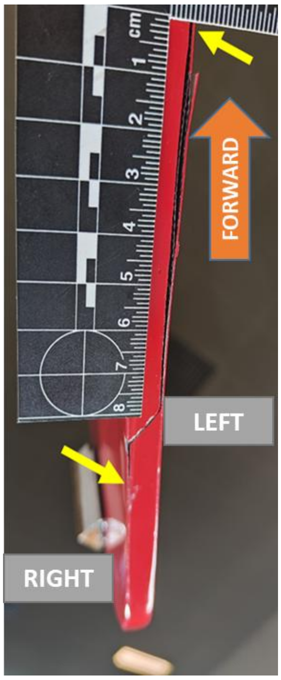

Figure 5 : underside view of the rudder crack

It is also visible on the right side and measures 15 cm.

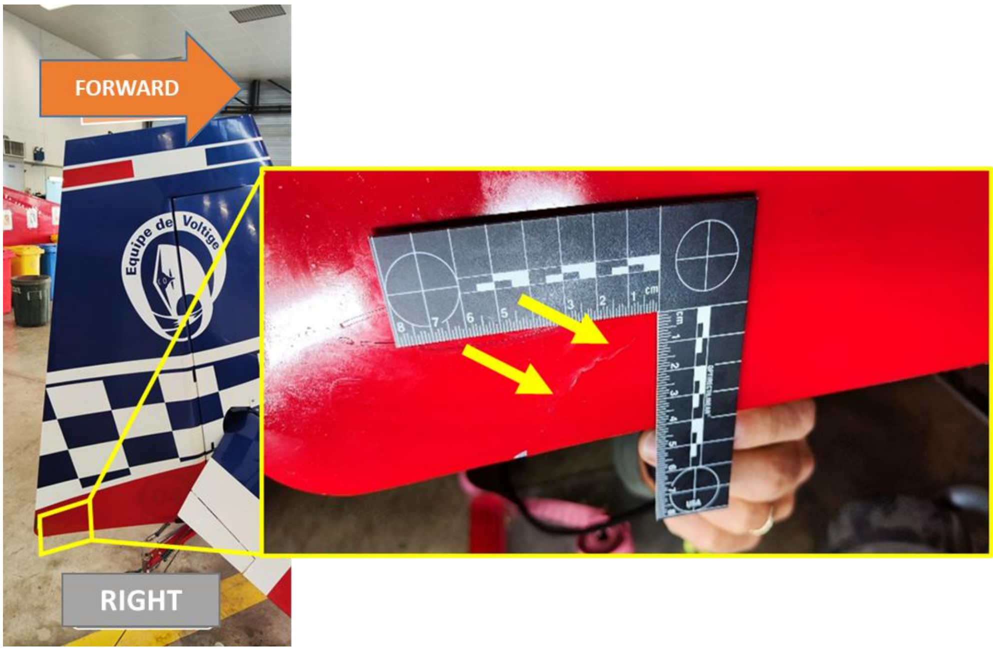

Figure 6 : crack on the right side of the rudder

Droplets of greasy fluid are under the rudder, and at the bottom of the rear fuselage.

1.13. Medical and pathological information of the pilot in command (PIC)

- Last medical examination :
  - type : examination at the Medical Center for Aviation Personnel (*Centre d'Expertise Médicale du Personnel Navigant, CEMPN*) on November 29, 2023
  - result : fit
- Screenings : not conducted
- Injuries : none

1.14. Fire

Not applicable.

1.15. Survival aspects

Not applicable.

1.16. Tests and research

The expertise of the rudder and the analysis of the fluids sampled from the rudder were carried out by DGA TA.
The flight data recorders and video were analysed by DGA EP / RESEDA.
The analysis of organizational and human factors was carried out by the BEA-É.

1.17. Information concerning the organizations

1.17.1. French Air and Space Force aerobatic team (EVAAE)

The EVAAE has been, since 1968, one of the components of the representation of the know-how of the aviators of the FASF. The unit currently has two single-seat Extra 330 SC aircraft, which have been in service since 2008, and a two-seat Extra 330 LC aircraft. It consists of 13 people, including 4 officer pilots. They participate in the unit's two main missions: participation in air acrobatics competitions and air shows. Some of the pilots selected for the French team, including the PIC of the event, participate in international aerobatic competitions. The EVAAE is responsible for part of the maintenance of the aircraft and ensures the return to service, daily inspection, and intermediate visits at 25 and 50 hours.

1.17.2. Sabena Technics ATP

Sabena Technics Aérotech PRO (ATP), a subsidiary of the Sabena Technics group, has held the contract for supporting the Extra 330 fleet of the EVAAE since May 2021. Based in Marignane (France), it is responsible for the 100 and 1,000-hour intermediate visits. It also intervenes for emergency repairs and to provide support to the AAEE during meetings.

1.18. Additional information

1.18.1. Aerobatics

Aerobatics in France is managed both by the French Federation of Aeronautics and International Aerobatic Commission (CIVA, « *Commission Internationale de la voltige aérienne* »), an international entity responsible for the regulation and management of international aerobatic competitions under the auspices of the International Aeronautical Federation (IAF).
Aerobatics is organized into several competition categories, varying according to the pilots' level of experience and the complexity of the figures to perform. The three highest levels of practice in France, in increasing order of difficulty, are: *National 1* (equivalent to the international Advanced level), *Excellence*, and *Élite* (equivalent to the international Unlimited level). Each category corresponds to programs of figures, flight durations, and restrictions on use (load factor, minimum flight height).

Pilots belonging to the *Élite* (Unlimited) category organize, with their coach, intensive training camps with the aim of maintaining the highest world level. A competition is structured around five programs: a « known-free » program (Free-Known), three « unknown-free » programs (Free-Unknown), and a freestyle program.
The « known-free » program includes five known figures imposed by CIVA at the beginning of the year, plus five free figures, taken from the aerobatic catalog Aresti[13], to be selected at the choice of each pilot.
Each « unknown-free » program is generally built 48 hours before the competition. Competitors propose, according to a draw order, their figure. This figure is generally a combination of "sub-figures" taken from a list of eligible[14] figures and whose achievement could put competing pilots at a disadvantage. In total, 10 figures of this type and 4 connecting figures are selected to constitute the program.
The freestyle program consists of a timed sequence of figures chosen by the pilot that do not necessarily appear in the Aresti catalog.

The pilot, before starting a program, does a warm-up. It allows the competitor to perform the first five figures of the program, before being able to run through the entire program again.

1.18.2. Tail-slide figure and its combinations

The tail-slide figure (figure 7) consists of linking, from a level flight trajectory ❶, a phase of vertical climb ❷ until the aircraft comes to a halt, followed by a vertical backward flight descent phase ❸, leading to a swing (forward or backward) similar to the movement of a bell's clapper ❹, and ending with a resumption of a diving flight trajectory ❺. This figure is one of the most difficult aerobatic maneuvers to perform correctly.

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13 The Aresti catalog allows defining and standardizing aerobatic figures through a dedicated notation system. It was written by the Spanish pilot José Luis Aresti in the 1960s.

14 The eligible figures for the "unknown" program are listed in the IAC code "Regulations for the Conduct of International Aerobatic Events" (Appendix A of Part 1, Section 6).

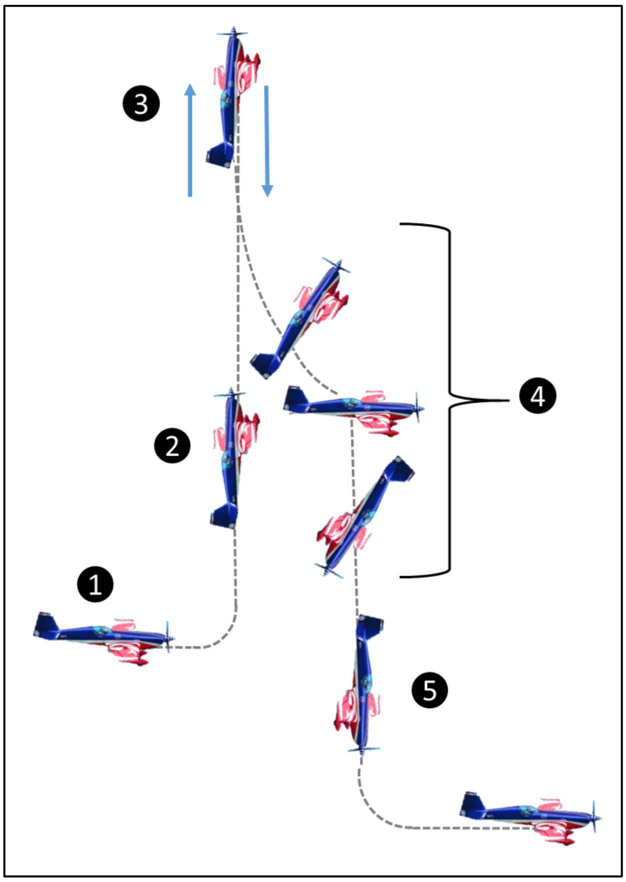

Figure 7 : pattern illustrating the tail-slide figure (case of a forward swing)

The aircraft's backward flight phase must be carried out over a minimum regulatory distance of half the aircraft fuselage in accordance with section 6 of the FAI sporting code[15]. For the Extra 330 SC, this minimum distance is therefore approximately 3.5 m.

The tail-slide figure can also be combined with other aerobatic maneuvers in its phases ❷ and ❺. The combination becomes an aerobatic figure in its own right that can be selected in a competition program. Thus, for the 2024 season, CIVA specified, among the five compulsory figures of the "known-free" program, the combination of a continuous roll[16] (full turn plus a quarter turn) followed by a tail-slide and then a flick roll[17] (three-quarter turn).

15 « Regulations for the Conduct of International Aerobatic Events » (FAI sporting code, Section 6, Part 1 Powered aircraft).

16 Aircraft rotation around its longitudinal axis controlled by the ailerons.

17 Rapid rotation of the aircraft caused by a dynamic dissymmetric stall (loss of lift on one wing). This maneuver is controlled by the elevator and rudder controls.

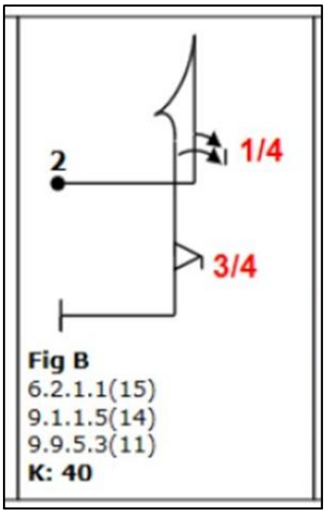

Figure 8 : tail-slide figure specified by CIVA for the Unlimited category fo the 2024 season

1.18.3. The sandwich-structured material

A sandwich-structured material results from the bonding assembly of two skins and a core material. The skins are of low thickness and have very good mechanical characteristics of stiffness and strength. Between the two skins is interposed a core material of high thickness and low density. The interest of such an assembly is to be able to increase the flexural stiffness of the material while minimizing the weight of the whole.

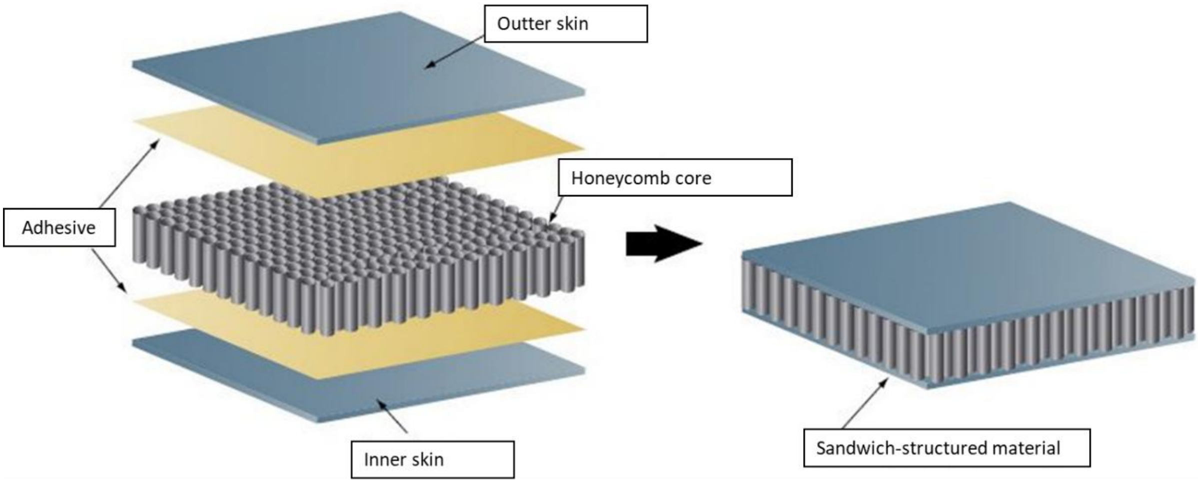

Figure 9 : schematic view of a sandwich-structured material

On the Extra 330 SC, the rudder is an assembly of two panels. Each of the two panels is a sandwich structure material consisting of two carbon fiber composite skins bonded to a Nomex[18] honeycomb (NIDA) core.

[18] Synthetic aramid fiber (aromatic polyamide).

2. ANALYSIS

2.1. Technical investigations

2.1.1. Rudder expertise

2.1.1.1. Flight potential and control operations

The SC04 was delivered in 2008 to the EVAAE. It recorded 3,600 flight hours during the event for a potential certified by the manufacturer of 6,000 flight hours. Among the structural elements composing the SC04, the rudder is original, making it one of the oldest structural elements in the world fleet of Extra 330 SC.

The rudder is visually checked by the EVAAE engineers at each DI, then at each pre and post-flight inspections. The structural integrity check of the rudder is carried out by coin tapping[19] (non-destructive testing – NDT) every 1,000-hour intermediate visit. This operation is the only one described in the detailed list of maintenance tasks that allows verifying the structural integrity of the rudder. The last 1,000-hour intermediate visit was carried out at the end of 2020 by Extra Aircraft, which was then the contractor for the support of the EVAAE's Extra 330 fleet. No damage was identified during this visit.

During the visits carried out by the EVAAE, mechanics are accustomed to performing a quick tap-test inspection during aircraft tours by tapping with their fingers or an appropriate object on the aircraft's composite structures to detect any anomalies by sound (mainly delaminations in sandwich-structured materials). Any necessary verification is systematically carried out by the approved maintenance organization in charge of the fleet, Sabena Technics ATP.

The rudder from SC04 has logged 3,600 flight hours out of a potential 6,000 hours. Its structural integrity is checked at every intermediate visit of 1,000 hours.

2.1.1.2. Structural expertise

NDT examinations by thermography, then by *bond-tester*[20], carried out on the rudder reveal in the left panel of the rudder a propagation in delamination of part of the structure. This delamination is restricted to a strip of a few centimeters on either side of the visible crack. No structural defect is detected in the right panel of the rudder.

[19] Coin tapping is a non-destructive testing method (tap-test type) where a coin is struck against the surface of simple materials or bonded assemblies to locate areas of delamination, cavities, or inclusions. The acoustic response obtained allows for the identification of any structural changes (stiffness, density, volume) in the inspected piece by comparing it to a healthy area.

[20] Bond-tester is an NDT method operating on the same acoustic response principle as tap-test. It is performed using a transmit-receive probe. The detectability of defects is improved compared to coin tapping.

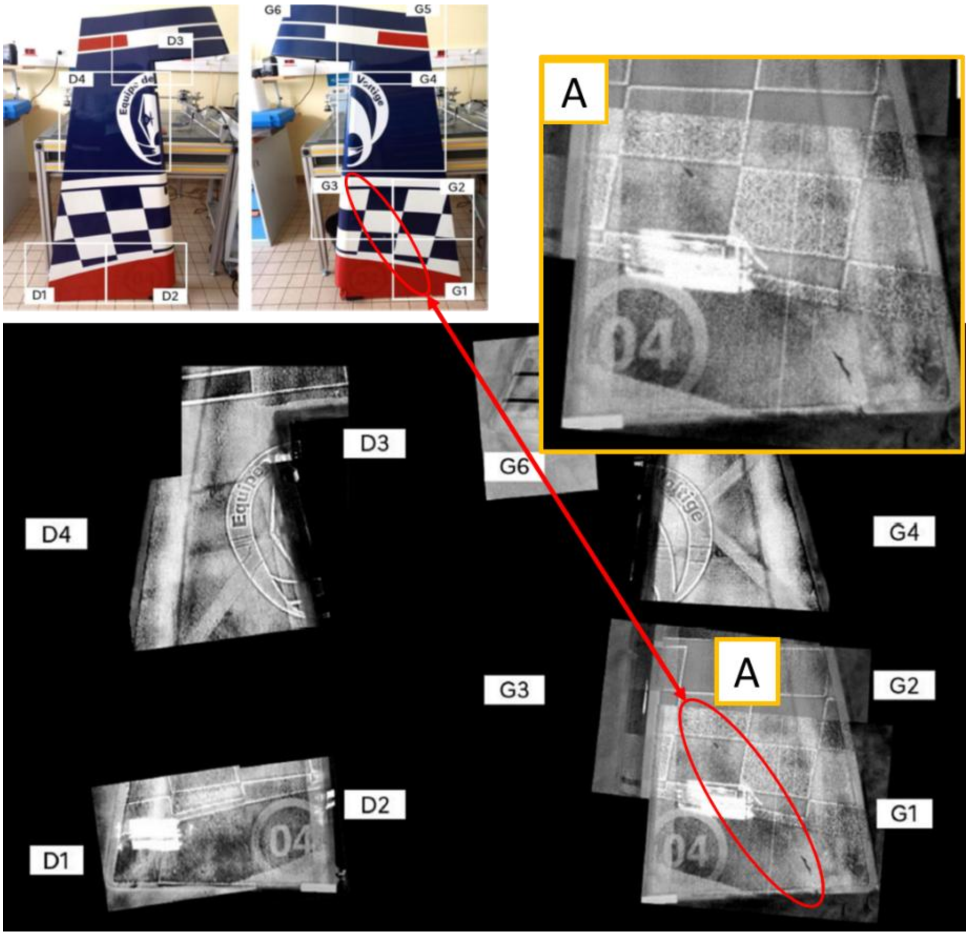

Figure 10 : visualization of the crack on the left panel of the rudder by thermography.

Following NDT inspections, the cracked area of the left panel was cut out. Examination of the cut shows that the inner skin of the left panel is cracked and has a separation from the NIDA over a strip of 20 to 30 mm. The morphology of the crack indicates that the inner skin was subjected to excessive compressive stress. After removing the inner skin, it appears that the NIDA and the outer skin are not cracked.

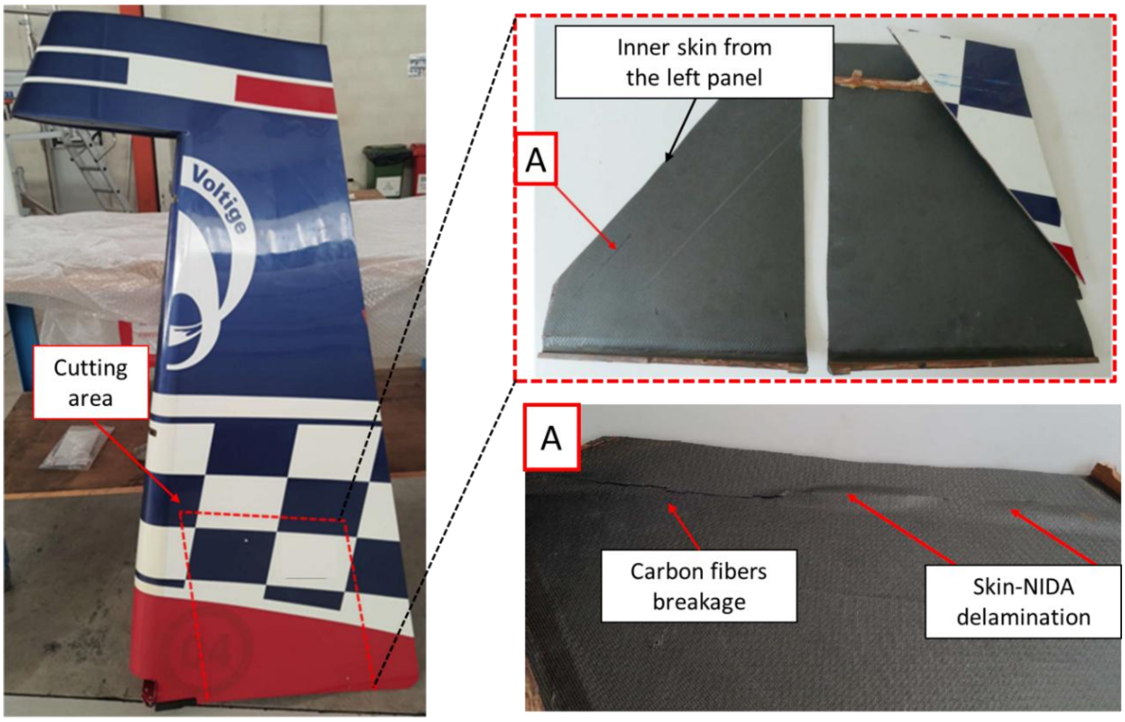

Figure 11 : cutting of the left panel of the rudder.

According to these observations, the damage to the rudder is the result of excessive asymmetric mechanical stress of the bending type (bending of the rudder « from left to right ») putting the inner skin of the left panel of the rudder under compression.

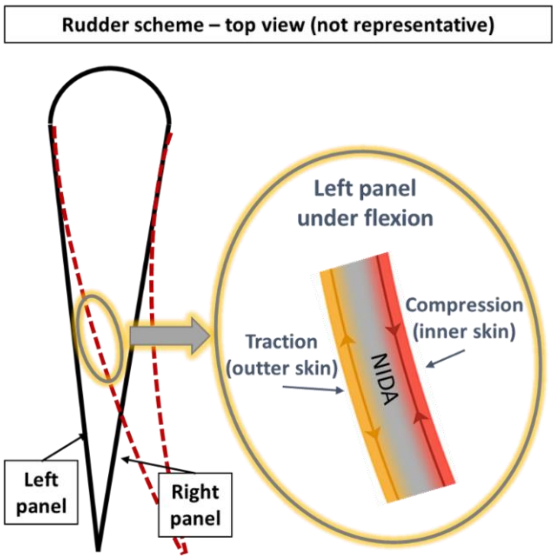

Figure 12 : illustration of the "left-right" bending effort on the rudder.

Exterior cracks observed on the rudder panels during visual inspections turn out to be paint cracks resulting from internal damage to the rudder.

The damage is locally isolated, visible and considered non-critical by Extra Aircraft. It did not affect the controllability of the aircraft, nor the safety of the flight and landing. No other case of rudder damage following aerobatic maneuvers is known to the manufacturer.

The cracking of the aircraft's rudder results from damage to the inner skin of its left panel due to excessive asymmetric bending stress from « left to right ». Flight safety was not affected by this damage.

2.1.1.3. Moisture absorption

The droplets of fluid sampled from the rear fuselage and the rudder of SC04 are paraffin oil, used for the aircraft's smoke.
The CND examinations carried out do not reveal any fluid retention phenomenon in the NIDA alveoli. After cutting, observations of the internal structure of the rudder do not show any traces of moisture: the surfaces of the composite skins and the NIDA alveoli are dry.

> **No sign of moisture absorption is detected on the material composing the rudder.**

2.1.2. Flight and recorded data analysis

2.1.2.1. Maximum speed and load factors limitations

The analysis of the flight data recorder shows that the maximum speed reached by the SC04 during the event flight is 216 kt, remaining below $\mathbf{V_{NE}}$.
The maximum (9 g) and minimum (-7 g) values displayed in the cockpit on the accelerometer during the flight are used to compare them with the load factor limitations. These values are reported at the end of the flight by the engineer in charge of the post-flight inspection in the aircraft activity documentation (FIA – *Fiche information activité*)[21]. These values do not exceed the authorized limits (± 10 g). The analysis of the flight's audio recording does not reveal any audible alarm associated with an exceedance of the maximum load factor (alarm with a frequency equal to 1,800 Hz).

> **According to the values displayed in the cockpit, flight SC04 is being conducted in compliance with maximum speed and load factor limitations.**

2.1.2.2. Flight video analysis

The flight video allows focusing on the flight maneuvers and sequences likely to reproduce the bending constraint that caused the damage to the rudder. Two types of maneuvers are identified :

- Flick rolls involving a deflection of the rudder to the left (action on the left rudder pedal of the aircraft). The aerodynamic forces during this maneuver subject the rudder to a « left-right » bending effort ;
- Backward flight phases of the tail-slide figure, during which rudder movements are observed.

2.1.2.2.1. Flick rolls analysis

Flick roll is an aerobatic maneuver performed energetically by first actuating the elevator (to increase the angle of attack in the case of a positive G-flick roll), followed almost instantly by a firm action on the rudder pedals to deflect the rudder, according to the desired direction of rotation.
During the flight, the pilot performs 11 flick rolls involving a left rudder deflection (action on the left rudder pedal of the aircraft). All flick rolls begin at speeds in accordance with the minimum (90 kt) and maximum (140 kt) recommended entry speeds by the manufacturer in the Pilot's Operating Handbook (POH), the aircraft's flight manual.
Firm actions on the rudder, even in the event of full deflection at the stop, are carried out below the maneuvering speed $\mathbf{V_A}$.

> **Pilot actions on the rudder during flick rolls are performed in accordance with the aircraft's flight domain.**

2.1.2.2.2. Tail-slide figures analysis

During the flight, the pilot performs the tail-slide maneuver 10 times: twice during his « known-free » program, and then eight times after the end of his program to practice this maneuver specifically following the radio debriefing with the coach.

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[21] FIA is an aircraft documentation that traces, for a given period, the history of flights carried out, the completion of pre-flight inspections, post-flight inspections and intermediate visits, as well as the next major maintenance deadlines. Filled out by pilots and engineers, this documentation ensures the transfer of responsibility between them, thus guaranteeing traceability of operations and approvals for the aircraft's return to service, if necessary..

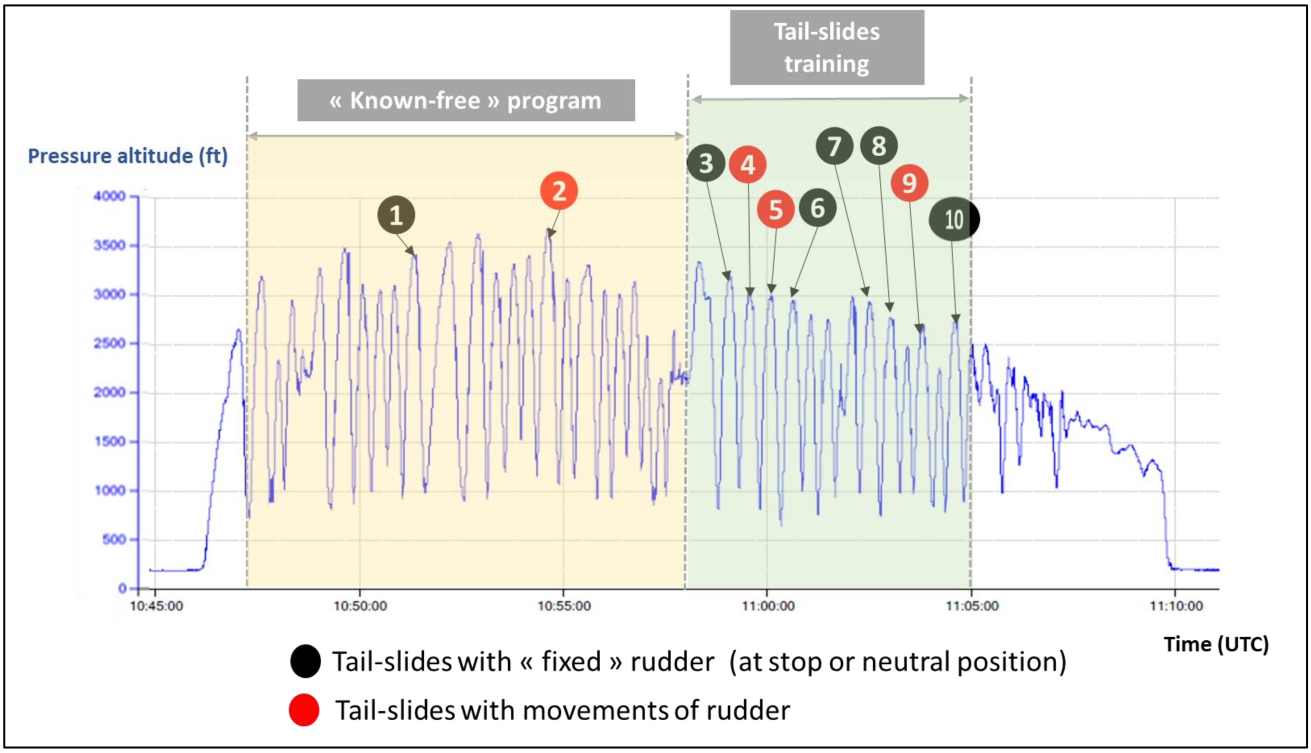

Figure 13 : flight profile (pressure altitude as a function of time) with identification of tail-slides performed

The first two tail-slides of the flight are each preceded by a continuous roll, followed by a flick roll. The length of backward flight phases of the tail-slides are substantially identical, around 16 m, corresponding to approximately two lengths of the aircraft fuselage.

The rudder, which has a travel of ± 30° from stop to stop, appears to be held at the left stop for a large part of the backward flight of tail-slide n°1 (figure 14).

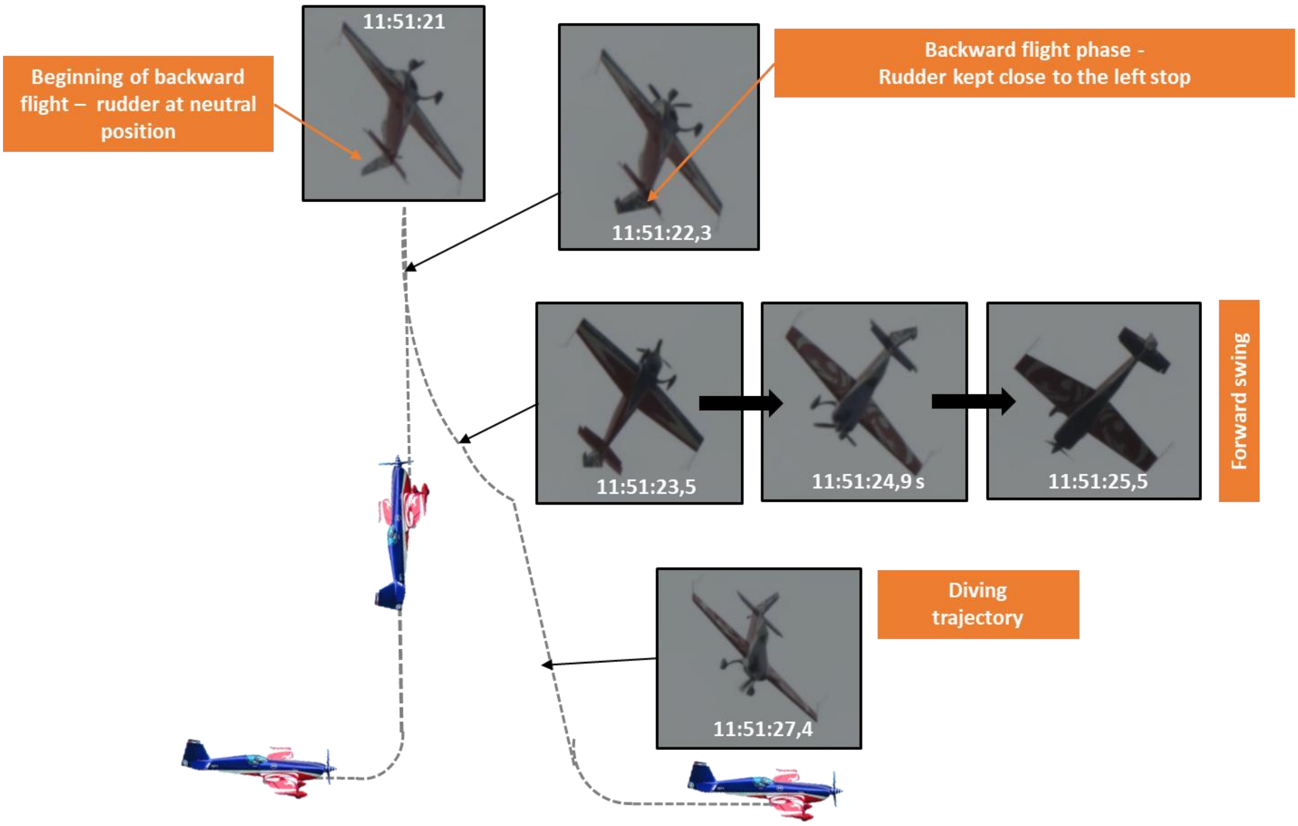

Figure 14 : illustration of the sequence of tail-slide number 1.

During the backward flight phase of tail-slide number 2, the rudder, initially held in the left stop, undergoes a dynamic « right to left » movement juste before the swing of the aircraft (figure 15).

Considered by the coach as « too confident » with a low backward flight length, the PIC will perform eight tail-slides to perfect the figure. The first four tail-slides are preceded by a continuous roll, the next four by a flick roll, in the vertical climbing phase.
The average backward flight length of the tail-slides is then equal to 27 m, equivalent to four lengths of the aircraft fuselage. The greatest length reached is 56 m for tail-slide number 4.
During this sequence, on three occasions (tail-slides numbers 4, 5 and 9) the rudder moves, sometimes in jerky movements, at the end of the backward flight phase just before the swing of the aircraft :

- for tail-slide number 4, the movement of the rudder is similar to that of the second tail-slide and likely goes all the way to the left stop ;
- for tail-slide number 5, for which the backward flight length is 14 m, beating movements are very likely to occur until the right stop of the rudder (figure 15) ;
- for tail-slide number 9, for which the backward flight length is 26 m, the rudder initially maintained at the left stop is subjected to a rapid « right to left » beating movement without visually reaching the right stop.

For the other tail-slides, the rudder seems to be maintained during the backward flight phases in the left stop, and only once in the neutral position.

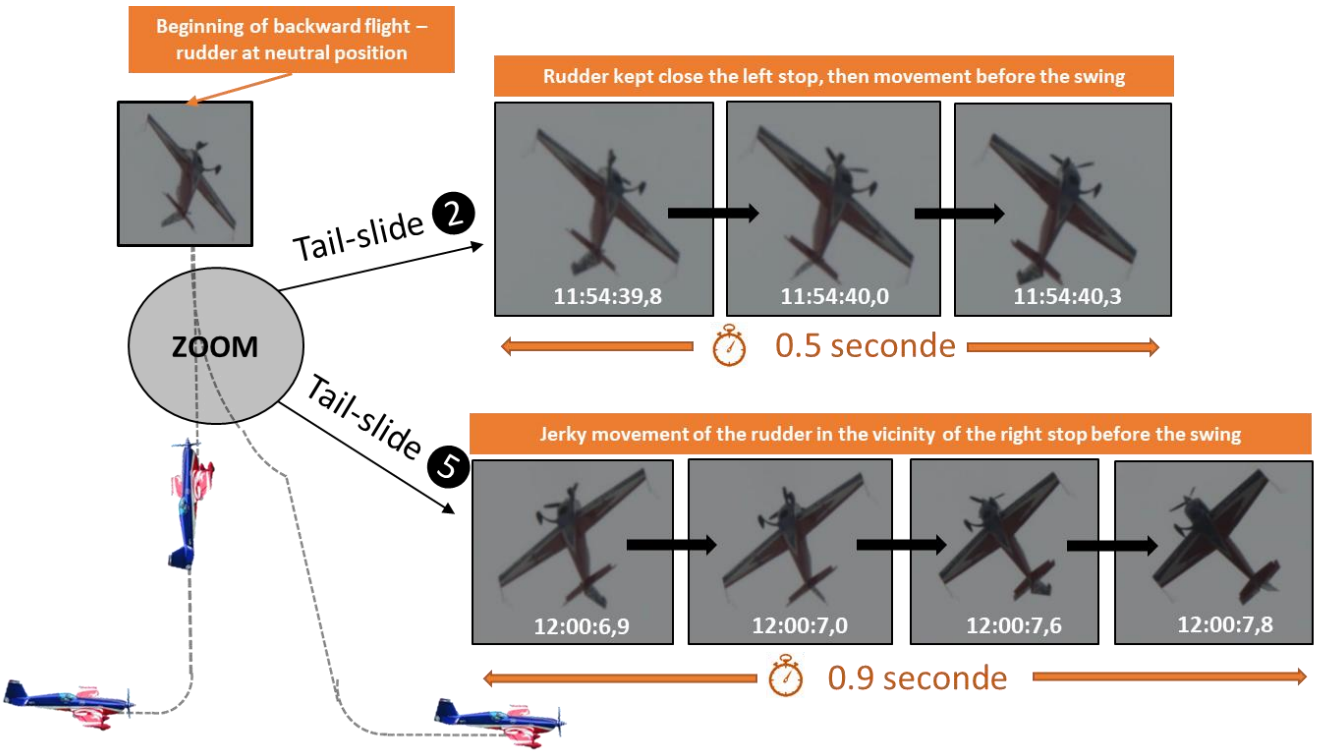

Figure 3 : illustration of the actions on the rudder for tail-slides number 2 and number 5.

> The PIC performs the tail-slide figure ten times. On four occasions, beating movements of the rudder are observe at the end of the backward flight phase, and once (tail-slide number 5), the movement very likely takes the rudder to the right stop.

2.2. Incident timeline

Technical expertise has made it possible to determine the sequence of events as follows :

- On February 12th in the late morning, the SC04 lined up on runway 16 at Salon-de-Provence airfield to perform a second aerobatic training flight in preparation for competitions and the opening of the 2024 season. The daily inspection, the pre and post-flight inspections from the first flight, as well as the pre-flight inspection from the flight of the incident, all went nominally.

- At 11:45, the PIC takes off and activates the aerobatic box.
- At 11:46:43, the PICB starts its « known-free » program. During this program, he performs the « continuous roll/tail-slide/flick roll » figure combination imposed by the IAC for the 2024 season twice. During the second execution, the PIC initiates a « right to left » movement of the rudder just before the swing of the aircraft during the backward flight phase of the tail-slide, without visually reaching the right stop of the rudder.
- At 11:58:07, the pilot completes his « known-free » program. Following the debriefing of the program conducted by radio with the coach of the French aerobatic team, he decides to specifically practice the tail-slide maneuver to improve on this figure.
- From 11:59:09 to 12:04:50, the PIC performs the bell figure eight times. In the vertical climbing phase, four tail-slides are preceded by a continuous roll, the other four are preceded by a flick roll. On three occasions (tail-slides numbers 4, 5 and 9), during the backward flight phases of tail-slides, just before the aircraft swings, beating movements are performed on the rudder. On tail-slide number 5, the beating movement is very likely to takes the rudder to the right stop.
- The PIC ends his flight with a freestyle sequence until 12:07. He then joins the downwind leg and lands at 12:10. After clearing the runway, he taxis to the EVAAE parking area and shuts down the engine. The engineer in charge of the post-flight inspection notes the presence of a significant crack on the rudder. The aircraft is declared unavailable for flight.

2.3. Investigation of the causes of the incident

The search for the causes of the event is carried out in the technical field as well as in the field of organizational and human factors.

2.3.1. Impact of the rudder right stop

The cross-analysis of the flight data recorder and the flight video allows identifying the flight sequences likely to have generated an excessive bending effort on the rudder. The backward flight phases of tail-slides are the most probable sequences to have caused a mechanical stress exceeding what the rudder could withstand.
During the backward flight phase, the airflow temporarily reverses on all surfaces of commands, particularly on the rudder. In normal forward flight, when the pilot operates the rudder, the airflow opposes the movement. In the absence of deliberate input effort by the pilot, the rudder will naturally tend to return to the neutal position. In the case of a backward flight, such as during a tail-slide figure, the rudder is in an unstable position. The slightest movement will not be countered but rather amplified by the reversed airflow. The induced efforts increase as the length of the backward flight phase and the speed of the aircraft increase. The instability of the rudder, particularly at the end of the backward flight phase, increases the risk of hitting the stops.
On four tail-slides, beating movements are performed on the rudder at the end of the backward flight phase over a range of positions near the stops, or even up to the stops. In particular, during tail-slide number 5, the rudder very likely moves all the way to the right stop, subjecting it to a bending effort whose direction is consistent with the effort that caused the damage to the rudder.

The excessive bending effort applied on the rudder is very likely due to a right stop impact during the backward flight phase of the tail-slide figure number 5.

2.3.2. Tail-slide figure realization

2.3.2.1. Execution of the tail-slide

During their integration into the EVAAE and learning the tail-slide figure, pilots are made aware of the specificities of the backward flight phase It is therefore recommended to respect certain safety points during this flight phase by firmly holding the flight controls in a neutral position or against the stop to avoid any sudden movement or involuntary departure against the stop. This vigilance particularly applies when the backward flight phase is prolonged and until the end of it. This initial awareness, based on oral transmission,

may fade over time, which may explain why some pilots develop skills specific to their flying style that aim to find a compromise between the best score in competitions and the structural constraints on the aircraft.
During the execution of the tail-slide maneuver, the rudder is positioned at neutral to start the backward phase without asymmetry. The control of the wings' horizontality is done with the rudder pedals with an inverse effect of the controls during the backward phase (example: left wing low, action on the left rudder pedal). The natural tendency of the aircraft to want to tilt to the left, due to the residual wash of the propeller on the rudder, leads pilots to often steer and maintain it at the left stop to keep the wings level during the entire backward flight phase. However, in case of aircraft imbalance, to maintain a perfectly symmetrical trajectory and correct the aircraft's attitude during this phase, the pilot may need to make several corrections to the ailerons (if the aircraft tends to roll) or to the rudder (if the nose of the aircraft tends to tilt to one side or the other).
During the flight preceding the discovery of the crack, over the course of four tail-slides, the PIC requests the rudder at the end of the backward flight phase, and on some occasions, the movement likely goes all the way to the stop. The repeated use of the rudder during this phase leads to a gradual decrease in the perception of the risk associated with this practice.
Moreover, the pilot's assessment of the backward flight distance is necessarily subjective. The pilots' testimonies indicate a sensation of flying backward over 10 to 15 m, whereas it is regularly around 27 m and can reach up to 56 m. After the aircraft's vertical immobilization, the reversal of the direction of the string at the wingtip indicates to the pilot the start of the backward flight phase**.** However, the aircraft does not have specific instrumentation that allows the pilot to access parameters that objectify this phase (examples: distance, time, speed). The pilot's situational awareness is partial during this specific flight phase, all the more so as he mobilizes a large part of his attentional resources to keep the aircraft in symmetric flight despite the instability induced by this flight phase.

> The regular use of the rudder during the backward flight phase of the tail-slide figure contributes to a reduction in the perception of the risk of this practice and therefore to its normalization.
> The length of the backward flight phase is at the pilot's discretion. An extension of this phase, due to a misperception, increases the efforts on the rudder, especially in case of movement up to the stop.

2.3.2.2. Regulatory context

In competition, the tail-slide figure is framed by the FAI sporting code (cf. note n°16). This code describes in its Appendix B « Criteria for judging aerobatic figures » the scoring criteria for each figure. For the tail-slide figure, the main criteria concerning the vertical backward phase are a minimum slide distance (at least half the length of the aircraft fuselage), compliance with the vertical plane (the nose of the aircraft must not be inclined towards the horizon during the slide) and then keeping the wings level with the horizon. There is no defined upper limit for the distance or duration of the backward slide. Beyond the minimum distance, the importance of the distance traveled does not appear to be an explicit rating criterion.
From a certification perspective, the Extra 330 SC is an aircraft designed and certified for aerobatics according to the CS-23[22]. The CS-23 describes the minimum requirements that must be met for the certification of an aircraft in its category, particularly with regard to the sizing of its structure. The rudder of the Extra 330 C is designed according to several aerodynamic load conditions for positive speeds that can go up to the maneuvering speed ($\mathbf{V_A}$) equals to 154 kt. While no specific CS-23 requirement addresses negative speed flight, such as when an aircraft is sliding backward, the minimum backward distance defined for the tail-slide maneuver within the FAI sporting code is not structurally critical for an aerobatic aircraft like the Extra 330 SC, which is designed for the most demanding level of competition use. Furthermore, the POH, which is the certified reference document for operating the Extra 330 SC, includes a chapter with a list of authorized aerobatic maneuvers, tail-slide included.

[22] Certification specifications (CS-23) - European certification standard applied to light aircraft, including for aerobatics.

This document specifies the minimum and maximum entry speeds for the tail-figure, but it does not detail any specific instructions or limitations framing a prolonged backward slide phase exceeding the minimum required distance in competition and which may consequently induce specific aerodynamic forces

Tail-slide figure is framed by FAI with rating criteria including a minimum backward slide distance, but with no defined upper limit. The POH of the Extra 330 SC allows the tail-slide figure but does not detail any specific instructions or limitations in the context of prolonged backward slide beyond the specified minimum distance.

2.3.3. Performance pressure

2.3.3.1. Migration of practices

Regulations in competition only require a minimum distance to be covered during the backward slide of the tail-slide figure. However, in practice, the distances of backward slide phases are rather in the order of three to four fuselage lengths. These margins allow the pilot to ensure that his backward slide is clearly visible to the judges. In fact, from their position on the ground, a backward slide limited to the minimum regulatory distance may go unnoticed, thus resulting in penalties in the scoring.
Moreover, although the sliding distance flown is not an official scoring criterion, feedback from the aerobatic pilot community indicates that tail-slides performed with longer backward slide distances are often perceived as more impressive. They can therefore positively influence the final rating, thereby implicitly encouraging pilots to increase the length of their backward slide phases in order to stand out. Maintaining the aircraft in its vertical plane throughout the entire backward slide phase becomes more delicate and prompts the pilot to act on the controls, particularly on the rudder, to correct imbalances. These control actions can cause the rudder to hit its stops, generating structural stresses. These stresses are even greater the longer the backward flight phase is and the higher the speed.

To stand out in competition, pilots strive to maximize the distance of the backward slide phase during the execution of the tail-slide figure.

2.3.3.2. Mastery of figures eligible for competitions

Since 2022, the IAC has authorized the combination of maneuvers consisting of performing a flick roll, in the vertical climbing phase, before executing a tail-slide. This combination complicates the execution of the tail-slide. During execution, pilots must counteract the aircraft's tendency to skid out of the flick roll, making it more difficult to achieve a perfectly vertical arrival at the top of the maneuver, the point of aircraft immobilization, and thus its symmetric maintenance during the backward flight phase of the tail-slide. This particularly delicate combination of figures is renowned for separating the best pilots during the point count at the end of the competition. Likely to be part of an « unknown-free » program, it requires pilots competing for the world championship title to master it perfectly, both technically and aesthetically. Therefore, since 2022, to master this sequence, the number of « flick roll / tail-slide » combinations performed through training has significantly increased for pilots in this category.

Due to a performance requirement, crews are increasing training sessions that combine a flick roll with a tail-slide, more frequently and intensely engaging the rudder.

2.3.4. Structural condition of the rudder

The rudder of SC04 is an original part. This aircraft is preferentially used by the two pilots in the Unlimited category[23], including the PIC. This suggests that the rudder may have already experienced flight control stops impacts during previous maneuvers in its lifetime.

[23] The SC04 was the available aircraft when these two pilots arrived at the EVAAE, which led them to get used to flying it. Each aircraft has its own characteristics in terms of stability and maneuverability. The SC04 is known for its stability, particularly suited for aerobatic programs of the Aresti type.

Without the investigation being able to determine this with certainty, it is possible that a previous rudder stop contact, or their repetition, may have led to pre-damage of the rudder, without compromising its overall integrity afterwards as long as the rudder remained subjected to nominal mechanical loads as provided in the aircraft's flight envelope[24].
Furthermore, the frequency of structural integrity checks of the rudder (every 1,000 hours) and the inherent limitations of the NDT method used do not allow for the prevention of the non-detection of minor damage, especially if it is below a certain size and located in depth.

Without being able to determine this with certainty, the high number of flight hours of the rudder, combined with the preferential use of SC04 by Unlimited category pilots, suggests that the rudder may have already experienced flight control stop impacts during the execution of previous maneuvers, which could have caused damage without necessarily affecting its overall integrity.

2.4. Element not related to the event but concerning safety

2.4.1. Full deflection of the ailerons beyond maneuvering speed

Flight data recorder analysis highlighted eight times during the execution of the « known-free » program full aileron deflection commands at a speed beyond the maneuvering speed V_A, which can reach up to 205 kt, i.e., 50 kt beyond the limit.
These occurrences are not isolated and can be observed on other flights of the EVAAE.

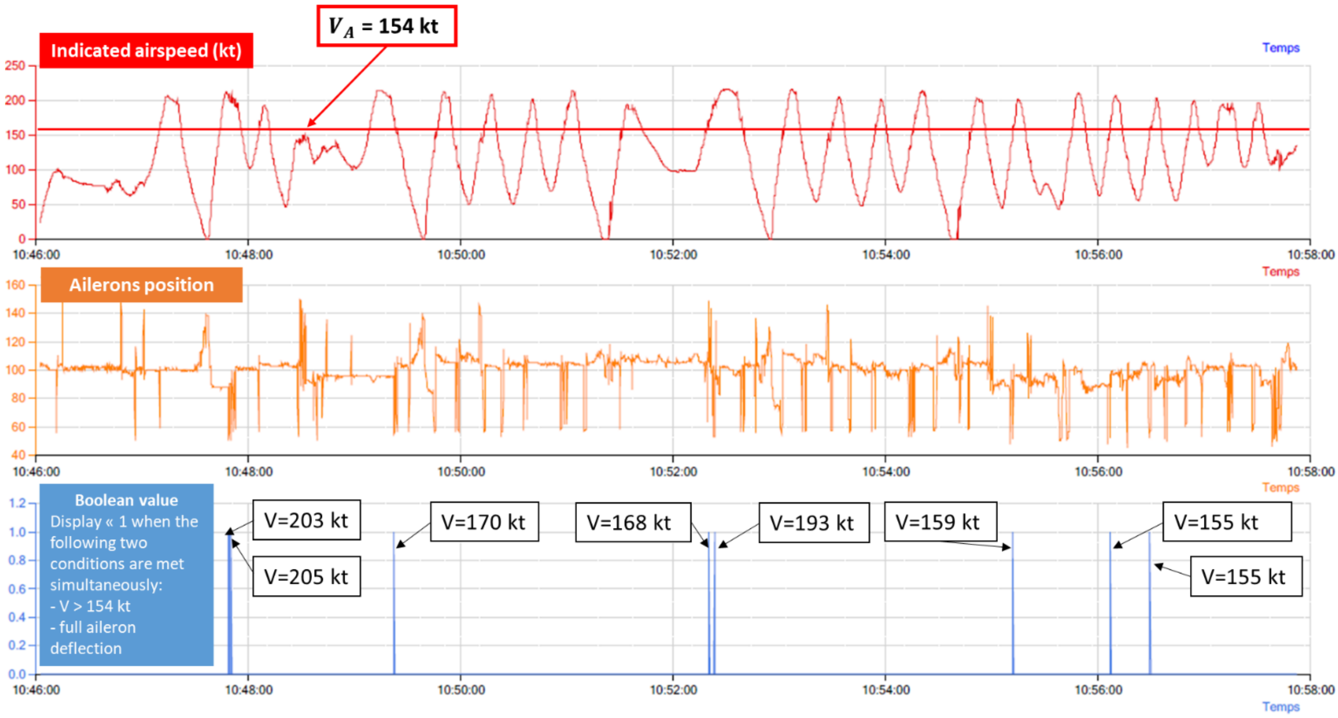

Figure 16 : indication of maneuvering speed exceedances with ailerons at full deflection for the flight of the event (time in UTC)

This limitation of the flight domain for the ailerons is well known to the unit's pilots. The POH of the aircraft mentions a single V_A applicable to the three flight controls of the aircraft (ailerons, rudder and elevator). Therefore, Extra 330 SC pilots should limit the aileron deflection as soon as the speed exceeds 154 kt, which is not practically achievable in competition for simple maneuvers performed at higher speeds (e.g., continuous roll). Respecting this limit would penalize EVAAE pilots compared to pilots of aircraft without the same type of restriction.

[24] Damage tolerance is a design principle for structures referring to their ability to withstand acceptable mechanical loads without any failure or significant deformation occurring until the damage is detected.

At the end of 2009, following the discovery of cracks on the extrados of the SC04[25], the analysis of flight parameters revealed that the presumed cause of the damage was linked to the use of the aircraft sometimes exceeding the flight limits imposed by the manufacturer, particularly full deflection of the ailerons at speeds between V_A and V_{NE}. This event led to a repair and the installation of a structural reinforcement by the manufacturer on the wings of the two EVAAE Extra 330 SC (numbers 04 and 05) thus increasing the safety margin of the wing sizing[26]. Without modification of the POH, the V_A applicable to the ailerons has nevertheless remained unchanged and remains equal to 154 kt.

Due to performance requirements, EVAAE pilots are regularly required to exceed the flight envelope limitations applicable to the ailerons of their single-seat aircraft, which, however, have reinforced wings.

2.4.2. Accelerometer operation

For the flight of the event, the analysis of the accelerometer data file shows twelve measurements points where the positive load factor strictly exceeds 9 g (maximum value displayed in the cabin and reported in the aircraft documentation at the end of the flight). For one of these points, the value reaches 10.3 g, this exceeding the maximum authorized limit (10 g).
The analysis of the flight's audio recording shows no audible alarm associated with exceeding the maximum load factor (1,800 Hz alarm). This observation aligns with the pilot's testimony (no activation of the red warning light in the cockpit in case of exceeding the limit) and the engineer responsible for the post-flight inspection (no alert message on the accelerometer screen in case of exceeding the limits).

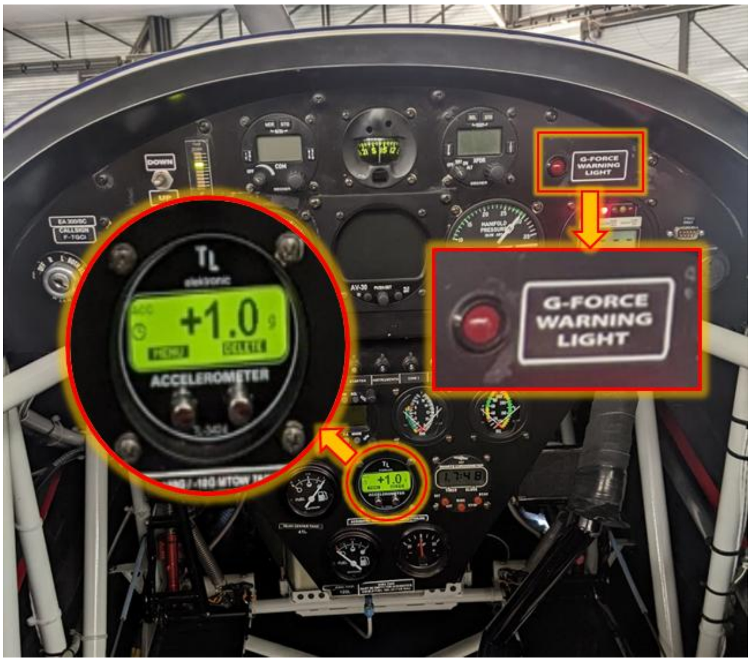

Figure 17 : accelerometer and warning light position in the cockpit of the Extra 330 SC

[25] Technical incident report – *Compte-rendu de fait technique (CRFT) n°773/BA 701/EPAA 20.300/CST EVAA*, December 3, 2009.
[26] Technical report of EXTRA, « Structural Assessment of the local wing damage of the EA 300/SC (SN SC004) » dated December 18, 2009.

According to the TL-3424_EXT accelerometer documentation, the load factor value is updated every 0.5 seconds for cockpit display. For long-term memory recording, a measurement is recorded every 0.1 seconds. The accelerometer LCD screen in the cockpit only shows one value out of five of the measurements recorded by the accelerometer.

The maximum reference value used to compare with the allowed load factor limit (10 g) is below several values recorded in the accelerometer.
A transient exceedance of the load factor limit was recorded (at 10.3 g). This exceedance did not trigger the accelerometer's alarm system.

3. CONCLUSION

The serious incident is an in-flight damage to the rudder of an Extra 330 SC during aerobatic training. #SCF-NP[27].

3.1. Identified factors useful to understanding the event

On February 12, 2024, late in the morning, at Salon-de-Provence Airbase 701, the Extra 330 SC04 performed its second flight of the day for aerobatic training, as part of preparations for competitions and the opening of the 2024 airshow season. The pilot in command planned to train based on his « known-free » program, and the aircraft took off at 11:45.
Around 11:58, the PIC completed its « known-free » program. He debriefed the execution of the program with its coach over the radio. Since the two tail-slides performed are deemed improvable, the PIC decided to carry out a specific training sequence for this figure. From 11:59 to approximately 12:05, the PIC performed eight tail-slides, half preceded by a continuous roll and half by a flick roll to cover the combinations likely to be selected in competition. During this sequence, the average backward flight length during the execution of the tail-slides was 27 meters (approximately four lengths of an aircraft fuselage), reaching up to 56 meters. At approximately 12:00:08, at the end of the fifth tail-slide's backward flight phase, the PIC initiated a beating movement of the rudder to keep the aircraft on a symmetric trajectory. This control input very likely caused the rudder to hit its right stop. The sudden stop of the rudder against this stop then subjected it to an abnormal « left to right » bending stress.
The PCB completed its flight with a freestyle sequence, then landed around 12:10. After clearing the runway, he taxied to the EVAAE parking area and turned off the engine. The engineer in charge of the post-flight inspection noted a significant crack on the rudder. The aircraft was damaged and the pilot was unharmed.

The expertise on the rudder highlighted that the cracking of the aircraft's rudder was due to damage to the inner skin of its left panel due to excessive asymmetric bending stress from « left to right ».

3.2. Causes of the event

The causes of the event fall within the technical domain and organizational and human factors.

The incident was due to excessive asymmetric constraint (bending effort) on the rudder during flight, whose cause was very likely a right stop impact during the end of the backward flight phase of one tail-slide figure. It can be explained by:

- the normalization of the rudder usage during the backward flight phase of tail-slide figures ;
- an incentive to extend the backward flight phase of the tail-slide figure, pushing for a gradual migration of practices ;
- an intensive training to master the new tail-slide figures combinations ;
- the absence of instructions in the flight manual for this phase of flight.

The following cause is possibly a contributing factor to the event:

- the high number of flight hours of the rudder, combined with the preferential use of SC04 by Unlimited category pilots, suggests that the rudder may have already experienced flight control stops during previous flights, potentially weakening it.

[27] System/component failure or malfunction (non-powerplant), according to the taxonomy of the ICAO Air Accident and Incident Data Definition Standard.

NO TEXT

4. SAFETY RECOMMANDATIONS

4.1. Preventive measures directly related to the event

4.1.1. Tail-slide figure realization

During the learning of the tail-slide figure, the EVAAE crews are made aware of the safety points related to the backward flight phase. If the first meters of this phase may require corrections to rectify the aircraft's trajectory, it is therefore recommended, when the backward flight is prolonged and until the end of it, to freeze the position of the controls, particularly the rudder, to avoid any involuntary action or departure in stop. Relying on oral transmission, this initial awareness is not sustainable and may lose its impact over time, which can explain why some pilots apply firm actions on the rudder in the final phase of the backward flight phase, sometimes with large beating movements that can reach the rudder stops. The progressive increase in backward flight distances, motivated by performance reasons in competition, contributes to the normalization of this practice.

Consequently, the BEA-É recommends :

to the French Air and Space Force, to integrate into the EVAAE operating documentation the various safety points related to the execution of aerobatic maneuvers.

R1 – [A-2024-02-I] *Recepient : CEMAAE*

The tail-slide figure is an aerobatic maneuver authorized in the Extra 330 SC flight manual, an aircraft CS-23 certified in the aerobatic category. While the backward slide phase of this maneuver is not covered by a technical requirement of the CS-23, the minimum regulatory distance defined in the FAI sporting code is considered non-critical fom a structural standpoint. However, in high-level practice, during tail-slide executions, backward slide distances often far exceed the theoretical and regulatory minimum distance. The aircraft's flight manual provides no cautions or instructions regarding prolonged backward flight phases, which can generate abnormal forces on the rudder not covered byt its initial design.

Consequently, the BEA-É recommends :

to Extra Aircraft, in conjunction with EASA, to include in the flight manual of the Extra 330 SC specific cautions or instructions framing aerobatic maneuvers involving prolonged backward flight phases.

R2 – [A-2024-02-I] *Recepient : Extra Aircraft*

4.1.2. Regulatory context and competition incentives

The tail-slide is a figure whose scoring criteria are described by the FAI sporting code. While this code defines a minimum distance to be covered, no upper limit restricts the backward flight distance of this figure. Moreover, although the backward slide distance is not an official scoring criterion, tail-slides with a prolonged backward flight phase are often perceived in practice as more impressive by the judge, thus encouraging pilots to increase the length of their backward slide phases in order to stand out.

Consequently, the BEA-É recommends :

to the *Fédération Aéronautique Internationale*, to consolidate criteria for judging the tail-slide figure, and more generally to raise judges'awareness of potential risks associated with certain phases of aerobatic maneuvers, particularly during prolonged backward flight phases.

R3 – [A-2024-02-I] *Recepient : FAI*

4.2. Preventive measures not directly related to the event

4.2.1. Exceeding the flight domain limitations of the ailerons

Due to a performance need, EVAAE pilots frequently exceed the maneuvering speed V_A when deflecting the ailerons to their maximum. A structural reinforcement of the wings of the Extra 330 SC aircraft of the EVAAE, carried out in 2010, increased their mechanical resistance, but did not result in an increase in the airspeed limitation associated with full aileron deflection.

Consequently, the BEA-É recommends :

to the DGA, to conduct a study with the manufacturer regarding the need for the FASF to increase the airspeed associated with the maximum ailerons control inputs for its Extra 330 SC.

R4 – [A-2024-02-I] *Recepient : DGA*

4.2.2. Accelerometer operation

Accelerometer data file analysis showed that the reference value used to compare with the upper load factor limit was lower than some of the recorded values reached in flight in the equipment's long-term memory. Additionally, the accelerometer's alarm system was not activated during the brief exceedance of the limit set at 10 g.

Consequently, the BEA-É recommends :

to Extra Aircraft, to confirm that the reference values used for the load factor ensure an accepted level of safety, and to detail the conditions for activating the accelerometer alarm.

R5 – [A-2024-02-I] *Recepient : Extra Aircraft*

4.2.3. Malfunction of the rudder position sensor

Flight data recorder analysis revealed that the rudder position sensor provided erroneous values, thereby limiting the technical analysis of the event. The data recorded on the SD card of the recorder, collected following the event, dates back to October 2023. The sensor malfunction was already there, without this being known to the EVAAE, nor to the approved maintenance organization holding the support contract.

Consequently, the BEA-É recommends :

to Sabena Technics ATP, to reassess the calibration frequency of the position sensors of the EVAAE aircrafts' flight data recorders.

R6 – [A-2024-02-I] *Recepient : Sabena Technics ATP*