MINISTRY OF INFRASTRUCTURE

SLOVENIA SAFETY INVESTIGATION AUTHORITY

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FINAL REPORT

ON

ACCIDENT INVESTIGATION OF

AIRPLANE PIPER PA32-301T

N710CC

at Predmeja – near Ajdovščina,

14th July 2016

Republic of Slovenia

» 2016 «

CONTENTS

ABBREVIATIONS

ATC	*Air Traffic Control*
AIRMET	*Airman's Meteorological Information*
ARSO	*Slovenian Environment Agency*
CAR	*Civil Air Regulations*
CAT	*Commercial Air Transport*
CPL	*Commercial Pilot's Licence*
EASA	*European Union Aviation Safety Agency*
EDDP	*Airport Leipzig*
EDKB	*Airport Bonn / Hangelar*
ELT	*Emergency Locator Transmitter*
FAA	*Federal Aviation Administration*
FAR	*Federal Aviation Regulations (USA)*
FL	*Flight Level*
GPS	*Global Positioning System*
HF	*High Frequency*
IFR	*Instrument Flight Rules*
ISM	*Institute of Forensic Medicine*
KZPS	*Slovenia Control Ltd. (used in Slovenian version of the report)*
LIPU	*Airport Padova*
LIPZ	*Airport Venice Marco Polo*
MTOM	*Maximum Take-off Mass*
NCC	*Non-commercial operations with complex motor-powered aircraft*
NCO	*Non-Commercial flights in Other-than-complex motor-powered EASA aircraft*
NMP	*Emergency Medical Treatment*
NFL GPD	*Nacional Forensic Laboratory of General Police Directorate*
OKC	*Operational Communication Center*
PU	*Police Department*
ReCO	*Regional Information Center*
SAR	*Search and Rescue*
SOP	*Standard Operational Procedures*
VFR	*Visual Flight Rules*
ZAG	*Institute of Civil Engineering*

INTRODUCTION

Final report on aircraft accident investigation contains facts, analyses, causes and safety recommendations of Committee for investigation of aircraft accident, taking into account the circumstances in which the accident took place.

This investigation has been conducted in accordance with Annex 13 to the ICAO Convention on International Civil Aviation, EU Regulation No 996/2010, Aviation Act (Official Gazette of the Republic of Slovenia No 81/10 and official consolidated text 46/16) and Regulation on investigation of aviation accidents, serious incidents and incidents (Official Gazette of the Republic of Slovenia No 72/03 and 110/05).

The sole objective of the investigation is the prevention of future accidents and incidents. It is not the purpose of the final report to apportion blame or liability. Using this report in any other intent may lead to wrong interpretation.

The final report should undoubtebly contribute to flight safety.

This document is the translation of Slovenian version of the Final report.
Although efforts have been made to translate it as accurately as possible, discrepancies may occur.
In this case, the Slovenian version is the authentic, official version.

Commission members:

1. **Toni STOJČEVSKI, – Investigator in-charge**, Head of SIA, Air Accident and Incident Investigator
2. **Urban Odlazek – External associate**
3. **Andrej Bračun – External associate**

SUMMARY

1. Date and time of accident: 14th July 2016 at 10:52[1] LT

2. Place of accident: Predmeja, Ajdovščina, N 45°57'13" / E 013°51'42"

3. Type of flight: IFR, commercial flight

4. Aircraft: 6 seat, engine powered airplane with retractable gear

- Aircraft manufacturer: PIPER AIRCRAFT INC.
- Aircraft type: Piper, PA-32R-301T
- Aircraft registration mark: N710CC
- Year of manufacture: 2004
- Aircraft serial number: 3257358
- Date of last airworthiness check: 18TH December 2015
- Maximum take-off mass: 1633[2] kg

5. Owner/Operator: KUERTZ ENTERPRISE LTD

6. Crew and passenger data:

- Crew: pilot (1)
- Number of passengers: 3
- Total: 4

7. Consequences:

Injuries	***Crew***	***Passengers***	***Other***
Fatal	1	3	/
Heavy	/	/	/
Light / None	/	/	

8. Aircraft and equipment:

Airplane, engine and equipment were damaged beyond repair.

[1] Local time is used in this report. On the day of the accident the local time was UTC+2.
[2] Maximum take-off mass according to the manufacturer.

1. FACTS

1.1 Flight data

Pilot and three passengers took-off at 10:16 from departure aerodrome Venice Marco Polo (LIPZ) with intention of landing at Leipzig (EDDP) Germany. Planed flight, which was conducted according to IFR, was accepted by Italian ATC and was forwarded to Slovenia Control (KZPS). At 10:45, upon entering Slovenian airspace, the pilot made a call to Slovenian ATC and requested a deviation from a filled route. Flight deviated towards NW with bearing of 034. A few minutes after the aircraft entered Slovenian airspace the controller has noticed, that aircraft is changing flight parameters and warned the pilot. The pilot explained, theat he is avoiding icing conditions and staying away from a larger build-up (towering cloud). At 10:51 pilot transmitted a distress call. After this call ATC was unable to make radio contact with the pilot again. Slovenia control immediately initiated SAR activities. In short notice the wreckage of the aircraft has been discovered on a sloped forest surface approximately 2 km NW of village Predmeja in municipality of Ajdovščina. Upon impact with terrain the aircraft caught fire. Pilot and three passengers lost their lives in the accident.

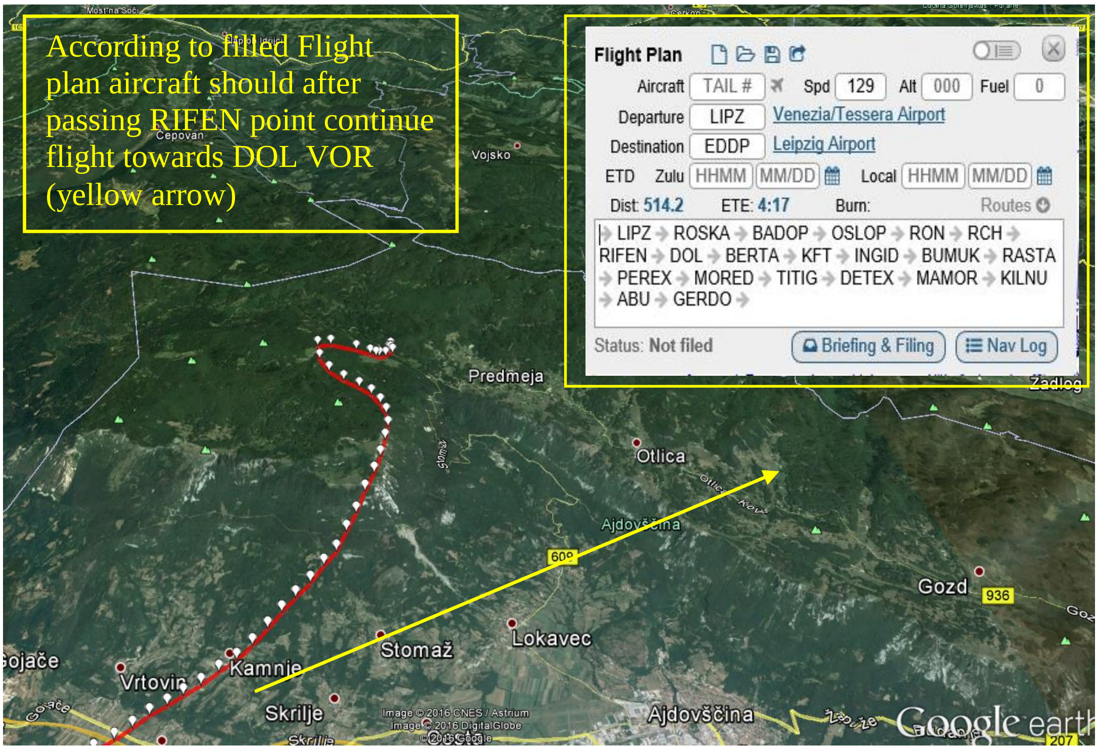

Image 1: Actual flight track (marked red) with Flight plan details in upper right corner

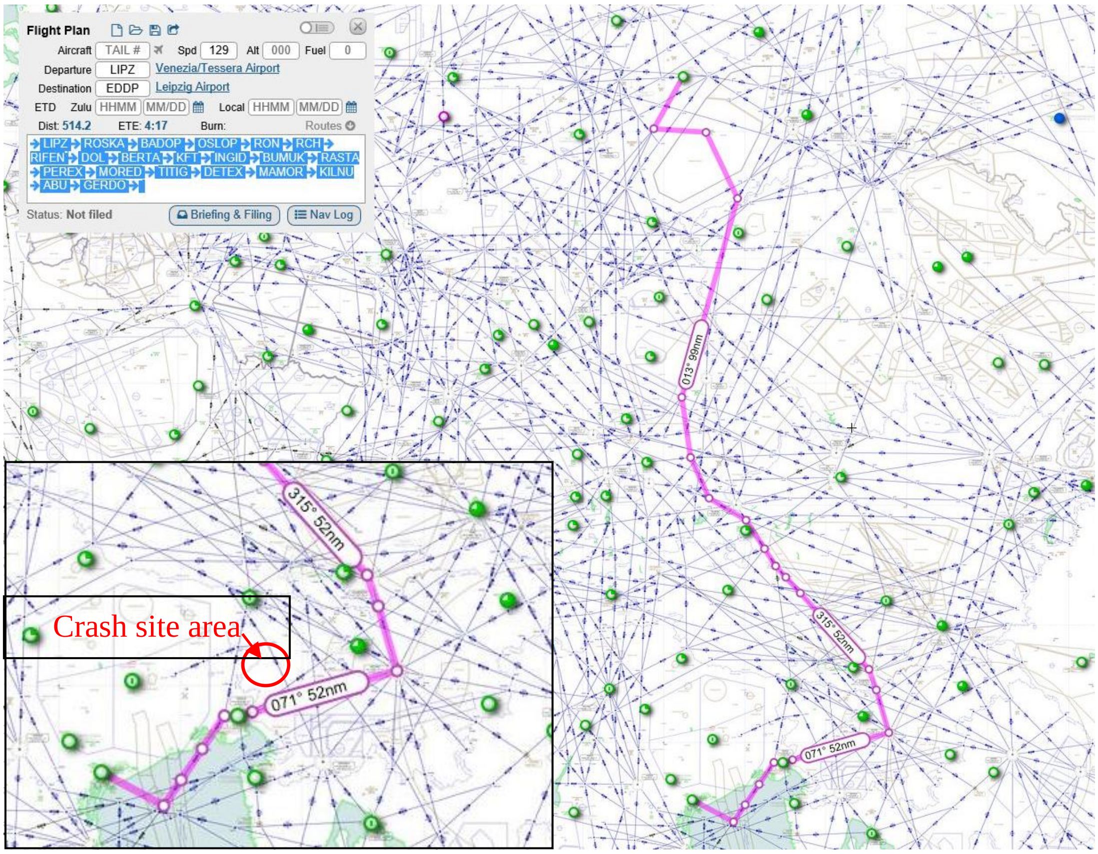

Image 2: Planned flight track and crash site area

1.2 Data on aircraft damage

The aircraft caught fire after the impact. Fire reached almost to tail where elevator surfaces were missing. Parts of left and right part of the elevator were discovered later, approximately 1 km away from the crash site. Left and right part of the elevator were found approximately 350 meters apart. Forward fuselage and wing were completely destroyed by fire.

Instrument panel was exposed to high temperatures and has melted. Lower part of the engine was found in an approximately 80 cm deep crater. Near the fuselage a part of an aileron was discovered. This part fell separately from the main structure.

Image 3: Tail surfaces at the crash site

1.3 Other damage

Due to fire, near-by grass surface and low bushes in radius of 5 meters from crash site also caught fire. There was no other damage.

1.4 Crew

1.4.1 Pilot

- German citizen, male, age 73;
- EASA Commercial pilot licence CPL(A) issued 20th August 2013 valid until 31st July 2017;
- FAA Commercial pilot licence CPL(A) issued 25th April 2006;
- Medical certificate Class 1, valid until 8th January 2017 (other commercial operations until 8th July 2017);
- **Total airplane flight time until the accident** – 3910 Hours 55 Minutes.

1.4.2 Licence data (transcript from actual lice

TYPE OF LICENCE:	CPL(A) PILOT LICENCE
Country of issue:	Germany
Issuing authority:	Luftfahrt-Bundesamt LBA
Ratings (from licence):	MEP (land) / PIC; IR …….. 31st July 2016 SEP (land) / PIC; IR ……… 31st July 2016 FI(A) / CPL; PPL; SE SP; ME SP; night; IR instruct. ……… 31st July 2018
Date of issue:	20th August 2013
Remarks (from licence):	***non-com ops only*** English Level 4 ……… 20th June 2017

1.4.3 Data on pilot medical certificate (transcript of medical certificate)

Type of medical certificate: ------------------------------------ (Validity):	MED. CERTIFICATE CLASS 1 (8TH JANUARY 2017) MED. CERTIFICATE CLASS 1 (8TH JULY 2017 - other commercial operations) MED. CERTIFICATE CLASS 2 (8TH JULY 2017) LAPL (8TH JULY 2018)
State of issue: Meeical examiner no.:	GERMANY DE AME 1001790-4
Date of exam	13th JUNE 2016
Limitations (from certificate)	- VML; - (Note the special conditions/ number LBA C 1138/00)

- **Experience of pilot and flight time:**

After examining the Pilot Log it has been established that the pilot was experienced and that he maintained flight qualifications on engine powered airplanes without major interruptions. In the last year the pilot flew N710CC 28 times. In last 6 months he completed N710CC 14 Hours and 38 Minutes, which implies that he was familiar with the airplane.

Pilot flight time:

- Total flight time until the accident: 3910 Hours 55 Minutes,
- Last 90 days: 26 Hours 10 Minutes.
- Last 24 hours: 6 Hours 10 Minutes (until the end of the day before the accident).

1.4.4 Passengers

There were three passengers present on board the aircraft. It is unknown if anyone of them had any aeronautical knowledge or experience.

1.5 Aircraft data

• Aircraft type:	6 seat engine powered airplane with retractable gear
• Manufacturer:	PIPER AIRCRAFT INC., Vero Beach, FL 32960, USA
• Type:	Piper, PA-32R-301T
• Serial number:	3257358
• Year of manufacture:	2004
• Operator/Owner:	Private owner
• Registration mark:	N710CC (remark: registered in USA)
• Date of last maintenance check:	18TH December 2015 (100 hours check)

1.5.1 Engine data

• Manufacturer:	Lycoming
• Type:	TIO-540-AH1A
• Part:	ENPL-10125
• Serial number:	L-11595-61A
• Date of installation:	28TH April 2004

1.5.2 Propeller data

- Manufacturer: Hartzell
- Type: HC-I3YR-1RF
- Serial number: HK653B

Total engine operating hours 2309 Hours 54 Minutes (on 18TH December 2015).

1.5.3 Mass and balance

Maximum allowable airplane mass is 1633 kg. Mass of empty airplane, fuel quantity, total mass of passengers and baggage, according to the available data did not exceed maximum allowable mass. More precise data on weight and balance is given in paragraph 2.5 of this report.

1.5.4 Other aircraft data

Airplane registered N710CC was according to Type certificate[3] and manufacturer instructions certified for VFR and IFR flight. Flight in icing conditions is prohibited for this type of aircraft.

For aircraft type PA–32R–301T Saratoga II TC EASA issued EASA TYPE-CERTIFICATE DATA SHEET, which is based on CAR 3 and FAR 23 regulations of the United States of America.

[3] https://www.easa.europa.eu/sites/default/files/dfu/EASA-TCDS-A.239_%28IM%29_Piper_PA--32-01-06042009.pdf
Document of EASA type certificate for PA-32R-301T Saratoga II TC is available via link provided above..

TCDS IM.A.239
Issue 01, 6 April 2009

Piper Aircraft, Inc.
Piper PA-32

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SECTION B: PA-32R-301T Saratoga II TC

B.I. General

Data Sheet No.: EASA IM.A.239 Issue: 01 Date: 6 April 2009

1. a) Type:	PA-32
b) Variant:	PA-32R-301T Saratoga II TC
2. Airworthiness Category:	Normal Category
3. Type Certificate Holder:	Piper Aircraft, Inc 2926 Piper Drive Vero Beach, Florida 32960 U.S.A.
4. Manufacturer:	Piper Aircraft, Inc 2926 Piper Drive Vero Beach, Florida 32960 U.S.A.
5. EASA Certification Application Date:	N/A
6. EASA Type Certification Date:	28 September 2003 (in accordance with EC 1702/2003, Article 2, para. 3. (a))

B.II. Certification Basis

1. Reference date for determining the applicable requirements:	Date of application for FAA TC for Model PA-32R-301T Saratoga II TC: 22 August 1996
2. (Reserved)	
3. (Reserved)	
4. Certification Basis:	a) For the basic PA-32R-301T Saratoga II TC aeroplane the applicable certification basis is based on CAR 3 and FAR23 (for details on the applicable amendments and paragraphs see B.V., note 5). b) For PA-32R-301T Saratoga II TC aeroplanes equipped with the factory installed Avidyne Entegra System option the additional certification basis for installation specific items only is defined in CRI-A01 (for details on applicable paragraphs see B.V., note 6). c) For PA-32R-301T Saratoga II TC aeroplanes equipped with the factory installed Garmin G1000 Integrated Flight Deck option the additional certification basis for installation specific items only is defined in CRI-A01 (for details on applicable paragraphs see B.V., note 7).

Airplane was initially registered in USA under registration mark N30964. In 2009 the aircraft was by the means of export certificate registered under GLOBE AERO LLC, with registration mark N710CC.

The airplane came to ownership of KUERTZ ENTERPRISE LTD, which is based in the USA, on 10TH April 2015. FAA issued a certificate of register entry to new owner on 17TH April 2015.

From the available data and maintenance documentation it was concluded, that during a major storm at Bonn/Hangelar (EDKB, Germany) airport on 23RD August 2010, the airplane suffered damage to wing while being parked at the airport. After analysing aircraft maintenance documentation, it was determined that repair works were conducted in accordance with the instructions of airplane manufacturer.

Image 4: Damage to the left wing induced during the storm on 23RD August 2010 at Bonn/Hangelar (EDKB) airport

From examined documentation about aircraft flight activities it was concluded that the aircraft completed the following flights:

- On 9TH July 2016, 1 flight in total duration of 1 Hour 10 Minutes (of which 1 flight hour was made under IFR).
- On 12TH July 2016, 1 flight in total duration of 30 minutes,
- On 13TH July 2016, 4 flights in total duration of 6 Hours 10 Minutes (3 Hours 40 minutes under IFR).

During the above-mentioned flights, no ATL entries on engine malfunctions, airplane systems malfunctions or radio navigation equipment malfunctions were made.

1.5.5 Aircraft maintenance

From the maintenance data available to the Commission we conclude that the aircraft changed a few owners during its operation in USA. Aircraft had an Airworthiness Certificate and was properly registered.

On the 2ND April 2008 installation of two new GPS Garmin 430W devices was completed. New devices replaced an older version of GPS Garmin 430. First Form 337 has been issued on 12TH May 2008, but was replaced with new corrected form. The first form did not include aircraft information on page 2 (aircraft type, serial number and flight hours).

On 24TH February 2009 works according to Major repair and modification instructions have been completed. Works included installation of fuel system for extended range flights, which enables an increase in fuel capacity to up-to two times 55 US Gal or 416 litres of fuel.

With this action, the MTOW can be increased to 110% and can, according to documents, reach 3960 lbs or 1796,2 kg, which can be seen in Form 337. This Form included calculation of mass and balance for extended range flight and an instruction that special permit must be issued for the conduct of the actual flight.

It must be stressed, that cruise speed is limited in this case to 136 knots and never exceed speed to 154 knots. During this operation usage of autopilot is prohibited. Areas of moderate and severe turbulence must be avoided. The airplane received a permit for extended range flight and the flight to Europe has been accomplished. During the flight no HF radio was carried on-board (which was compulsory) and the flight was detected as incident after landing on Portugal soil, by Transport Canada.

In August 2010 left wing of the airplane N710CC was extensively damaged during thunderstorm at Bonn/Hangelar airport. When AN-2 airplane was moved by wind gusts, it hit N710CC which was parked nearby.

Aircraft was removed from operation and repair works on damaged parts of the wing were conducted. Documentation on repair works did not include any abnormalities and repaired parts of wing, according to thorough examination results of wreckage, did not contribute to the accident.

From maintenance records it can be deducted, that after being imported to Europe (first to Luxemburg and then to Germany) the airplane was properly maintained within FAA approved maintenance facilities. 100-hour check in 2015 was completed on 8TH February 2015 and on 18TH December 2015. Commission also checked the compliance with AD Notes which were accomplished up to AD note BW 2015-25. Airworthiness was each time confirmed with signature and stamp.

In the process of investigation, it was determined that airplane registration expired on 30TH April 2018. The airplane was removed from FAA register on 13TH September 2018.

Aircraft maintenance documentation did not include any deviations or errors. Aircraft has been maintained according with manufacturer's instructions and in accordance with the Airplane Maintenance Manual.

- Documentation on maintenance was obtained from the last owner,
- Maintenance has been conducted according manufacturer's instructions and according FAA regulations,
- The aircraft was registered as CORPORATE,
- Last maintenance inspection has been completed on 18TH December 2015.

1.6 Meteorological data

The weather analysis is based on official data of Slovenian Environment Agency (ARSO), valid for 14TH July 2016.

1.6.1 Weather situation

Major part of Europe was under the influence of mainly cold and wet Atlantic airmass. The weather front covered areas from Baltic through Eastern Europe to centre Balkans. Over this area unstable weather with showers prevailed and thunderstorms were also present. Sunny and hot weather prevailed only in SE Europe and in southern Mediterranean.

On coasts of northern Adriatic skies cleared during the afternoon. In the inland showers and isolated thunderstorms were still forming.

1.6.2 Meteorological data for LIPZ (Venice) and EDDP (Leipzig)

LIPZ

METAR LIPZ 140650Z 35018KT 310V030 9999 BKN060 20/08 Q1007 TEMPO RA=
METAR LIPZ 140720Z 35021KT 310V020 9999 VCSH BKN060 19/10 Q1008 TEMPO RA=
METAR LIPZ 140750Z 35017KT 320V020 9999 SCT060 20/10 Q1009 RESH NOSIG=
METAR LIPZ 140820Z 36017KT 280V050 CAVOK 21/09 Q1009 NOSIG=
METAR LIPZ 140850Z 36011KT 330V040 CAVOK 21/08 Q1009 NOSIG=

At LIPZ airport the wind was northern with speeds of around 20 knots, visibility was more then 10 km, first layer of clouds was at 6000 FT and after 10:20 LT, ceiling and visibility was OK.

EDDP

TAF EDDP 140500Z 1406/1506 31012KT 6000 BKN005 TEMPO 1406/1410 3500 RA BR BKN003
BECMG 1407/1411 30015G25KT SCT008 BKN025 BECMG 1416/1418 28010KT=

Weather forecast for EDDP included visibility of 6 km and until 12:00LT temporary rain with reduced visibility down to 3500 m. After 13:00LT northern wind was forecasted with gusts up to 25 knots and temporary clouds at 800 FT and ceiling at 2500 FT.

1.6.3 Wind

Over northern Italy at FL100, mainly northern winds were blowing. Over Slovenia the wind changed direction into SW.

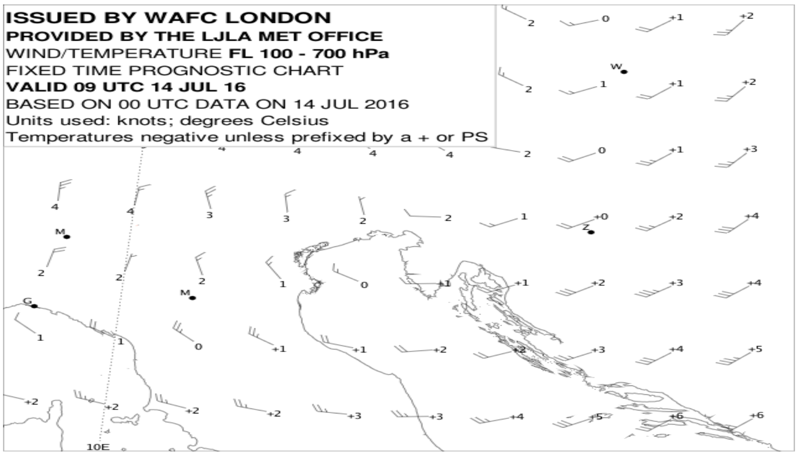

Image 5: General wind directions at FL100 on 14TH July 2016 at 11:00 LT

WEATHER SITUATION

At the time of accident showers were present in the area. Before the accident thunderstorms with convective activity were detected. During showers and thunderstorms visibility locally decreased, local high winds with wind shear were present and accompanied with turbulence and icing conditions.

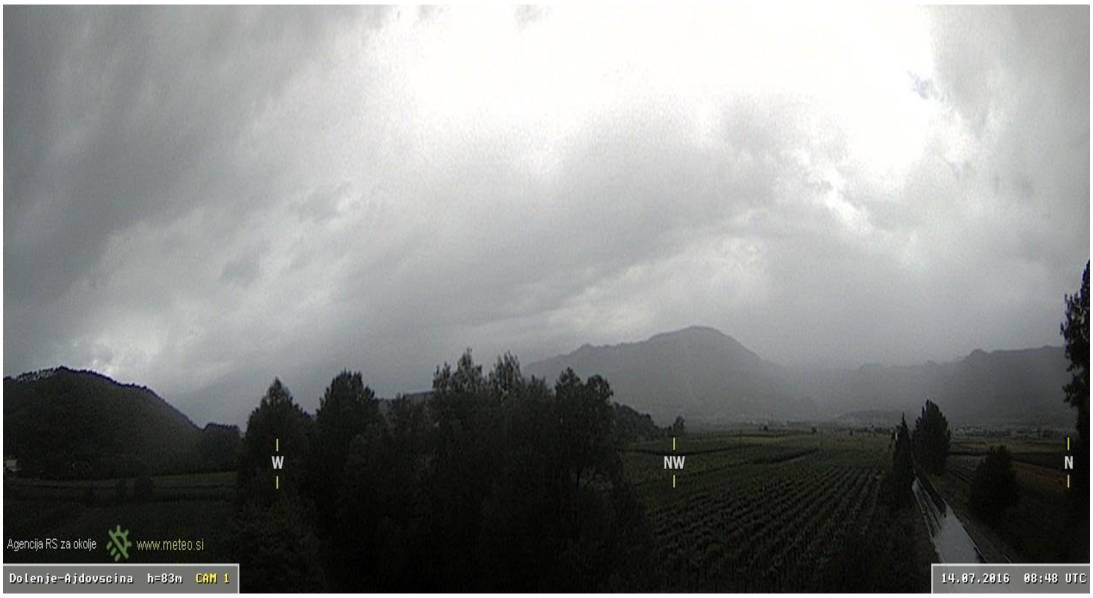

Image 6: Camera took image in NW direction from location Dolenje/Ajdovščina on 14TH July 2016 at 10:48LT

Image 7: Image taken in direction S from location Otlica on 14^TH July 2016 at 10:30LT

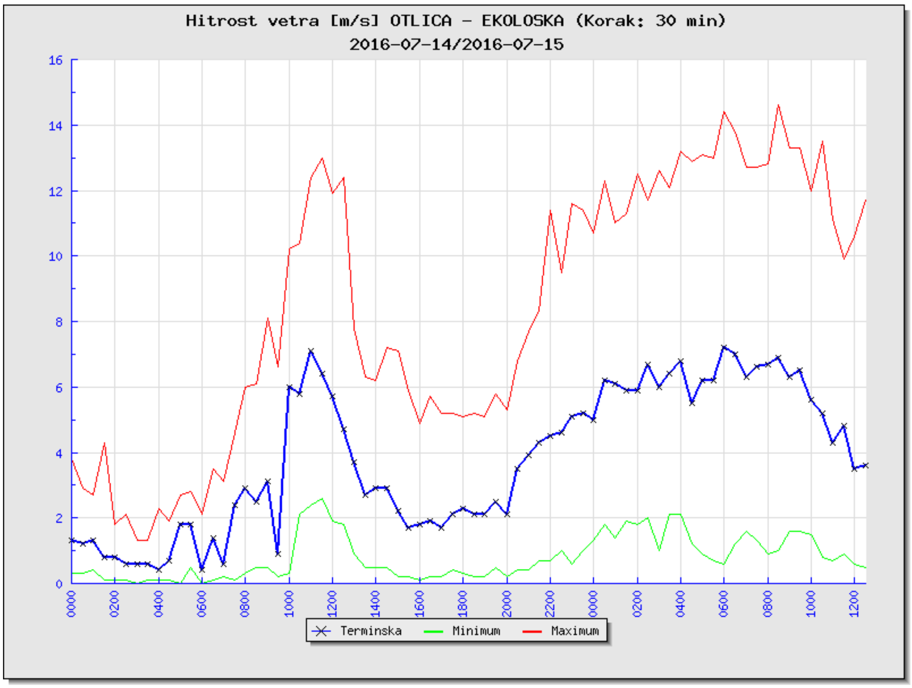

Image 8: Wind speeds at weather station Otlica

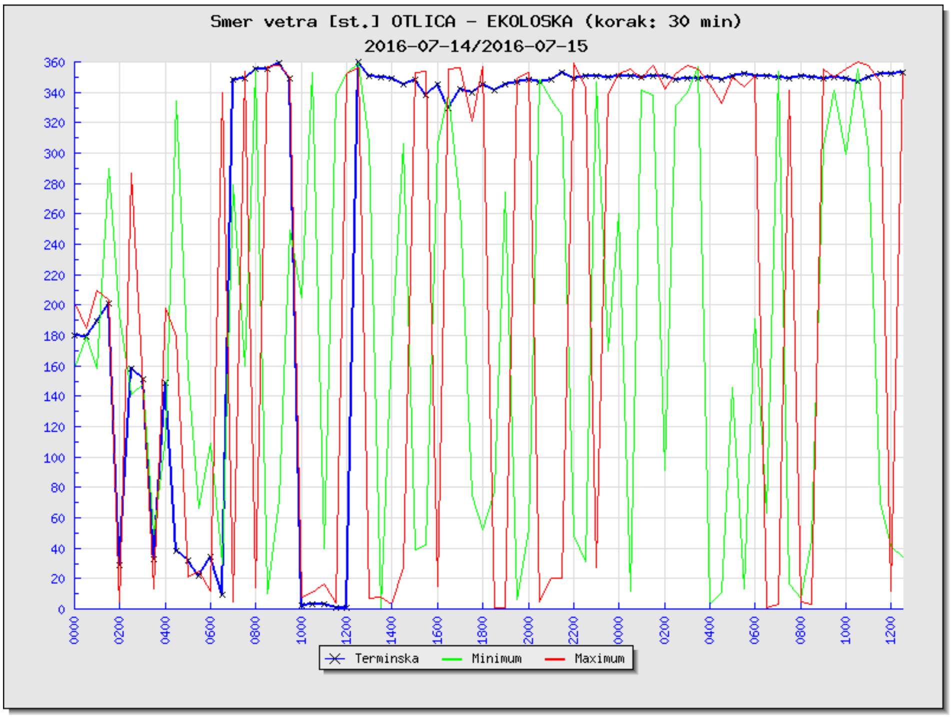

Image 9: Wind directions at weather station Otlica.

1.6.4 Clouds

Webcam images and weather radar images show that area of accident was mainly covered by: *towering cumulus* (TCU) clouds. Isolated *cumulonimbus* (Cb) clouds were present. Cloud ceiling was at around 4000 FT above terrain. Cloud tops were between FL200 and FL280.

TEMPERATURE

Air temperature was 0^{o}C above 2800 m but in case of high intensity showers temperature of 0^{o}C can be lower by around 100 m.

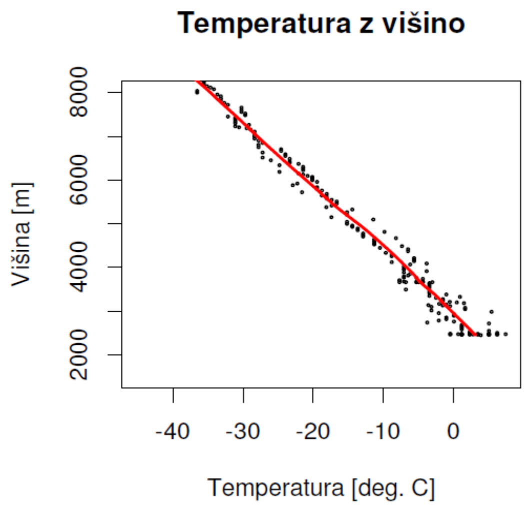

Image 10: Temperature and altitude (višina (SLO) = altitude)

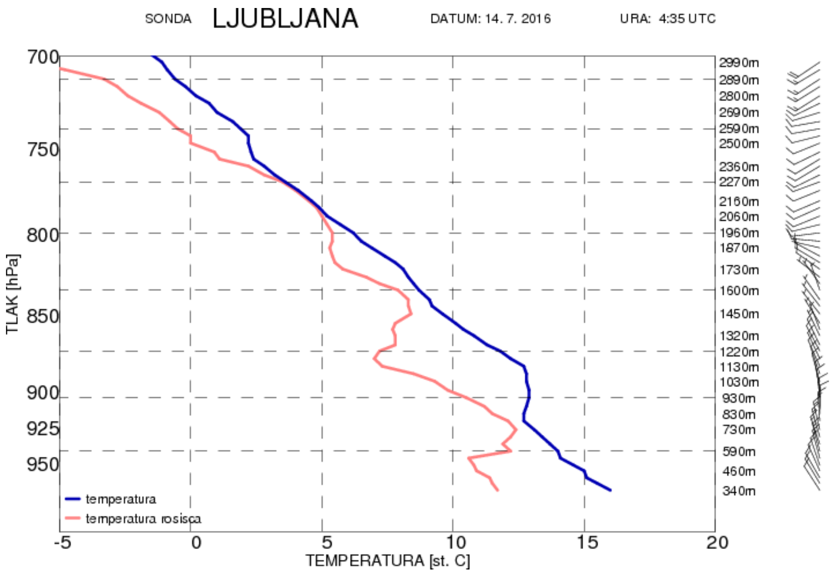

Image 11: Temperature (blue) and dewpoint (red) on 14TH July 2016 over Ljubljano (TLAK (SLO) = pressure)

RELATIVE HUMIDITY

In clouds relative humidity reached 100% or was near that value.

ISSUED WARNINGS

Near the time of the accident, aeronautical meteorological service issued a warning about possible thunderstorms inside SW part of LJUBLJANA FIR. Warning was issued at 9:23LT.

WSLJ31 LJLJ 140723
LJLA SIGMET 3 VALID 140715/140845 LJLJ-
LJLA LJUBLJANA FIR EMBD TS OBS WI N4615 E01330 - N4610 E014 - N4540 E01350 - N4545 E01320 - N4615 E01330 TOP FL280 STNR NC=

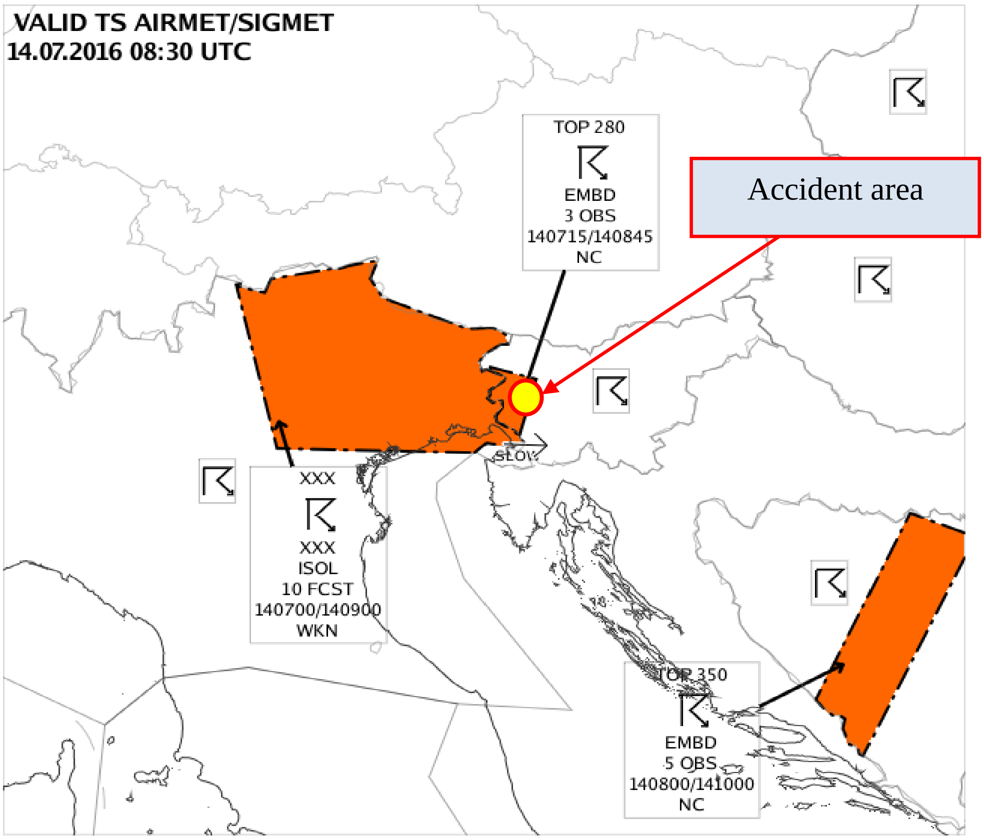

Image 12: Areas of forecasted thunderstorms

WEATHER RADAR IMAGES

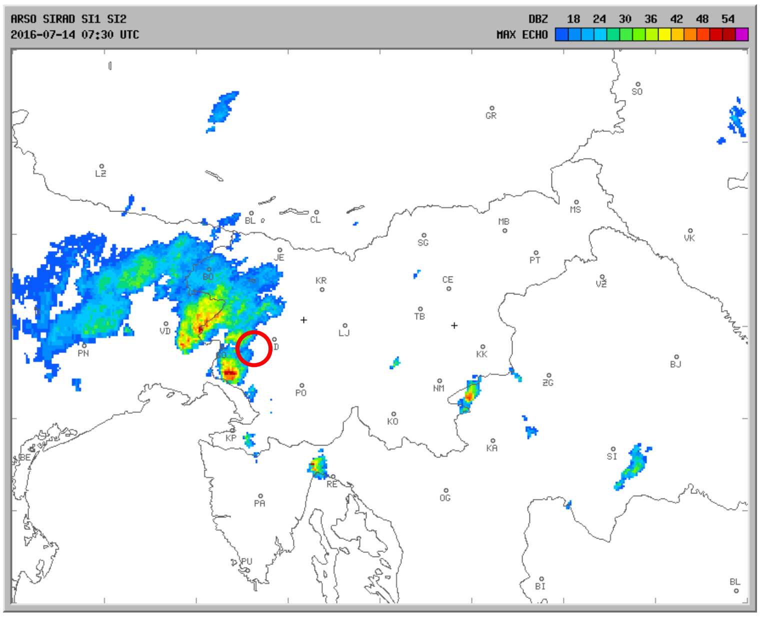

Image 13: Weather radar image taken at 9:30LT

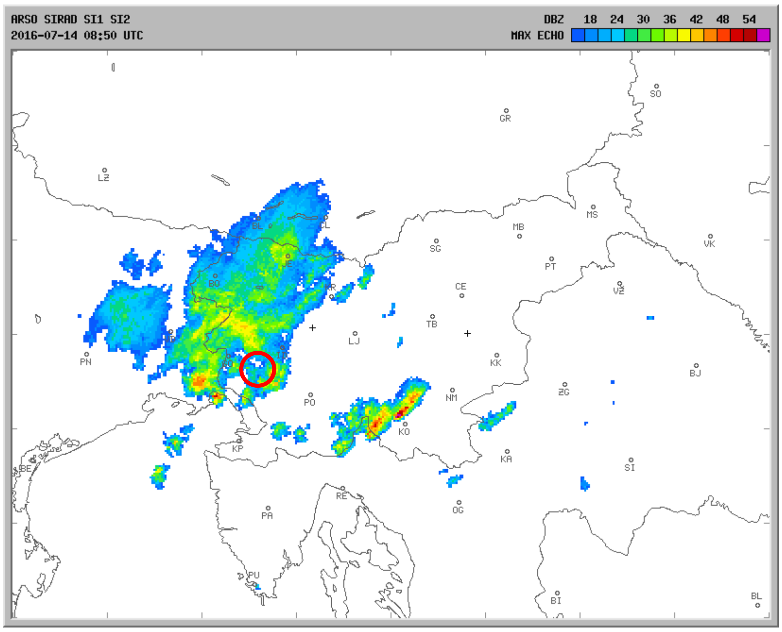

Image 14: Weather radar image taken at 10:50LT

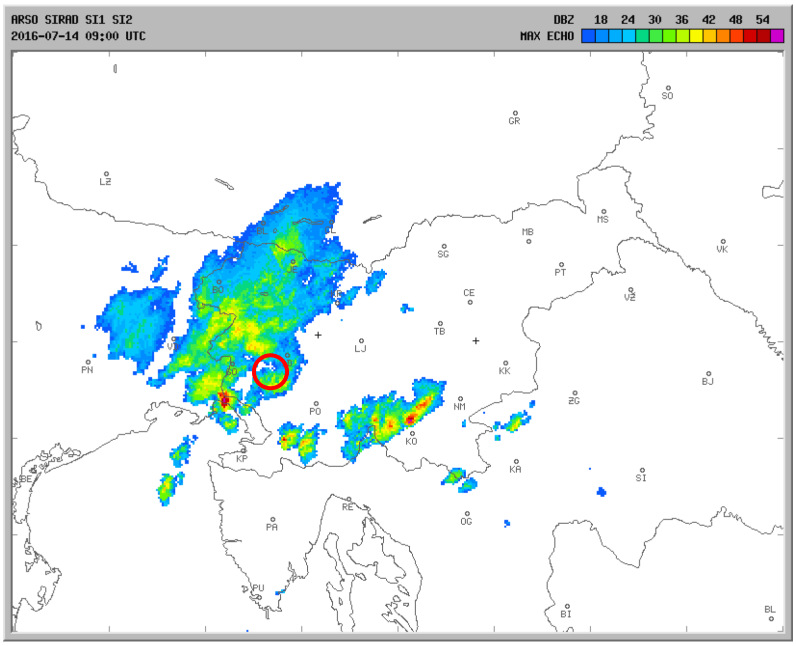

Image 15: Weather radar image taken at 11:00LT

After analysing weather radar images, we can deduct, that highest convective activity in the area was present from 9:00 until 10:00LT. Later the convective activity reduced. Precipitations were present in the form of showers (images 13, 14 and 15). New thunderstorm cell developed on the border with Italy, south of Nova Gorica after 11:00LT (image 15 – red colour).

1.6.5 Weather situation summary

In the area of Predmeja, at the time of accident of N710CC, following weather situation was present:

- On part of flight from Venice to Slovenia area of low clouds was present reaching up to approximately FL100 (10000 FT);
- In SW Slovenia convective clouds with ceiling at around 4000 FT and tops at FL200 and FL280 were present;
- Visibility was reduced due to clouds and precipitations;
- Temperatures of bellow 0°C could be found over 9000 FT, but lower in case of intense precipitations. Showers were present, before and after accident also thunderstorms;

- Due to clouds areas of vertical movement of airmass existed. Moderate to severe turbulence and moderate to severe icing were possible from 8500 FT to FL200;
- Relative humidity was around 100%.

1.7 Radio communication data

Pilot of N710CC after take-off from Venice at 10:26 (8:26:48 UTC) established radio communication with Padova ACC. Airplane climbed initially to FL120. Due to arrivals to Ronchi airport, N710CC had to stop climb at FL90. In initial communication pilot requested avoiding action due to adverse weather with direction change of 10˚ to the right in duration of one minute, which was approved by ATC. At that time airplane was passing 6500 feet. Padova ACC forwarded the airplane to Ronchi radar. The airplane needed higher altitude to overfly SW part of Slovenia and Alps. Pilot anticipated climb to FL110 and continuation of the flight towards E (to DOL VOR) and then towards KFT VOR. After passing DOL VOR the airplane was supposed to continue climb to FL120 according to the flight plan.

Commission obtained recordings of communication between ATC and the pilot from Slovenia control Ltd. (KZPS). Recordings start when airplane enters Slovenian airspace, until radar identification was lost. Duration of recording is 7 minutes 19 seconds. Transcription shows communication between the pilot and the ATC and partially describes a weather situation in this area of the FIR.

COMMUNICATION TRANSCRIPTION

Time (UTC)	Pilot:	ATC:
08:45:28	November...eh...Ljubljana Radar N710CC good morning.	*N710CC Ljubljana Radar...Ljubljana Approach Radar dober dan, identified. Maintain FL 130, confirm avoiding action?*
	Ok, we maintain 130 due to freezing conditions, then I would prefer to go direct Klagenfurt, if possible.	*N710CC roger, when convenient direct Klagenfurt approved.*
08:46:02	Direct Klagenfurt approved, thank you very much Sir.	
08:46:25		*N710CC sqawk 6501.*
	6501 is coming down.	
		And N710CC verify your level, I have indication level 135.
	Ok we descend a little bit, but I have icing problems, so if possible, I would pre...prefer to stay a little bit longer on this altitude.	*N710CC roger, level 135 is approved.*
08:46:54	135 is approved, thank you very much Sir.	
08:50:40		*N710CC advise intentions.*
	Intentions are going to ...eh... Klagenfurt first.	*Ja, but you are in turn now.*
	Ok, but I am avoiding here a big CB, now I am going back on course 034 (*static interference due to thunderstorm cloud proximity near airplane*).	*N710CC for information minima ahead is level 120.*
	(*Transmition, with no modulation*)	
08:51:27	Mayday, Mayday (*followed by a few transmitions with no modulation*)	*Confirm N710CC Mayday Mayday?*
		N710CC Ljubljana do you read?
		N710CC M...(unclear sound, background communication of controllers about Mayday).
		N710CC?
08:52:10		*N710CC identification lost.*

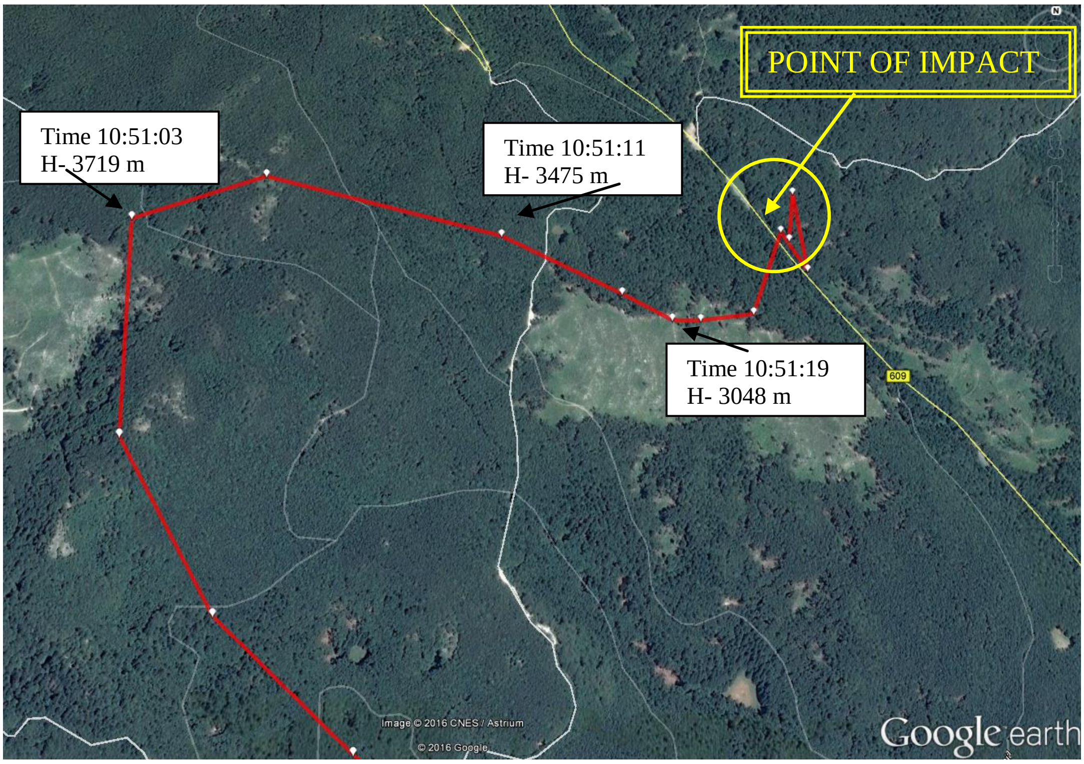

Image 16: Part of flight parameters obtained from ATC radar recordings

1.8 Crash site information

Only a few minutes after accident, SIA was informed about the event by OKC, later also ReCO and Slovenia control (KZPS) contributed information. Police has secured the area before the investigator-in-charge arrived to the site. Upon the arrival of investigator-in-charge, representatives of NMP, fireman, Police officers and representatives of PU Nova Gorica were present. Investigation process started parallel with the police site examination. The crash site examination lasted for two days.

Point of impact was near the local road, which gave quick access to fireman, Police and rescue services. The wreckage of the airplane was stationed inside a narrow radius of 5 to 7 m from the point of impact. On nearby tree cabins there was no trace of wreckage, which means that the airplane vertically approached the point of impact. Forward part of the wreckage was destroyed beyond recognition due to fire. Cabine of the airplane and instrument panel were destroyed by fire. Fuselage deformations showed signs of exposure to high temperatures. Fire continued to extend towards the tail surfaces of the airplane. By the central part of the wreckage several burned parts could be found, when they were propelled from the cabin upon impact.

Approximately 15 m from crash site a part of aileron has been found.

Bodies of the pilot and passengers were transferred to ISM Ljubljana.

1.9 Medical and pathological data

Based upon ISM report and after examining the pilot documentation, no evidence was found which would indicate a disease or medical limitations, which could contribute to the accident. All toxicologic examination results were negative.

1.10 Fire information

Airplane caught fire upon impact. Fire started at the forward part of the airplane and continued via cabin and wings. Due to exposure to high temperatures parts were highly deformed. Firemen of local Fire brigades extinguished the fire and prevented further progression of fire towards rear part of fuselage and tail surfaces. Surrounding terrain did not catch fire.

1.11 Information on chances of survival

Due to force of impact there was no chance of survival for the pilot and passengers. Airplane was equipped with the ELT which was triggered upon impact. Contact point for SAR in Slovenia received an information about signal at 10:57LT and forwarded the information to initiate search and rescue. From the analyses of the ELT signal reception procedures it could be seen that time of accident (from loss of radar identification by ATC) which counts as 10:52:10 LT, until reception of ELT signal and successful identification of device, 5 minutes have passed. As ATC, upon loss of communication and radio identification, already initiated SAR the rescue services were already on the way by that time.

1.12 Search for and position of recovered parts of horizontal stabilizer

After the examination of crash site was completes, the Commission organised search for parts of horizontal stabilizer. According to radar image images, weather situation at the time of the event and from communication of the pilot with ATC, parameter of search was defined as area of 750 m x 1200 m located W of crash site. Logistic support enabled search with UAV. After analysing images obtained from UAV the Commission determined primary search area and requested support from Civil protection from the area – Predmeja, municipality of Ajdovščina. During preparation and search 120 persons were involved.

Two parts of horizontal stabilizer were recovered in search action on 8TH October 2016 in the area approximately 1 km SW of point of impact of the airplane. Later, in December 2019, a smaller part of metal size of 45 x 30 cm was recovered and identified as part of the horizontal stabilizer.

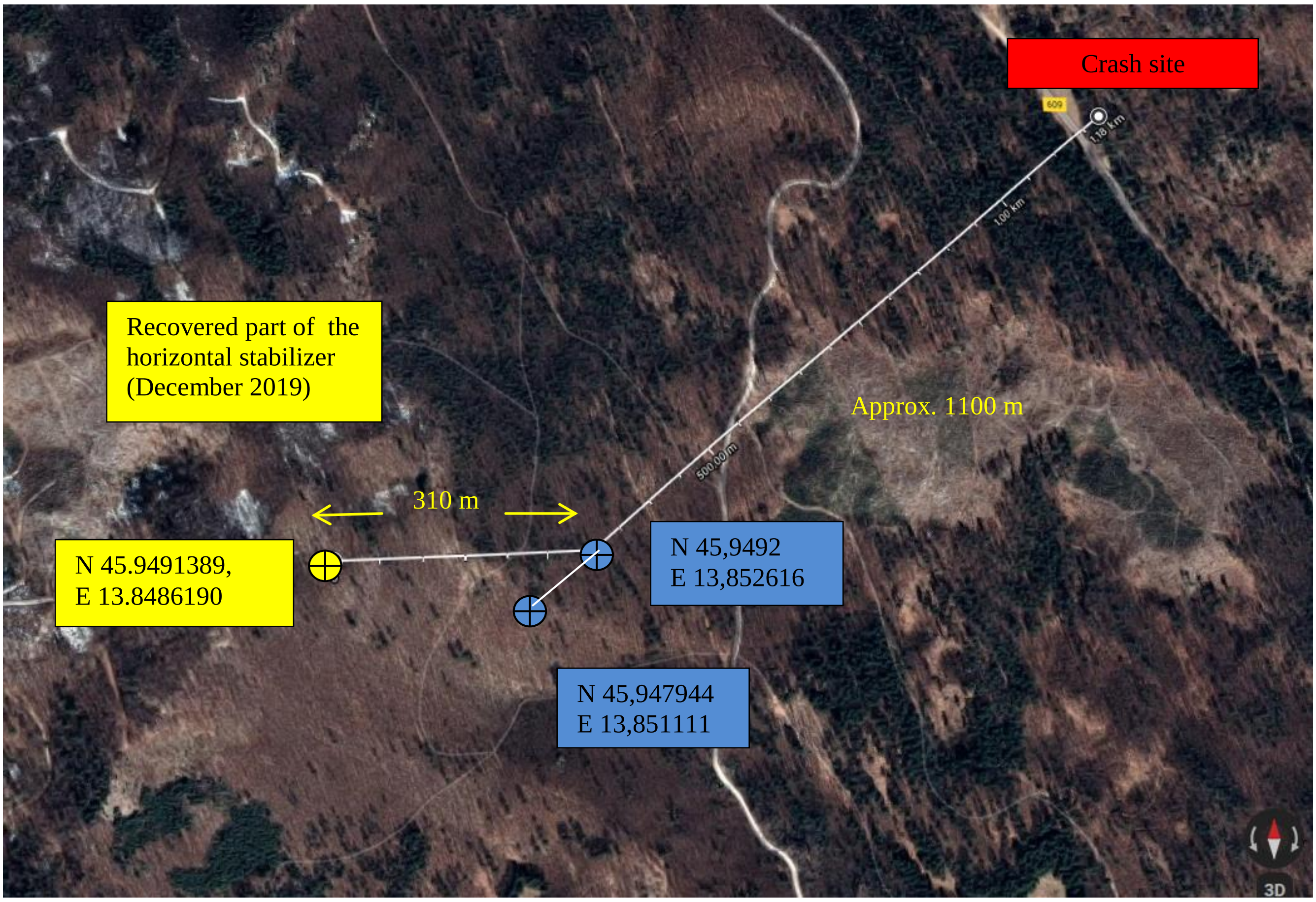

Image 17: Position of recovered parts of horizontal stabilizer

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2. ANALYSIS

2.1 General

Based on obtained ATC radar recordings monitoring flight track of the airplane and analysis of radio communication, both provided by Slovenia control (KZPS), analysis of flight progress was possible. After the examination of wreckage, engine and propeller, no evidence could be found like deviations or mechanical errors, which would indicate malfunctions of engine and propeller. Flight controls deformation indicated severe malfunction of elevator flight controls – in-flight disintegration. All the indicators of the instruments have been destroyed in the crash. Also the navigational equipment[4], from which it was impossible to obtain any flight elements data.

2.2 Analysis of the horizontal stabilizer - ZAG

(Analysis was conducted by ZAG, The Department of Materials, Laboratory for Metals, Corrosion and Anti-Corrosion protection).

Visual and fracture examination of the horizontal stabilizer did not reveal any damage on the materials, which would be indicating a presence of fatigue. All examined samples of sheet metal belonging to the horizontal stabilizer, which has been recovered on a location away from the main wreckage, comply with required quality standards for materials used in aviation.

The analysis revealed, that structure failure resulted from a few alternating bending loads, at which stress levels exceeded yield stress values (plasticity limit) of the material. Near the breaking points metal sheets were deformed in multiple directions. Nowhere in the area of breaking points the corrosion damage was detected nor there were any other mechanical defects, which could represent a starting point for fatigue cracks initiation or would decrease carrying ability of the construction elements or the structure of the horizontal stabilizer as a whole.

[4] This category of aircraft does not require any Flight Data Recorder or Cockpit Voice Recorder equipment.

From analysis of the horizontal stabilizer we can conclude, that horizontal stabilizer failed after a few consecutive cycles of alternating banding (in multiple directions), which is known as low cycle fatigue. Alternate banding of the horizontal stabilizer could indicate dynamic aeroelastic phenomena called flutter[5].

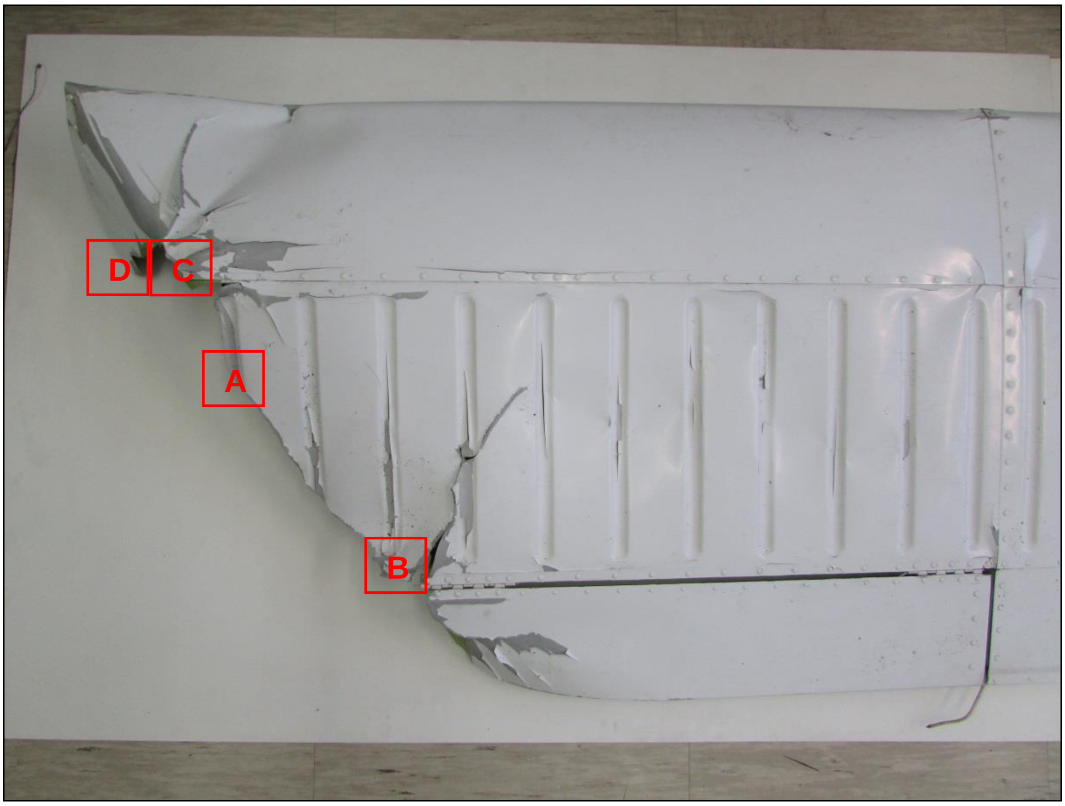


Image 18: Upper surface of horizontal stabilizer with part of trimmer surface (right side)

[5] Flutter is an aeroelastic phenomena, which in its extreme form causes structure failure.

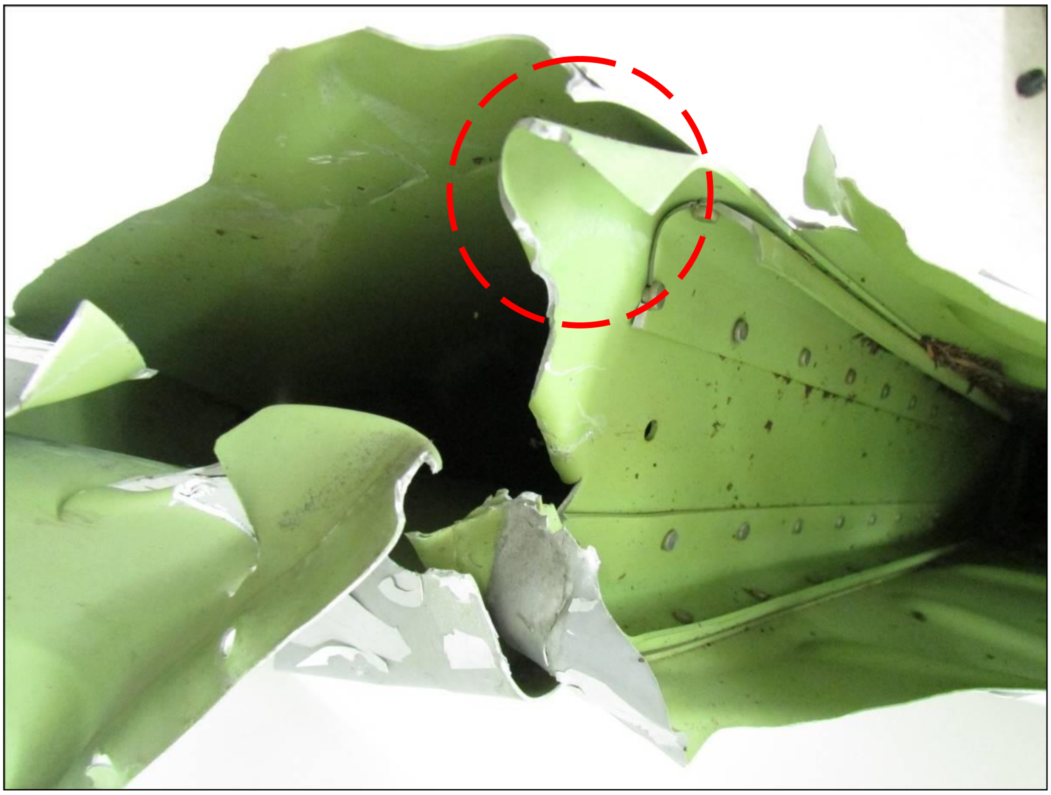


Image 19: Elevator spar (point of failure)

Squares mark locations of metal sheet samples, where detailed examination of failed surfaces was carried out. Locations D and C: forward metal sheet lower and upper side – beginning of the fracture surface, location A: middle upper metal sheet – fracture, location B: aft part of middle metal sheet. Fractures, which run over two riveted points.

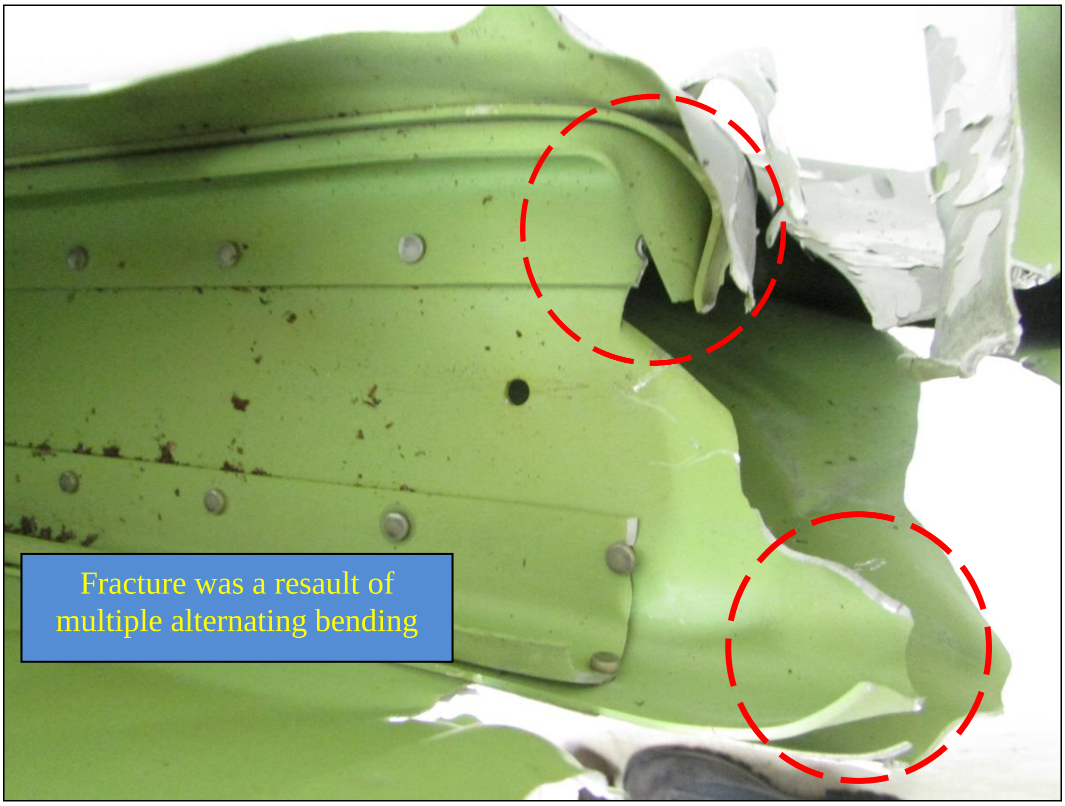


Image 20: Point of fracture on a profile of a spar (upper side is down!)

Both initial points of fracture are marked with circles. Looking at the shape of the side of the profile we can conclude, that fracture was a result of multiple alternating bending.

Phenomena of flutter could be worsened by the accumulation of ice on the horizontal stabilizer (which is situated in front of the pivot point of the elevator), vertical stabilizer and especially on the fin of a rudder which is situated above the vertical stabilizer and extends also in front of the rudder pivot point. If the surface of the rudder fin froze to the vertical stabilizer, the pilot was unable to move rudder control surface. During the structural failure vertical fin was sheared off and was never recovered.

2.2.1 Resaults of the metallographic examination – Metallographic images – ZAG

Due to original ZAG document extent, only part of this document is presented in the Final report. This part contains metallographic examination details. Numbering of images in this part of the Final report is identical with image (Figure) numbering in ZAG **Report about the visual and fractographic investigation of a horizontal stabilizer of the airplane**, prepared by The

Department of Materials, Laboratory for Metals, Corrosion and Anti-Corrosion protection at ZAG (ZAG Report number P 808/17 – 440 – 1).

Results of the metallographic examination – metallographic images

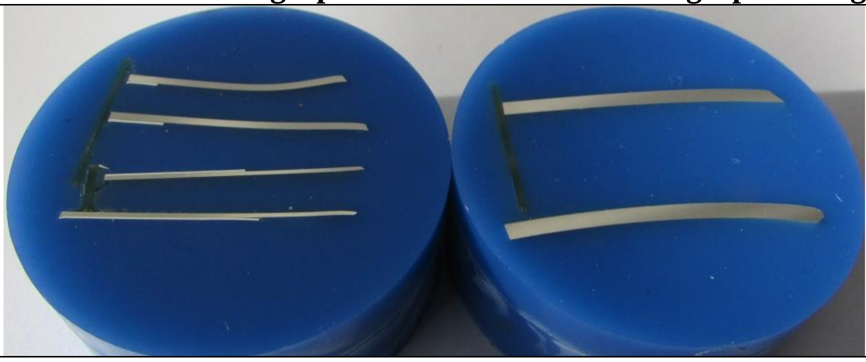
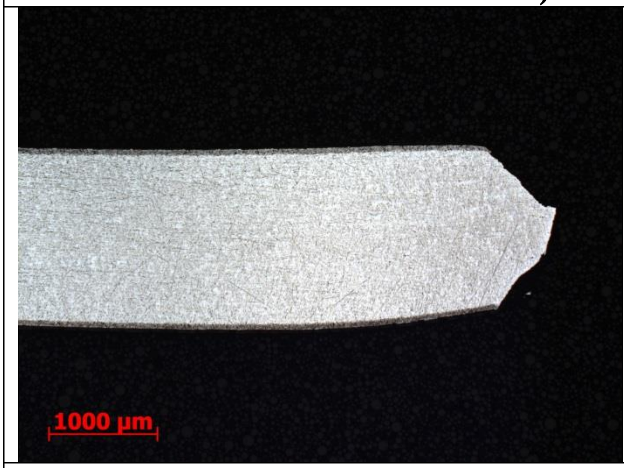
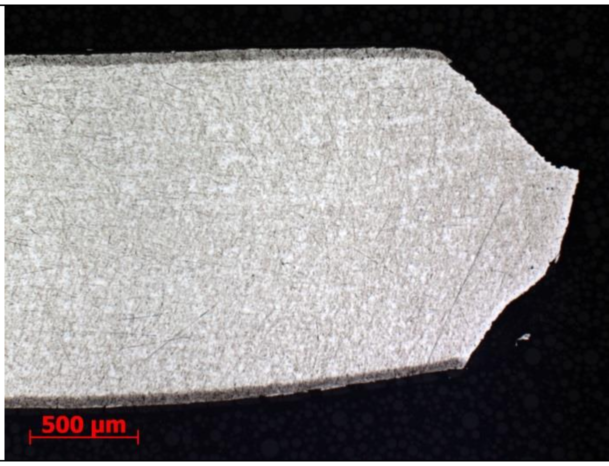


Figure 89: Prepared metallographic samples of the cross-sections of the sheets of the formwork and the longitudinal profile in addition to the fracture points. On the left-hand sample there are cross-sections of the front sheet metal (places C and D) and sheet metal from town B (B 1 and B 2). The locations of cutouts are shown in Figure 12. On the right sample are sections of the sheets of the longitudinal profile (samples 1 and 2 - longitudinal profile), the location of the removal is shown in Figures 61 to 63. IMG-559

Longitudinal section of the sheet of the longitudinal profile of the horizontal stabilizer (in addition to the location of the fracture)





Figures 90 and 91: Longitudinal cross-section of the sheet of the longitudinal profile. Sample 1 in addition to the fracture. The shape of the fracture is due to the alternating bending load (polished).

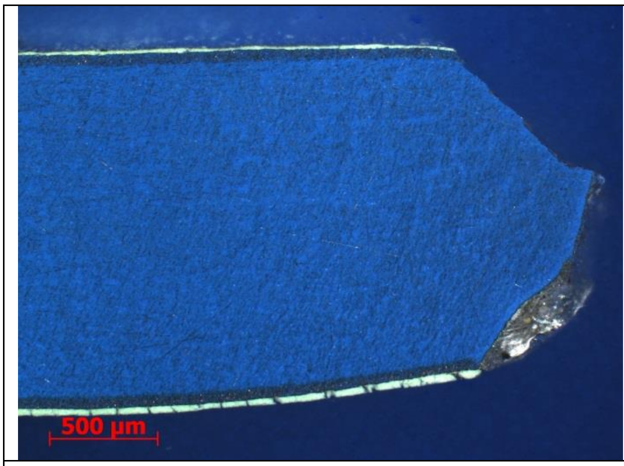


Figure 92: Sample 1 in addition to the fracture (unetched, polarized light ilumination). The corrosion coating (primer) on the surface is cracked due to the elongation of the sheet near the fracture.

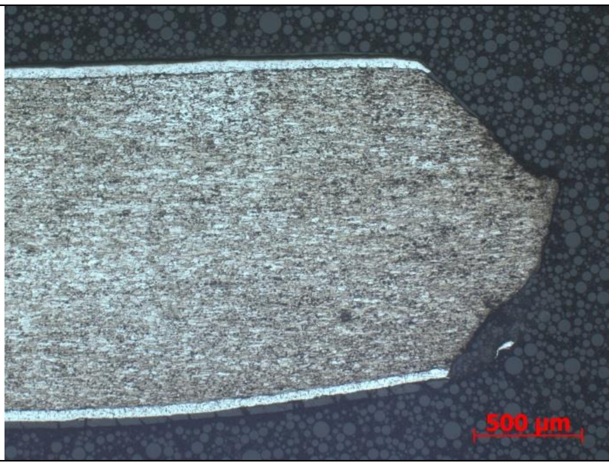
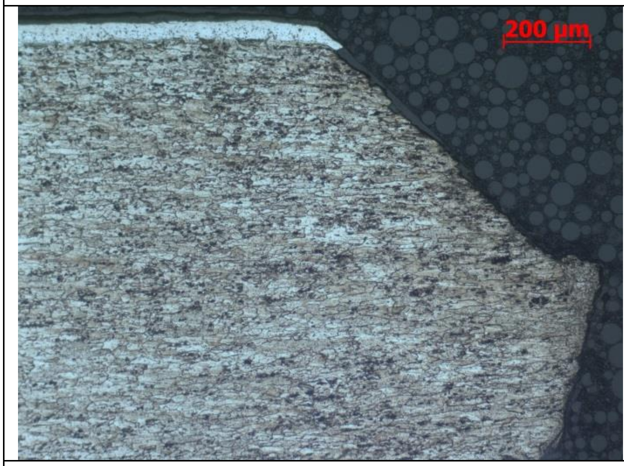
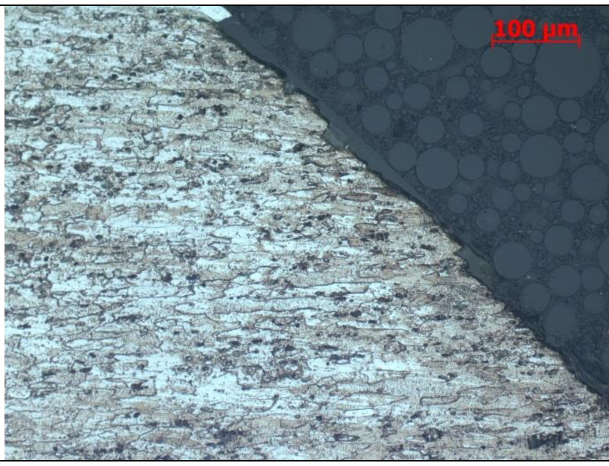
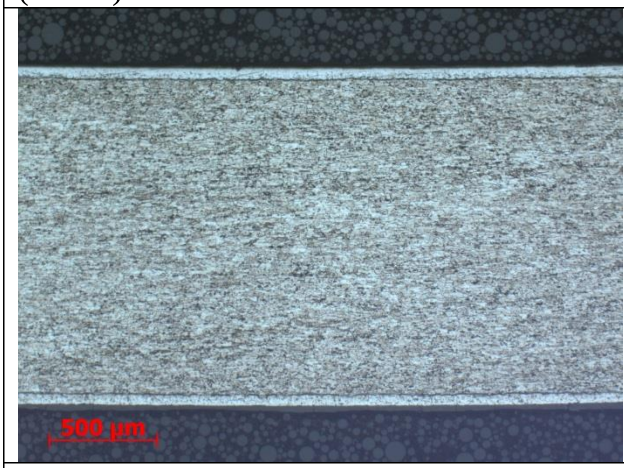


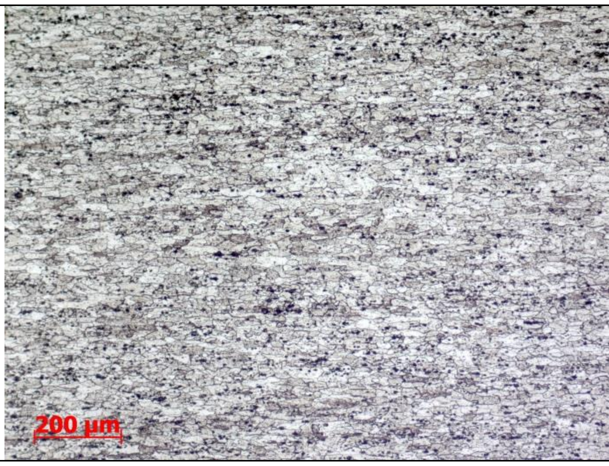
Figure 93: Sample 1 in addition to the fracture (etched). Due to the elongation and contraction of the sheet near the fracture, crystall grains are also deformed.



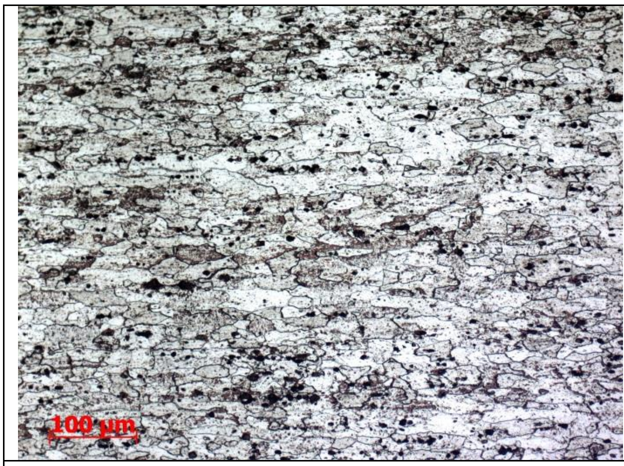


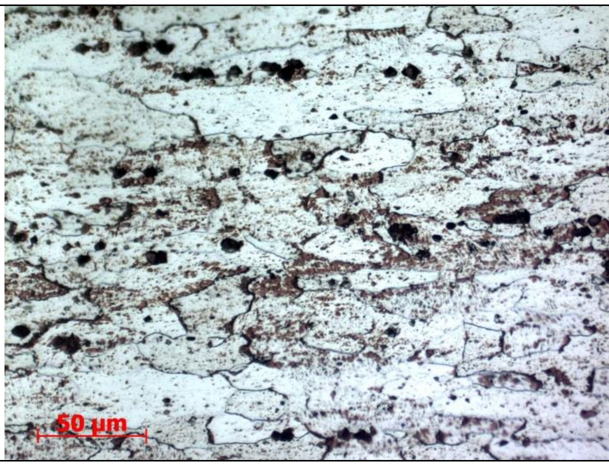
Figures 94 and 95: Detail of microstructure in addition to the fracture. The crystall grains at the fracture surface were demolished in the direction of loading, the fracture is of a tough nature (etched).



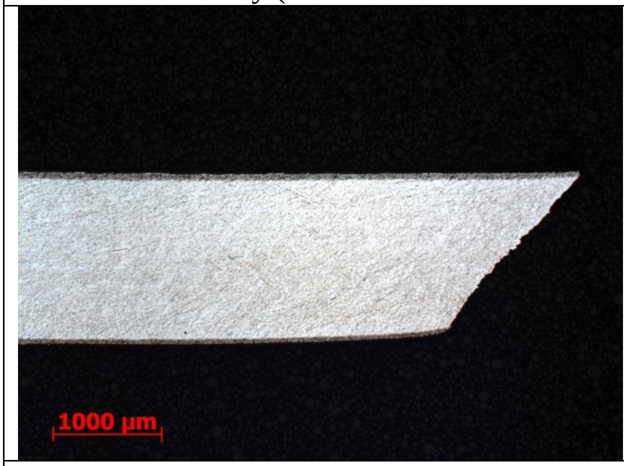


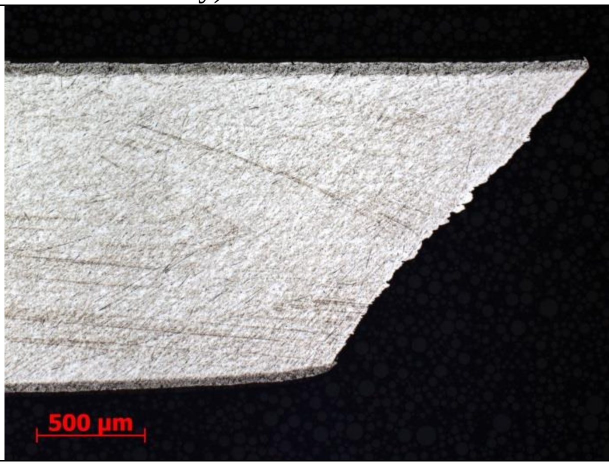
Figures 96 and 97: Sample 1 - the longitudinal cross-section of the profile plate in approximately 20 mm from the fracture. A thin layer of alloy (probably alloys AW-1230 or pure Al high purity, i.e., "Alclad") is deposited on the surface of the sheet - etched.



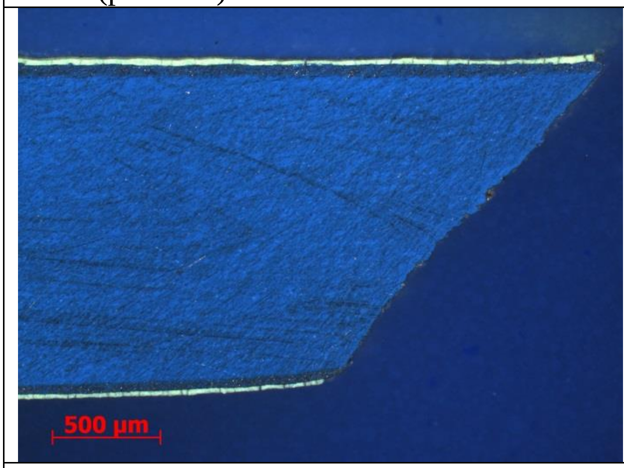


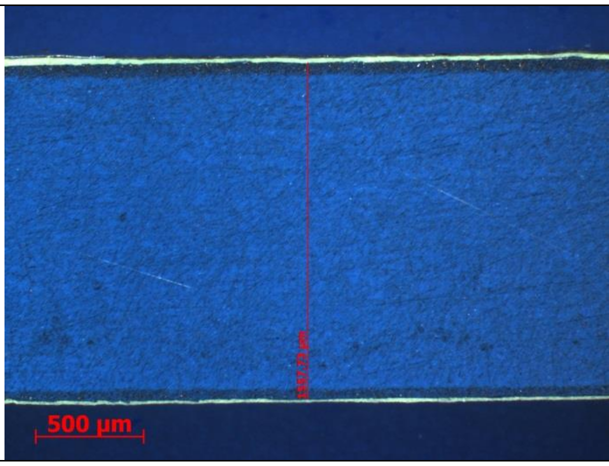
Figures 98 and 99: Sample 1 - the longitudinal section of the sheet of the profile at a distance of about 20 mm from the fracture. Details of the microstructure of the sheet of alloy 2024: various precipitates of intermetallic compounds are dispersed over crystalline grains α: insoluble particles (Cu, Fe, Mn) Al_7, fine particles are $CuMgAl_2$, $Cu_2Mn_3Al_{20}$ and Cu_2FeAl_7. In particular, the presence of the $CuMgAl_2$ (S-phase) and $CuAl_2$ (θ ') phases indicated precipitation strengthening of the aluminum alloy (solution heat treatment of the aluminum alloy) - etched.



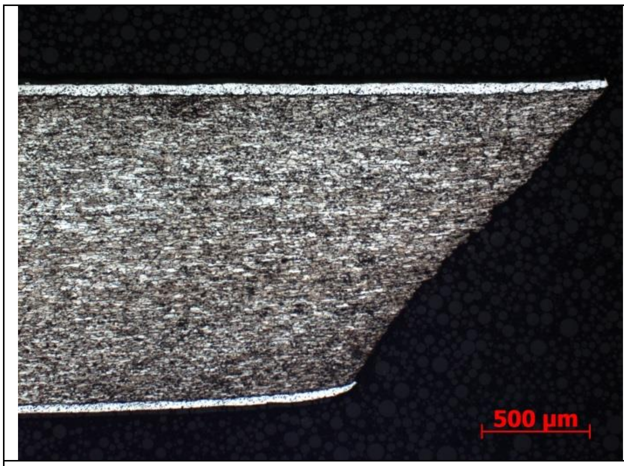


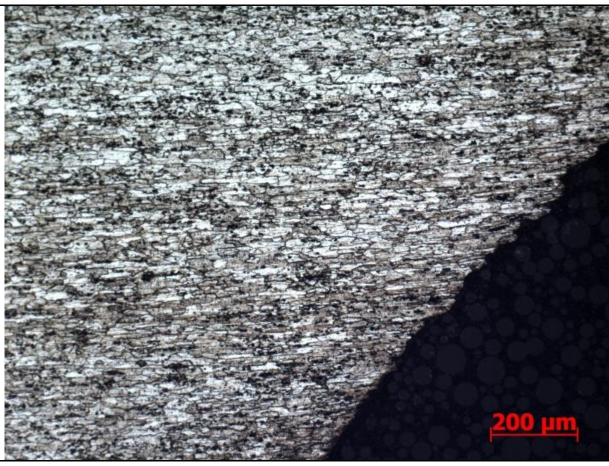
Figures 100 and 101: Longitudinal cross-section of the sheet of the longitudinal profile. Sample 2 in addition to the fracture. The shape of the fracture is consequence due to bending and tensile stress (polished).



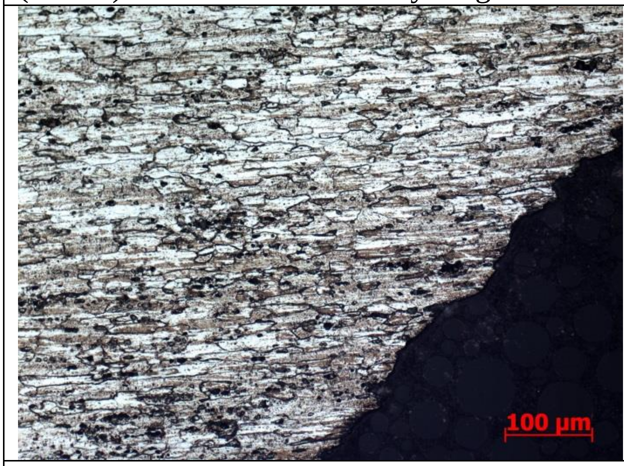


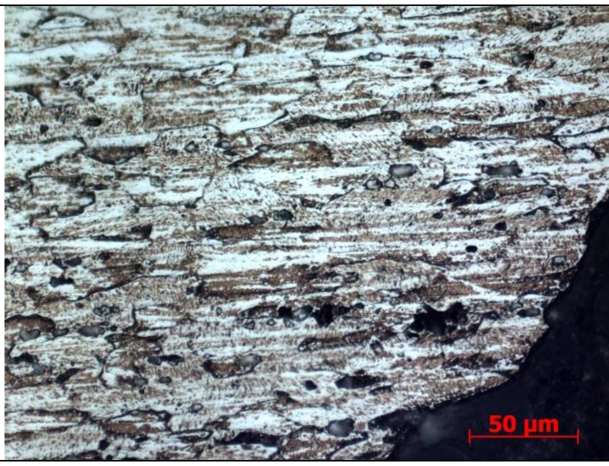
Figures 102 and 103: Longitudinal cross-section of the sheet of the longitudinal profile. Sample 2 in addition to the fracture and at a distance of approximately 20 mm from the fracture (unetched, polarized light illumination). The corrosion coating (primer) on the surface is cracked due to the elongation of the sheet near the fracture. The sheet thickness is 1.560 mm.





Figures 104 and 105: Longitudinal cross-section of the sheet of the longitudinal profile. Sample 2 in addition to the fracture. Due to the elongation and contraction of the sheet metal near the fracture, crystall grains are also cold deformed. As a result, the hardness near the fracture increased (etched). The break is relatively tough and is similar to the usual tensile failure.





Figures 106 and 107: the longitudinal cross-section of the sheet of the longitudinal profile. Sample 2 in addition to the fracture - a detail of the microstructure (etched).

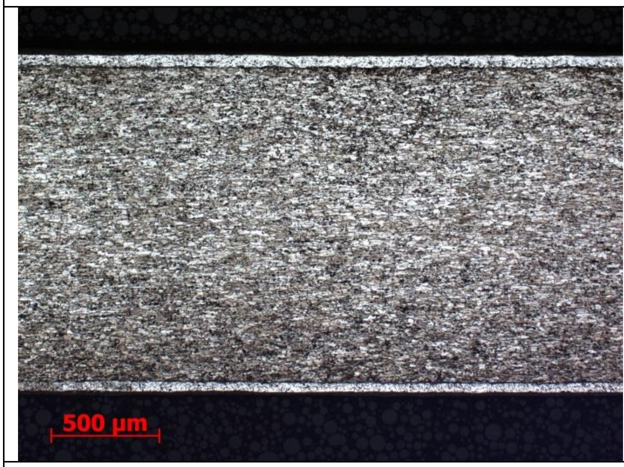
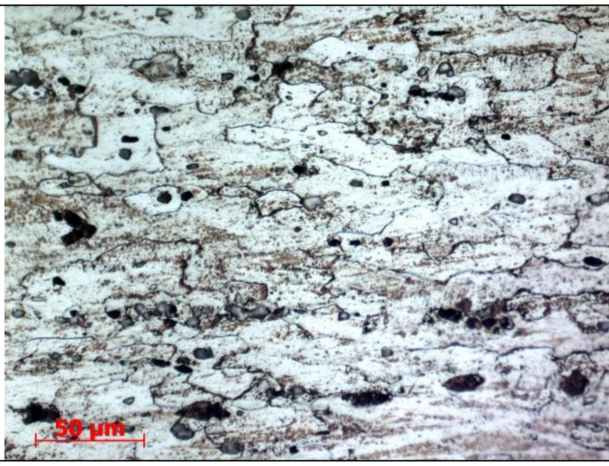
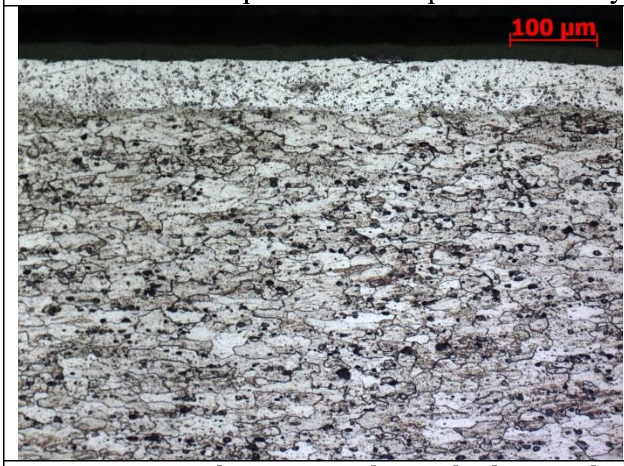


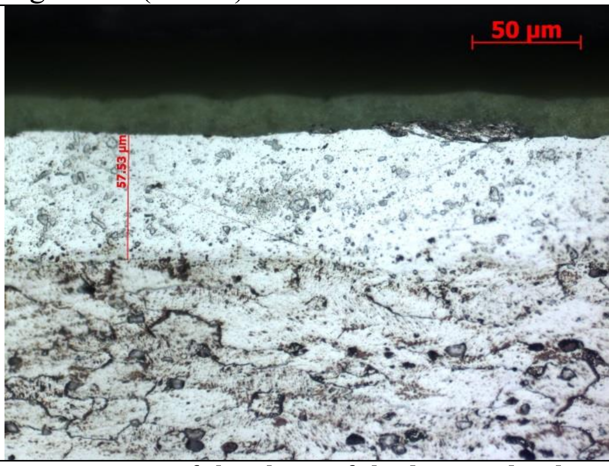
Figure 108: Sample 2 – the longitudinal cross-section of the sheet of the longitudinal profile at a distance of about 20 mm from the fracture. A thin layer of alloy (probably AW-1230) on the surface of the sheet metal (etched).

Figure 109: Sample 2 - the longitudinal cross-section of the sheet of the longitudinal profile at a distance of about 20 mm from the fracture. The microstructure of the sheet is uniform over the entire cross section, the crystall grains are deformed in the direction of rolling the sheet (etched).



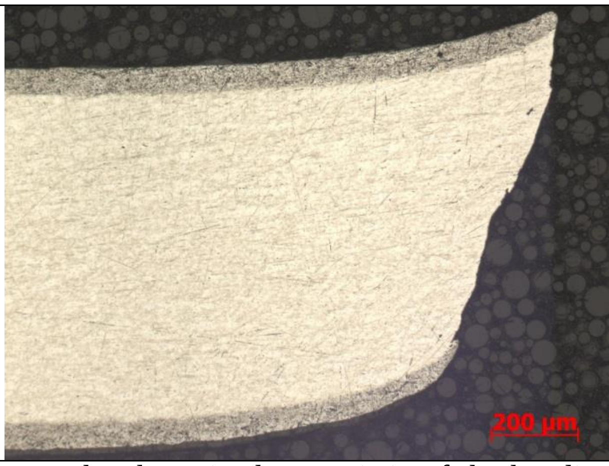
Figures 110 and 111: Microstructure details of aluminium alloy 2024 sheet: various precipitates of intermetallic compounds are dispersed over crystall grains α (etched).





Figures 112 and 113: Sample 2 - the longitudinal cross-section of the sheet of the longitudinal profile at a distance of about 20 mm from the fracture - the detail of the cross-section at the surface. A thin layer of alloy (probably alloy AW-1230 or pure Al high purity, i.e., "Alclad"), a thickness of about 60 µm, is deposited on the surface of the sheet metal. On the surface there is also a thin layer of basic anti-corrosion coating (etched).

Longitudinal sections of the front plate of the horizontal stabilizer in addition to two fractures



Figures 114 and 115: Sample C next to the fracture. The shape is characteristic of the bending - tensile fracture (unetched). The breakthrough is tough - ductile.

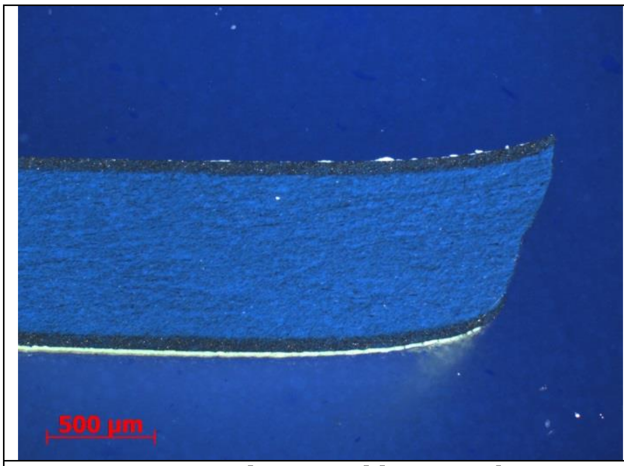


Figure 116: Sample C in addition to the fracture (unetched, polarized light illumination). The remainder of the anti-corrosion coating (light) is visible on the surface.

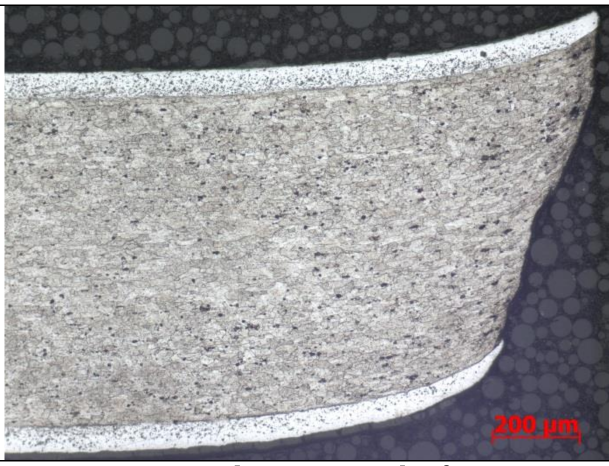
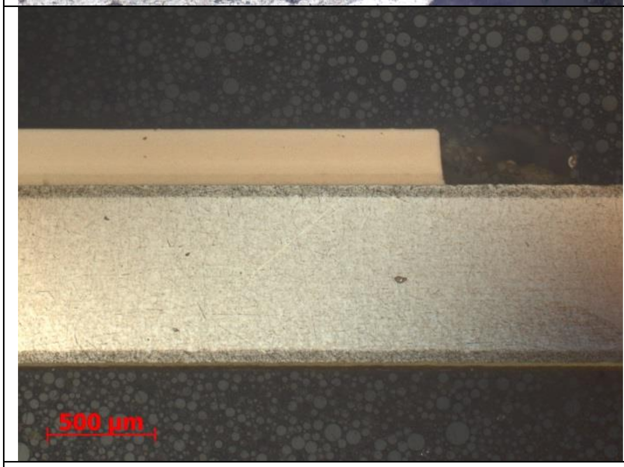
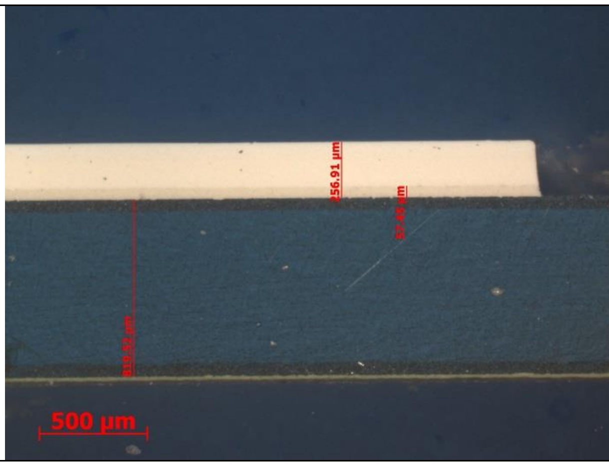


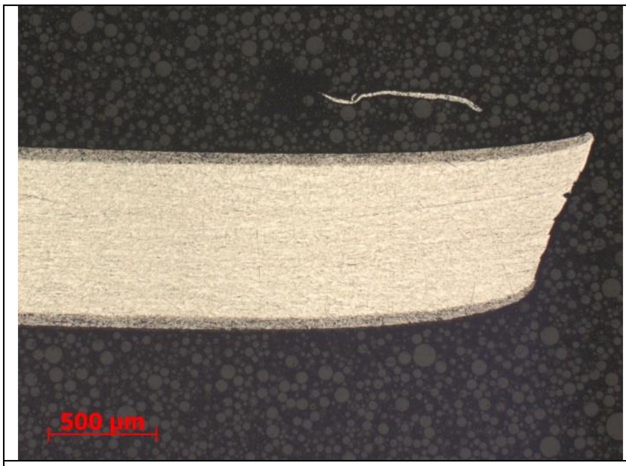
Figure 117: Sample C next to the fracture (etched). A strongly plastic deformed microstructure is the result of a fracture resulting from overload.

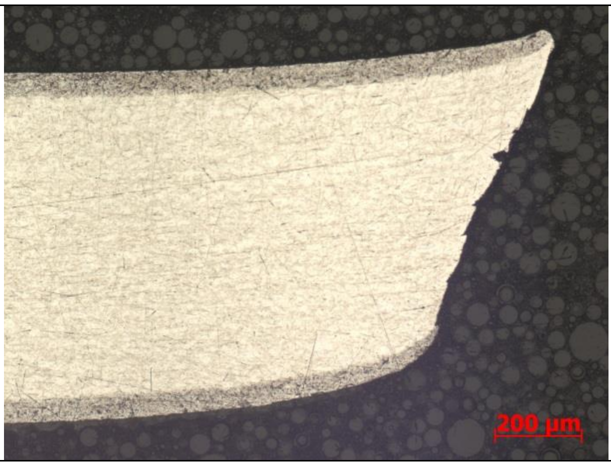
Figure 118 (to the left): Sample C next to the fracture (etched). The microstructure at the break is strongly plastic deformed. Breakthrough occurred when overloading. The microstructure is completely conventional for the heat-treated alloy 2024: the various precipitates of the intermetallic compounds are dispersed over the crystall grains α (etched).



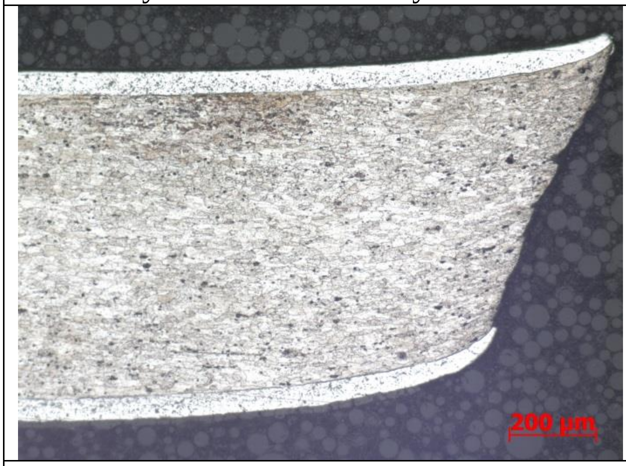


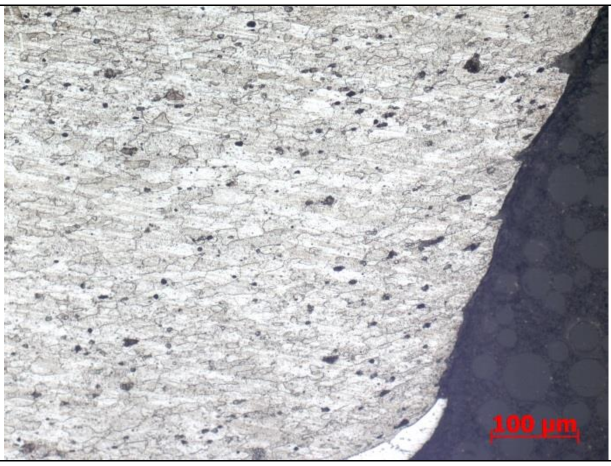
Figures 119 and 120: Sample C - sheet cross-section at a distance of about 20 mm from the fracture (unetched, white and polarized illumination). A thin layer of alloy is deposited on the surface of the sheet (probably AW-1230). On the outer side (in the figures above, two layers of anti-corrosion coating in a total thickness of about 260 µm. The thickness of the front sheet is 0.82 mm.



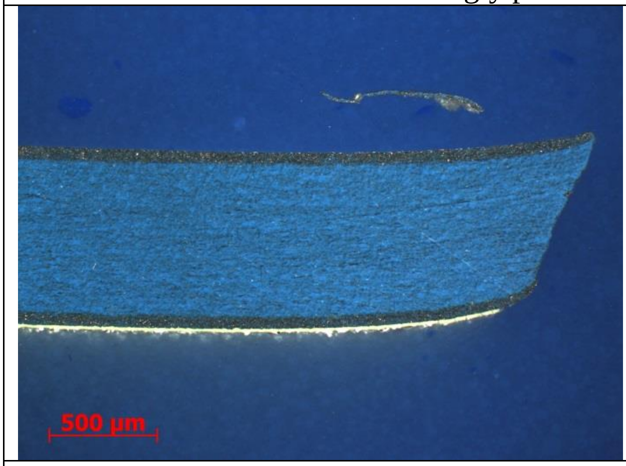


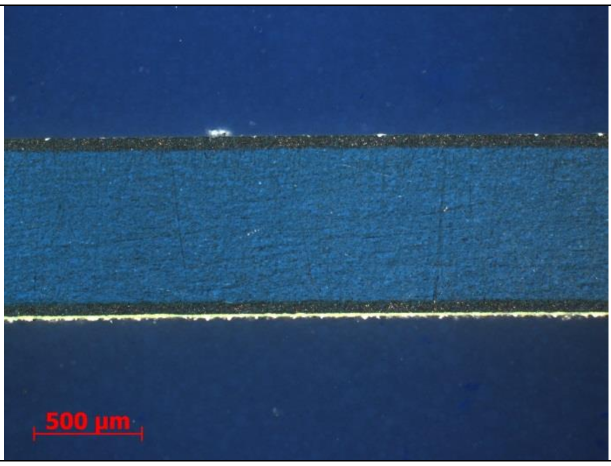
Figures 121 and 122: Sample D - cross-section of sheet in addition to fracture. The shape is characteristic of the bending - tensile fracture (unetched). The breakthrough is tough - ductile. The surface layer of the claded alloy is also ductile.



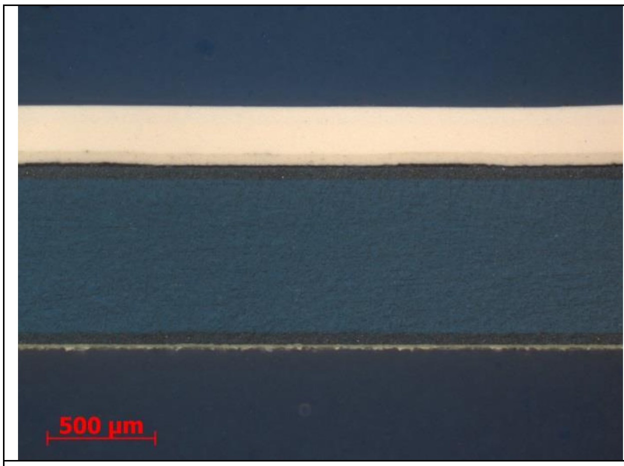


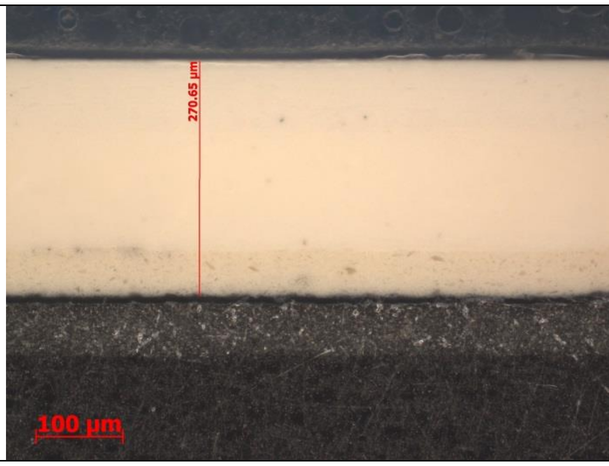
Figures 123 and 124: Sample D - cross-section of sheet in addition to fracture (etched). The microstructure at the break is strongly plastic deformed.





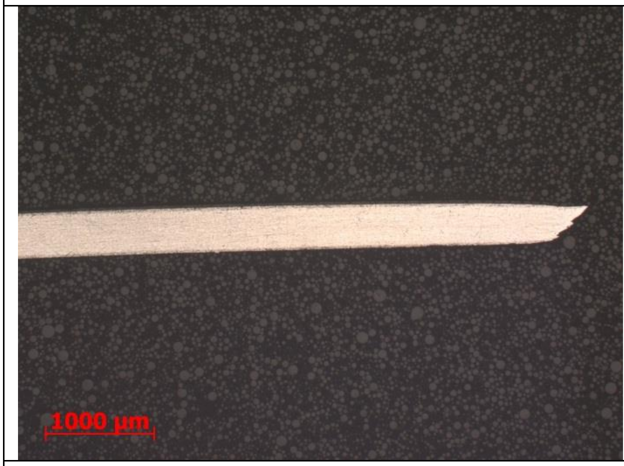
Figures 125 and 126: Sample D - cross-section of the sheet in addition to the fracture and at a distance of about 20 mm from the fracture (polarized light illumination). On the outer side, the anti-corrosion coating was delaminated, on the inside the basic anti-corrosion coating remained on the surface (light – on the bottom).



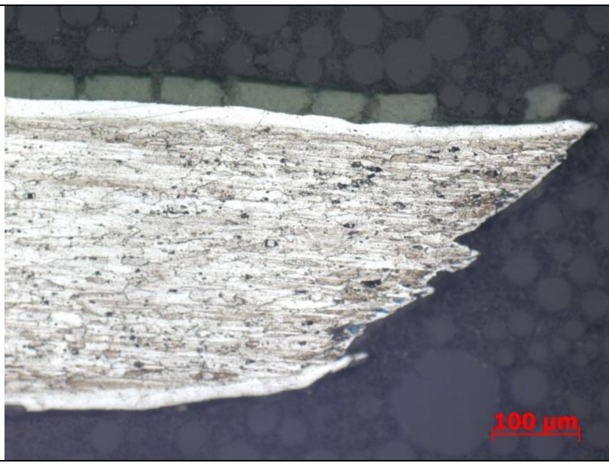


Figures 127 and 128: Sample D - approximately 20 mm from fracture (polarized light illumination). On the plate are layers of white anti-corrosion coating in the total thickness of 270 µm remained on the outside.

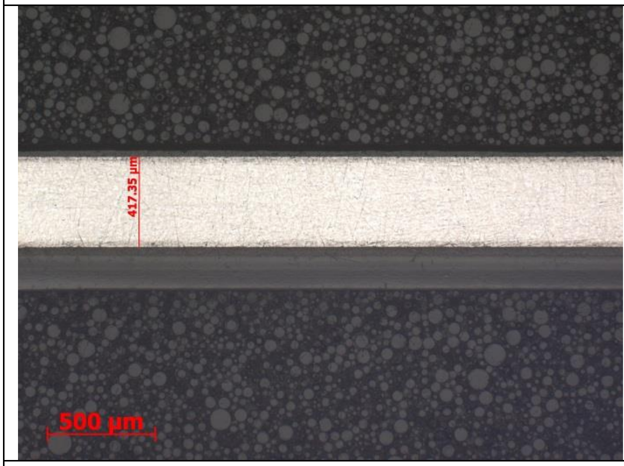
Cross-section of the middle plate of the of the horizontal stabilizer in addition to two fractures

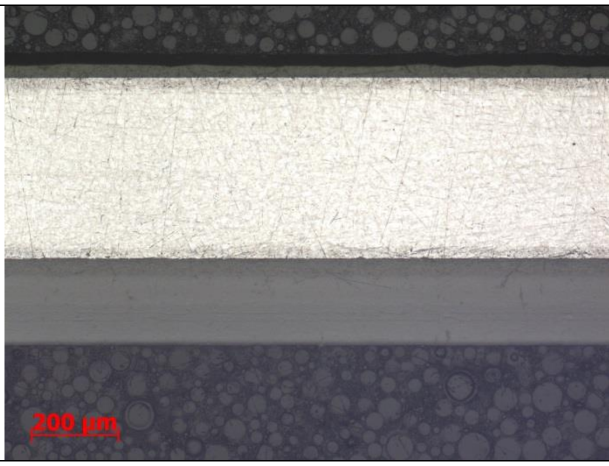


Figures 129 and 130: Sample B 1 - cross-section of the middle sheet next to the fracture (unetched). The shape is characteristic of collapse in tensile loads. The sheets are also slightly curved as a result of the presence of bending loads.

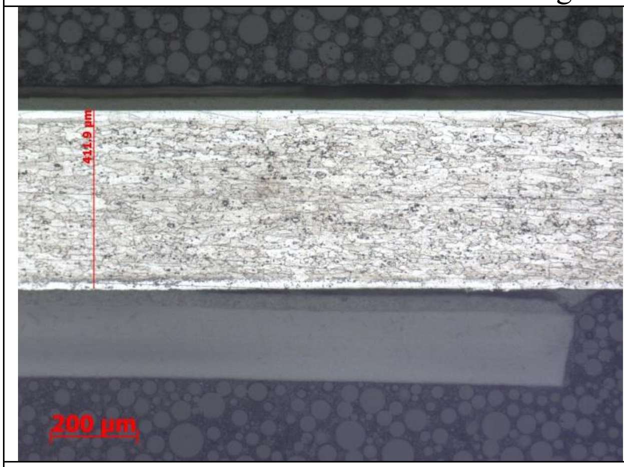


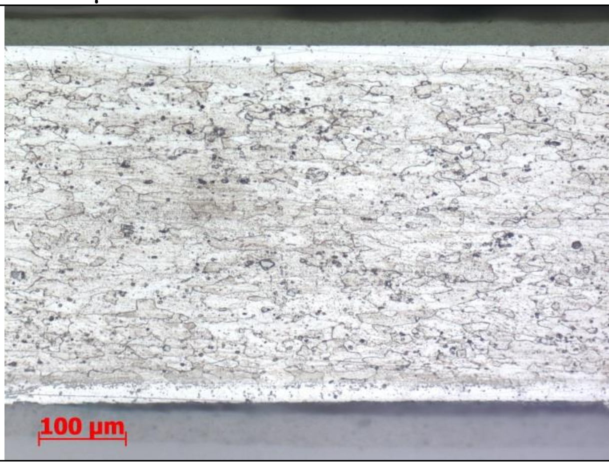
Figures 131 and 132: Sample B 1 - cross-section of the middle plate next to the fracture (etched). The breakthrough is tough - ductile. The microstructure at the break is strongly plastic deformed in the direction of tensile loads. The corrosion coating (green) is cracked due to excessive elongation. In addition to the breakage, the corrosion coating on the outer side of the sheet metal fell off.



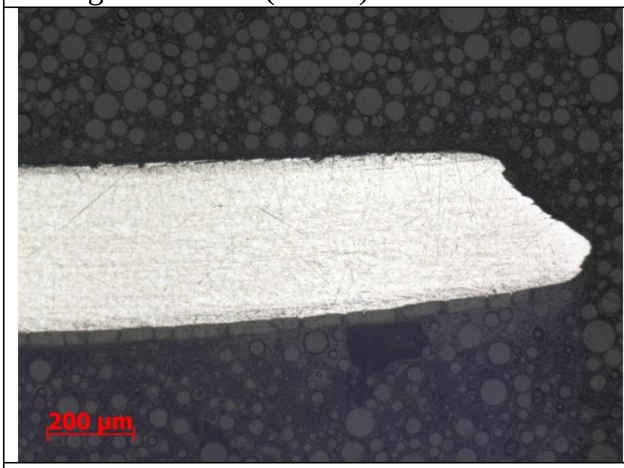


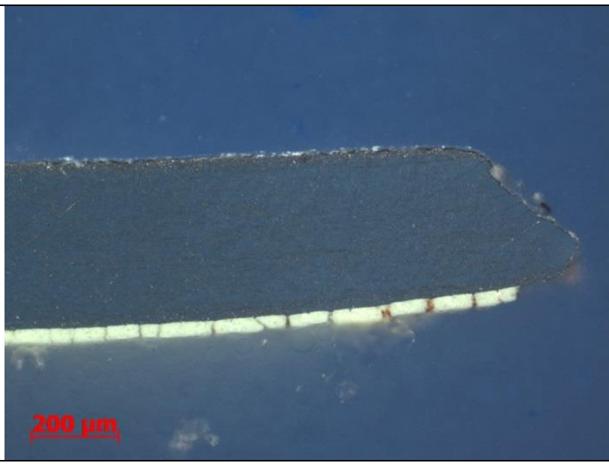
Figures 133 and 134: Sample B 1 - cross-section of the middle sheet at a distance of 20 mm from the fracture (unetched). The thickness on the undamaged part is between 412 and 417 µm. On the underside there is an anti-corrosion coating of about 250 µm thickness.





Figures 135 and 136: Sample B 1 - cross-section of the middle sheet at a distance of about 10 mm from the fracture. Microstructure of metal sheet 2024: various precipitates of intermetallic compounds are dispersed over crystall grains α, which are slightly extended in the direction of rolling sheet metal (etched).





Figures 137 and 138: Sample B 2 - cross-section of the middle plate in addition to the fracture (unetched, white and polarized light illumination). The shape is characteristic of collapse in tensile and bending loads. The anti-corrosion coating (green color - on the right figure below) is cracked due to excessive elongation. In addition to the fracture, the corrosion coating on the outer side of the sheet metal fell off.

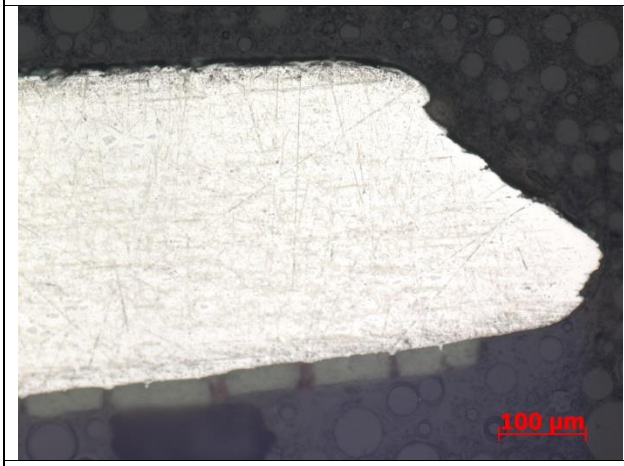


Figure 139: Cross-section in addition of the fracture (unetched).

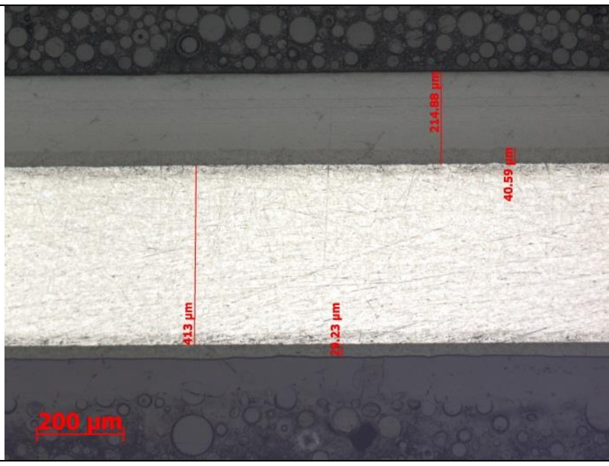
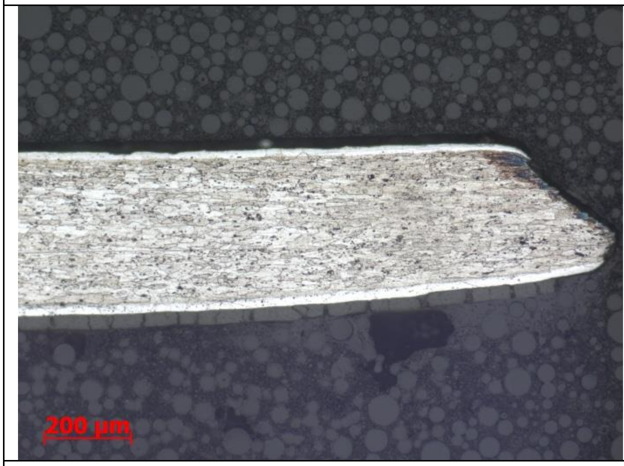
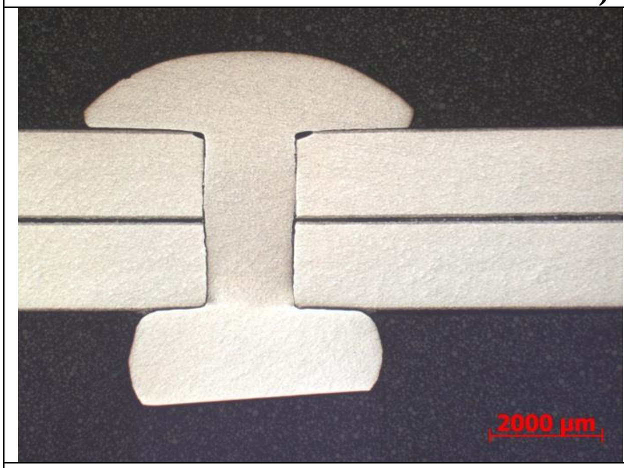


Figure 140: The cross-section at a distance of about 20 mm from the fracture. The sheet thickness is 413 µm.

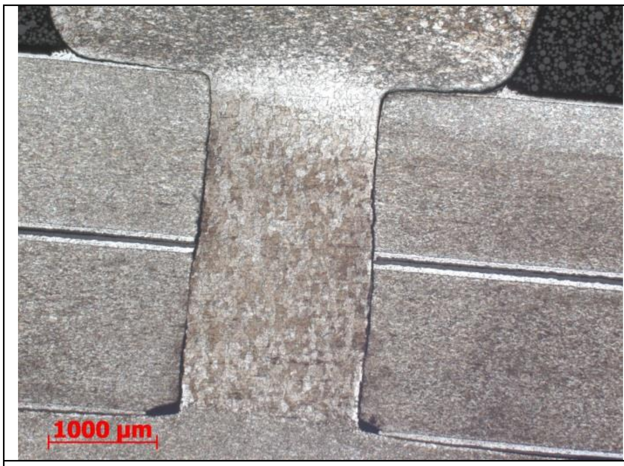


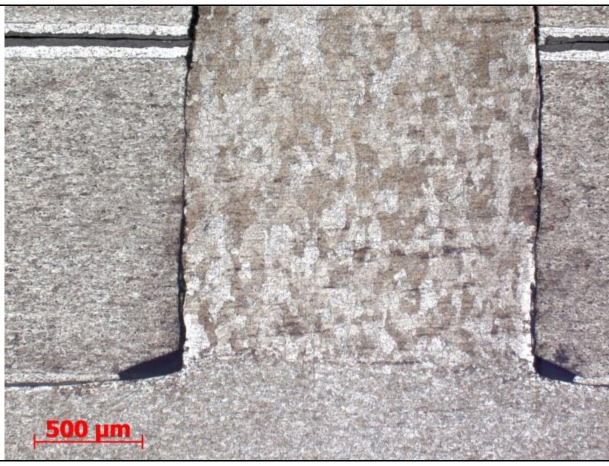
Figures 141 and 142: Sample B 2 - cross-section of the middle sheet in addition to the fracture (etched). At break, the microstructure is strongly plastic deformed.

Cross-section of the sheet of the longitudinal profile of the horizontal stabilizer (at a distance of about 80 mm from the fracture)

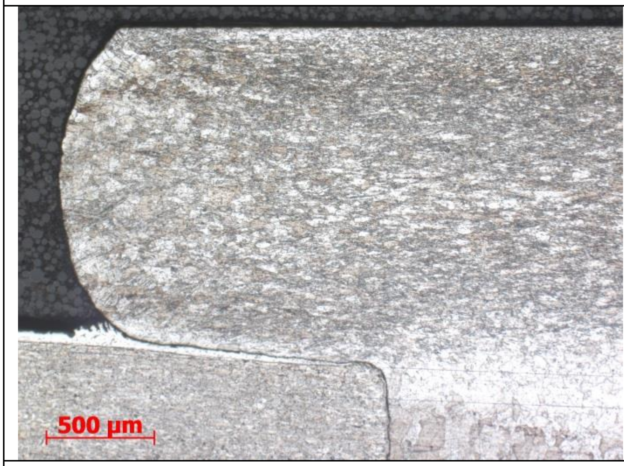


Figures 143 and 144: Riveting joint between the longitudinal profile and the reinforcing profile (unetched and etched). Both elements are made of the same sheet (1.57 mm thickness). There are no corrosion damages in the contacts (crevices) between the various elements.





Figures 145 and 146: Riveting joint between the longitudinal profile and the reinforcing profile (etched) - detail. The rivet stem fits nicely in the hole. The rivet is forged with cold forging. On the rivet head in the deformed part, the microstructure is cold hardened, and the crystall grains are smaller.



Figures 147 and 148: Riveting joint between the longitudinal profile and the reinforcing profile (etched) - details between the riveted part and the sheet metal, rivet head and sheet metal.

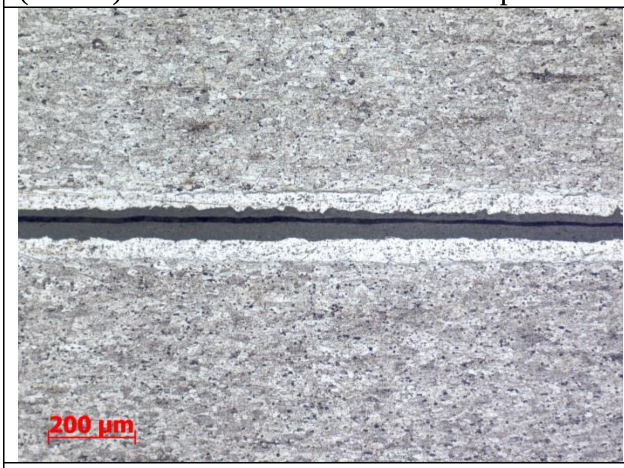


Figure 149: Contact between sheets (etched). On both sheets, there is a thin layer of green anti-corrosion coating on the claded layer of Al alloys with high Al content (bright layers along the slit).

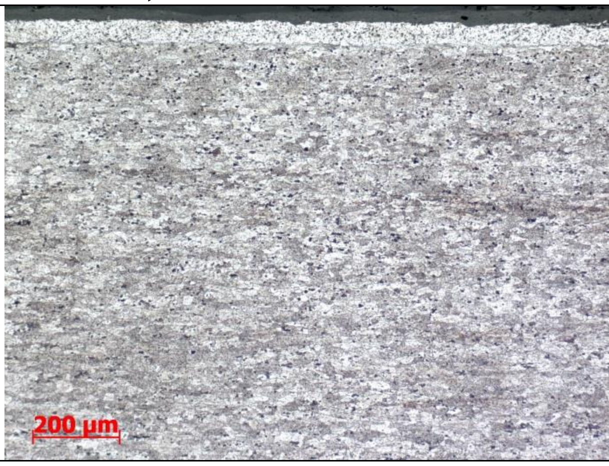


Figure 150: Sheet of the longitudinal profile at the edge (transverse direction - etched). Crystall grains are cross-sectional of the same size. Various precipitates of intermetallic compounds are dispersed by crystall grains α (fine dark spots).

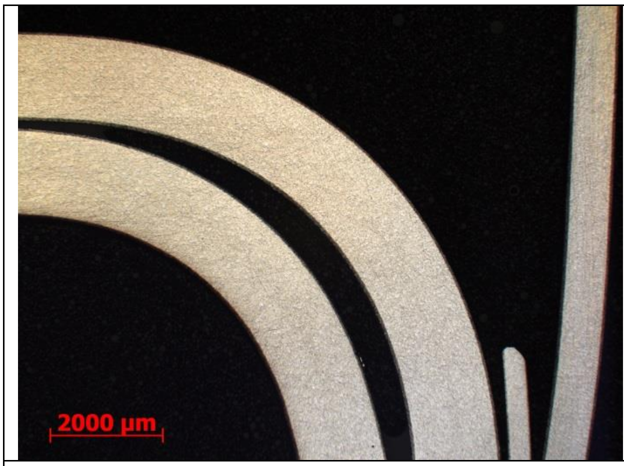


Figure 151: In the vicinity of the breaking point, due to the deformation, the plates of the longitudinal profile and the reinforcement profile were spaced apart.

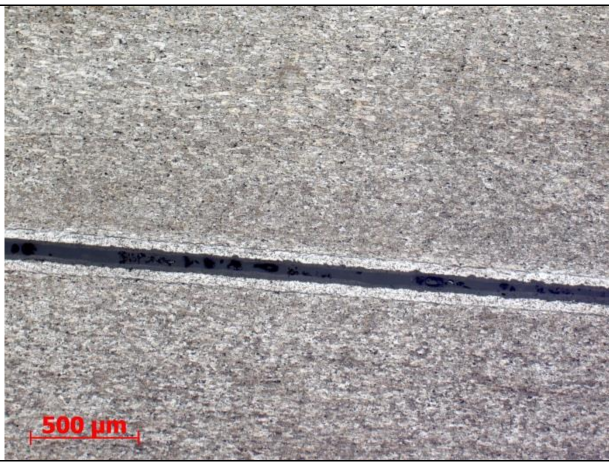
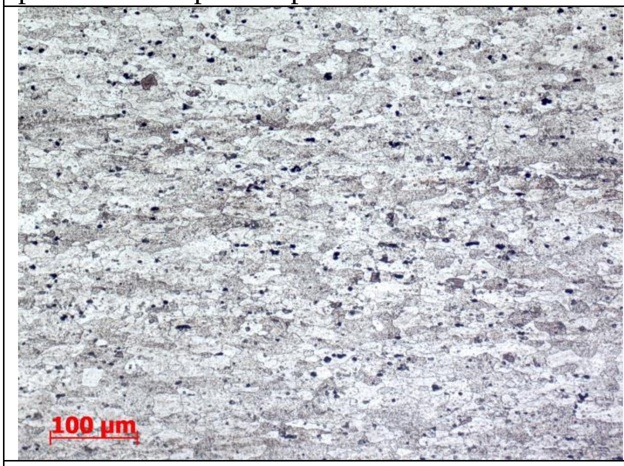
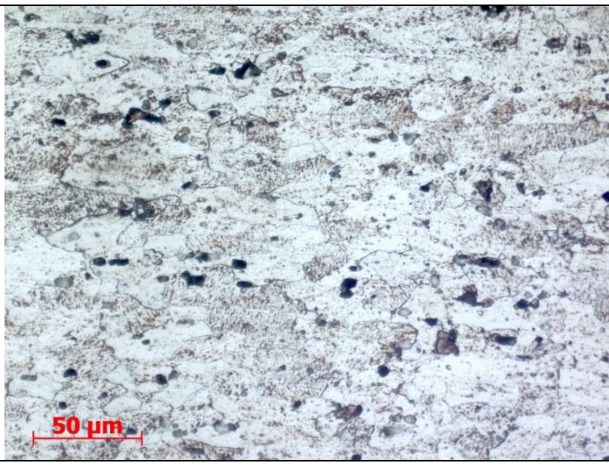


Figure 152: The microstructure of both sheets is very similar in the longitudinal cross-section.





Figures 153 and 154: Sheet of the longitudinal profile in the transverse cross-section. Details of microstructure of metal sheet of the alloy 2024: various precipitates of intermetallic compounds are dispersed over crystall grains α. In the transverse direction, the orientation of the crystalline grains is less visible than in the longitudinal direction. At a distance of 8 cm from the fracture, no changes in the microstructure are observed, which could be due to fatigue of the material.

The purpose of the examination was determination of the nature of breaks, datermination of presence of the fatique fractures or other damages, which would contribute to the reduction of structural resistance of the horizontal stabilizer and to analyse mechanical properties of the aircraft structure materials. Collected wrackage were marked with internal code Z/1886/17. Laboratory examinations and tests were performed from 23RD October 2017 until 6TH December 2017 in ZAG laboratories.

When examining the cross sections at the points of the fracture surfaces in their vicinity, we found the following: depending on the shape of the fracture profile and the contraction in the fracture area, it can be concluded that the fractures are the consequence of repeated overloads (alternating bending loads in which the yield strength of the metal was exceed). The shape of the fractures are also characteristic of a combination of bending and tensile loads. The breaks are tough, ductile. The microstructure is in the vicinity of the fracture surfaces deformed in the direction of the load.

Microstructure of all three inspected aluminium sheets (longitudinal wing profile with a wall thickness of 1.560 mm, front skin panel with a wall thickness of about 0.82 mm in the middle plate (skin) of a wing with a wall thickness of 0.41 to 0.42 mm) is composed of various precipitates of intermetallic compounds that are dispersed in crystal grains α (insoluble particles (Cu, Fe, Mn)Al_7, fine dark particles $CuMgAl_2$, $Cu_2Mn_3Al_{20}$ and Cu_2FeAl_7). In particular, the presence of the $CuMgAl_2$ (S-phase) and $CuAl_2$ (θ ') phases indicated precipitation strengthening of the aluminum alloy (solution heat treatment of the aluminum alloy)[7, 8, 9, 10, 11].
The microstructure is completely conventional for metal sheet made of alloy EN-AW-2024 (or also EN-AW-2124), which is heat-treated, cold-formed and aged (temper T3: naturally aged, temper T4: artificially aged or “overaged”)[6].

A thin layer of aluminium alloy is claded on the surface of the sheet metal (probably EN-AW-1230 alloy, AlZn1 alloy or high purity aluminium "Alclad")[12]. The thickness of this layer is on a sheet with a wall thickness of 1.560 mm, about 60 µm, and thinner on other sheets (about 30 µm). The EN-AW-2024 alloy sheet is claded with better corrosion resistance alloy, because the corrosion resistance of the 2xxx series alloys is poor. We have not found any microstructure faults that could in any way affect the deterioration of the mechanical properties of the material.

2.3 Analysis of the flight

The airplane entered Slovenian airspace at point RIFEN at 10:44:47 LT at the altitude 13400 feet, according to ATC radar data. As flight was progressing in NE direction, pilot had to choose odd flight level.

From the analysis of the trajectory of the airplane and from the radio communication with ATC, we can establish, that the pilot, soon after he took-off from Venice, started to avoid adverse weather. This type of whether was not suitable for this kind of airplane. Flight was performed according to IFR. Pilot was avoiding the areas of icing and convective activity near clouds, he tried to accomplish that by changing direction of flight.

As icing started to occur (which was also forecasted for 9000 feet in W part of Slovenia), pilot decided to fly higher. To obtain approval for altitude change Padova ATC consolidated with ATC in Ljubljana, who approved FL130 in the telephone communication with Padova ATC, before the airplane entered Slovenian airspace. Reason for climb to higher altitude (according to telephone communication between ATC) were meteorological phenomena (clouds, icing conditions). Before reaching RIFEN the airplane already established cruise at FL130. At 10:46:41 N710CC was in coordination with ATC cleared towards Klagenfurt (KFT VOR). At that moment the airplane was at 13400 feet. ATC warned the pilot about the altitude deviation and approved temporary flight at FL135. At 10:49:31 the airplane initiated a left turn (approximate bearing 315˚). At 10:50:39 ATC noticed the deviation and warned the pilot. At that time, the airplane was at 12900 feet.

After the pilot explained the reason for lateral deviation, he decided to change the direction of flight again (despite adverse weather proximity) to the right for approximately 90 degrees. The airplane started a shallow descent and ATC warned the pilot about the minimum safe altitude in the direction of flight, which is FL120. Pilot at this time (10:51:10 LT) did not replay to ATC instruction. At 10:51:30 LT pilot transmitted a distress call. At that time the airplane descended at more or less constant speed and passed 8000 feet AMSL in the descend. At 10:51:43 LT radar contact with the aircraft was lost at 5500 feet AMSL near village Predmeja, which is located at 950 meters AMSL (approximately 3100 feet). Uncontrolled descent took place until the airplane hit the terrain.

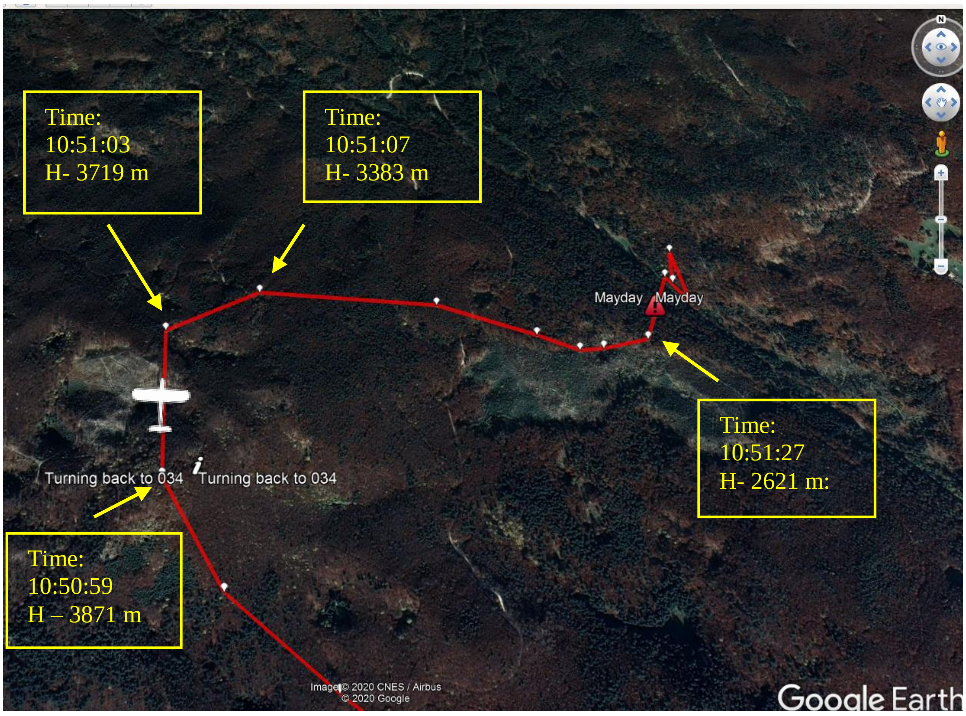


Image 21: Radar detected flight elements at 4 seconds sampling rate

At the same time, that the accident happened, two passenger aircraft with destination Ljubljana entered Slovenian airspace from the West (one from Paris and the other from Zurich). Both aircraft were, in coordination with ATC, avoiding adverse weather conditions by means of their airborne weather radar systems and were descending towards East and South-east in arrival to Ljubljana airport. Both aircraft were flying approximately 20 nm North of position of N710CC, that is over the area of Julian Alps. Position of N710CC was at the time over Trnovski gozd near Ajdovščina.

After the pilot of N710CC transmitted distress call one of the passenger aircraft informed ATC about moderate icing during descend in layers between FL110 and FL180. According to the ground weather radar images, conditions were the same also in the area where N710CC was present.

According to the weather radar images we can be quite certain, that the airplane flew in conditions of moderate icing (of unknown intensity) in duration of around 10 minutes. In that time span of moderate icing, on extremities like horizontal and vertical stabilizer, ice can form to more than 6 mm[6] thick. In case of supercooled liquid water droplets near the thunderstorm clouds falling on cold aircraft surface, the accumulation of ice can be even more intense.

Commission estimates, that indicated airspeed of the airplane never exceeded v_{NE}, or never exceed speed. As ice accumulated on control surfaces, imbalance of flight control surfaces induced flutter and that can happen bellow v_{NE}.

Communication between the pilot and ATC was according to standard procedures, until the moment of impact after final distress call. ATC tried several times to make radio contact, but failed in the attempt.

2.3.1 Studies related to inflight icing

In past years many studies and analysis have been done on the topic of Inflight icing, which describe the nature and consequences of ice accumulation on aircraft surfaces causing flight controls aerodynamic instability and thereby reduction of the total aircraft stability. Studies on small general aviation aircraft accidents which included inflight icing as a cause, concluded that in many cases even experienced pilots have less than 5 to 8 minutes time to deviate from deteriorating icing conditions before they lose control of the aircraft which leads to accident. One of the studeies was performed by NASA (Icing Effects on Aircraft Stability and Control Determined from Flight Data, Preliminary Results).

Studies especially point on issues with small general aviation aircraft, which are not equiped with Anti-ice systems or are **not approved for flight into known icing conditions**. Ice accumulation and its influence on aircraft stability is at first hardly detectable. When manouvering starts, accumulated ice causes turbulent airflow over control surfaces, which can lead to lose of control or even inflight structural failure.

[6] Pilot Handbook of Aeronautical Knowledge - FAA

Actual weight increase due to ice build-up is of secondary importance when viewed from the perspective of interupted airflow which the accumulated ice is causing. When the power for compensation of increased drag is intruduced the angle of attack increases, which causes the ice to build also on the lower surface of the wing or flight control surface (causing airflow inturuption and also flight control mass imbalance, especially on all-moving stabilizer!).

Links to resarches related to dangers of inflight icing can be found bellow:
https://www.skybrary.aero/bookshelf/books/659.pdf
https://ntrs.nasa.gov/citations/19930005642

2.4 Analysis of meteorological situation in the area of flight

From the above meteorological data, we can see that the weather situation was marginal to conduct a flight with concerned aircraft type at planned flight altitudes and flight path. Undoubtedly icing conditions were present in the wider area (already upon entering Slovenian airspace), which was directly confirmed by the crew of an airliner in communication with Slovenian ATC. N710CC was, during flight in Slovenian airspace, avoiding dangerous weather phenomena. At first pilot was informing and coordinating avoiding actions with ATC. Later in the chain of events when pilot started uncoordinated avoiding in lateral and vertical path, he was warned by ATC. Initially pilot of N710CC complied in a natural manner. Communication was never interrupted, until after distress call.

Considering, that the SIGMET was posted at 9:23 and the airplane took-off from Venice at 10:16, there is a great possibility that the pilot came across meteorological data in flight planning phase and filed a flight plan in a way to avoid adverse weather area. From communication between airplane and ATC it can be seen, that the pilot was avoiding weather phenomena (but it was hard for him to say how deep inside the weather mass he was located).

2.5 Analysis of aircraft mass

According to the available data, the airplane was never heavier than mass limitations stated in AFM. Until the moment of entering into the icing conditions, the aircraft mass and balance were within limits. According to AFM Limitations, Basic empty mass is 1033 kg. Maximum ramp mass is 1640 kg and Maximum take-off mass is 1633 kg.

From the above we can see, that the available underload on the Basic mass is 600 kg.

Pilot, a day before accident, took-off from Venice Marco Polo – LIPZ airport to relocate to Padova – LIPU airport where he uplifted fuel for the next day return flight. According to provided data, from the airport authorities, he uplifted (on 13^{TH} July 2020 at 14:50) 225 liters of fuel 162 kg into the main tank.

		NOTE
Basic empty mass	1033 kg	From AFM
Fuel mass	162 kg	- Maximum capacity of fuel is 405 liters (291,6 kg) - NOTE: General calculation 225 liters (at 0,72 kg/l) = 162 kg.
Pax mass	400 kg (approximation)	Standar mass for pax in 1-5 passenger aircraft is 104 kg, actual mass could be used for Mass and Balance calculations.
APPROXIMATE TAKE-OFF MASS	**1595 kg**	

If we calculate average masses of pilot and passengers, baggage and fuel mass before departure from Venice (LIPZ) we can calculate, that total mass was less than maximum allowable take-off mass.

2.6 Type of flight, pilot jurisdictions and jurisdictions of the owner – operator

From gathered statements and available documentation it was established, that pilot was reached by the owner on the telephone a few days before the accident. He received the information, that he needs to transfer a few business associates to Italy and perform a return flight a day later. Pilot did not know the passengers before the flights. In communication between operator and customer details of financial compensation for the flights were stated. Pro-forma invoice mentioned passenger transfer, departure and destination airports and time. Pro-forma invoice was sent to customer and financial transaction type was stated. It is unknown to the Commission weather the actual financial transaction has been made or not, but this is not the goal of the investigation.

From the above the Commission deducts, that this was a charter flight. In the scope of this it must be stressed, that point FCL.010 Appendix I to Commission Regulation (EU) No. 1178/2011 defines „commercial air transport“ as transfer of passenger, cargo or mail for remuneration or hire.

From examination of pilot documents and in the scope of Commission Regulation (EU) No. 1178/2011 — Appendix I, point FCL.065(b) we can conclude, that pilots who possess commercial pilot licence and are older than 65, must not act as pilot of aircraft involved in international commercial air transport.

Part MED[7] of the regulation (medical criteria for pilots) does not specifically limit criteria – or pilot certification according to age, if they satisfy the criteria for Medical class 1, but Article FCL.065 reduces privileges of pilots aged 60 years or more, who operate in commercial air transport (FCL.065(b). From this we can see, that the owner of pilot licence, who completed 65 years cannot operate as pilot on international commercial flights.

After the examination of airplane documents and operator documentation we concluded, that N710CC, according to FAA Register information, was used as corporate aircraft.

Aircraft registered in USA, would in case of conducting commercial operation inside EU, need the EASA approval for commercial and non-commercial operations carrying passengers and cargo.

[7] EASA Part MED

EASA[8] has for general aviation aircraft established technical rules for flight operations (such as CAT, NCC, NCO, SPO), taking into account the principle of proportion and different safety levels.

2.7 Analysis of colour traces on the horizontal stabilizer

Commission has after recovery of horizontal stabilizer made a visual check and requested detailed analysis of questionable colour traces, present on the upper layer of both recovered parts. NFL GPU performed the examination. According to NFL request the results are published in Slovenian language in full form. From the analysis of the samples, it was determined, that there was no difference in chemical composition of questionable scratches and that they are originating from the aircraft involved in the accident. Traces did not result from impact of a foreign object, but from impacts with other parts of aircraft structure upon disintegration of horizontal stabilizer.

Report from NFL is in Slovenian language and is available at SIA headquarters in Ljubljana.

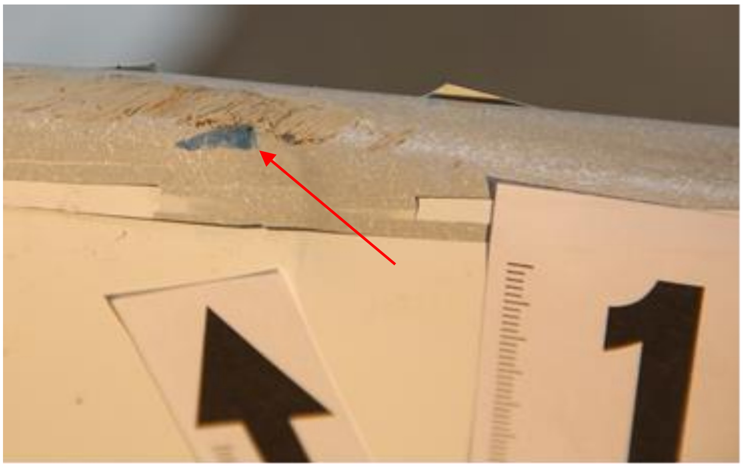


Image 22: Documenting of questionable scratches – colour traces

[8] https://www.easa.europa.eu/domains/general-aviation/operations-general-aviation

Image 23: Check and sampling

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3. CONCLUSIONS

The sole objective of the investigation is the prevention of future accidents and incidents. It is not the purpose of the final report to apportion blame or liability. Using this report in any other intent may lead to wrong interpretation.

3.1 Findings

1. Pilot held a valid licence and ratings to conduct flight under VFR and IFR in concerned type of the aircraft; pilot had enough experience (in both VFR and IFR) and was continuously performing flight activities.

2. Pilot held a valid Medical Certificate Class 1 valid until 8^{TH} January 2017.

3. Investigation concludes that pilot medical conditions did not influence the accident. All toxicologic test results were negative.

4. According to the limitations in pilot licence, the pilot after the age of 65 shall not operate in commercial air transport. If the flight was considered commercial, the pilot was not allowed to execute it.

5. Aircraft was operated in accordance with FAA, 14 Part 91 CFR state of registry and basic rules for operation and flight execution. Aircraft maintenance was conducted according to Part 43. Usage of this regulations is allowed, when the aircraft is privately used. Operator did not possess any EASA approvals for commercial operations inside EU, so operation of such nature is not conducted according EASA safety standards.

6. ATC monitored the trajectory of N710CC and altitude. ATC waned the pilot about a few deviations; pilot responded to ATC and was correcting the elements of flight.

7. Meteorological conditions (in flight icing) at the time of the accident were not suitable for the aircraft type. Airliner operating in close proximity after the accident reported moderate icing. Weather contributed to the accident.

8. Quantity and availability of Oxygen for crew and passengers is not known to the Commission. Installation with oxygen bottle has been recovered at the crash site, but state of the bottle precluded determination of oxygen pressure inside it. As the flight was planned above FL100 (10000 feet) for a longer period, Hypoxia could not be excluded as contributing factor which would influence pilot performances and decision-making.

9. In the examination of crash site, it was determined, that engine and propeller did not contribute to the accident. Flight control system was operating normally until icing conditions prevailed. After the ice accumulation on tail surfaces, flutter occurred and structural failure resulted. This chain of events contributed to the outcome of the accident.

10. Immediately after entering Slovenian airspace the pilot decided to change direction of flight. Commission concluded, that pilot’s decision at »RIFEN« could be made because he thought that he already overflew the majority of adverse weather conditions.

11. Last radar contact (SSR) with the aircraft was at 10:52:10.

3.2 Other information and factors contributing to the accident

In the initial phase of accident investigation SIA was informed about ongoing criminal investigation, which was conducted by judicial authorities and was related to criminal activity of persons who were passengers on the accident flight. Activities involves act of fraud that happened before the departure from Venice. If any criminal activity would be detected by SIA during the accident investigation, SIA would inform the judicial authorities according regulations.

In the process of investigation and after the analysis of horizontal stabilizer (ZAG and NFL reports) the Commission concludes that this accident did not include criminal acts.

Having in mind that the pilot had years of experience with flying in instrument meteorological conditions and that he continuously flew on light aircraft the Commission in long lasting investigation searched for signs of pressure on pilot that would induce stress and would influence pilot’s decision making in connection to lateral deviation request »Direct Klagenfurt« which brought the aircraft in more adverse weather conditions. Reliable indications of existance of such influences could not be confirmed. Despite this, the Commission cannot exclude the influence of suppose criminal activity of passengers prior to flight.

After reviewing flight plan, we can determine that pilot was aware of the danger of adverse weather over the Alps and according to this he planned to fly more to the East towards central Slovenia. Flight was supposed to take place at the altitude 12000 feet and after overflying the FIR boundary the flight would turn towards DOL VOR. This would enable the aircraft to gain height for overflying the Northern part of Slovenian Alps and flight would successfully deviate from adverse weather in Western Slovenia.

Initially the pilot was deviating adverse weather (inside Italian and Slovenian airspace), but since the clouds formed in layers and high temperatures were present on the ground, the pilot did not expect icing of so high intensity.

When the ice started to accumulate on the aircraft structure (pilot probably coould see ice accumulation on wings, windshield and extremities). Intensity of accumulation, shape and colour or transparency of ice depends on local meteorological conditions. Pilot decided to increase altitude as one of possible correcting actions in case of flight into unknown icing conditions. The airplane has with great certainty come into a layer with no clouds, but as the OAT at this altitude was already bellow 0 degrees C and taking into account rain showers (supercooled liquid water droplets near thunderstorm) the conditions get even worse. Airplane has without ATC being notified, gained 500 feet, most probably this was a corrective action for reducing effects of accumulated ice. When ATC warned the pilot about the deviation, the pilot informed the ATC that he is experiencing inflight icing and requested to stay at this altitude for some period.

The pilot continued the flight towards North-west, which broth him to the edge of cloud mass of stronger vertical activity, moderate showers and moderate icing. Avoiding action was not coordinated with ATC and was probably accomplished as visual avoiding of towering clouds.

Despite the proximity of thunderstorm which the pilot was avoiding, the pilot after ATC made complaint about deviation, discontinued the avoiding and turned towards North-east (towards the thunderstorm). At first the manoeuvre started with descent which was noticed by ATC and pilot was warned about minimum altitude, which was 12000 feet for that portion of flight.

As the flight progressed small changes of vertical speed were present (alternating values). As the airplane was most probably for 10 minutes in conditions of moderate icing, flight controls were also most probably frozen.

If the pilot tried to move the elevator and same was frozen, he probably used extensive force. When he was successful in his attempt, the elevator came into airstream, but due to mass imbalance as the result of ice accumulation and this induced flutter bellow v_{NE}, above which the flutter is more certain to exist.

If in this turn the pilot also tried to move frozen rudder, this resulted in the structural failure of the rudder fin which was horizontally sheared off. This part of rudder was never found and was probably the first to be torn off the aircraft structure.

Combination of mass imbalance of flight controls (horizontal and lateral) induced flutter and made space for increased loads on flight control surfaces, which resaukted in loss of control in flight.

Weather was worse towards North-west with cloud tops at 28000 feet.

The pilot entered an area of known icing condition and this prohibited according AFM. The manufacturer did not provide any instructions for procedures of encountering infight icing conditions. Procedures used in such situation include direction or altitude chane, to enable us to leave icing conditions as soon as possible. If inflight icing continues, ATC must be informed and if necessary and distress call transmitted. Pilot failed to do this nor did he try to obtain meteorological data from ATC or local traffic in the area.

Due to structural failure of tail surfaces, control over the aircraft was lost and as a result the airplane impacted the terrain.

3.3 Causes

- ***Indirect cause***
  - Impact of the aircraft with the terrain as a result of loss of control due to structural failure of the horizontal stabilizer in flight, which failed due to onset of flutter during change of flight elements in the area of unstable weather conditions and moderate icing.
- ***Direct cause***
  - Pilot decision to deviate from planned flight which resulted in the entry of adverse weather area with moderate icing.

4. SAFETY RECOMENDATIONS

After completing the investigation, the Commission concludes that certain National Aviation Authorities within the EU are facing illegal activities connected to performing “commercial flights” on light aircraft (General aviation), especially on aircraft registered outside EU member states. Between commercial flights for remuneration and flights with cost sharing a thin line exists and passengers flying onboard light aircraft should be made aware and informed about their rights. Such activities should also promote flight safety and protect the rights of licenced crew.

From the time of the accident and after exchange of information between EASA, European CAAs and Safety Investigation Authorities, EASA already introduced a few safety measures:

In 2017 EASA published “EASA Leaflet 02” (and updated in 2018) on European rules (Commission Regulation (EU) No 965/2012) for non-commercial air operations with airplanes and helicopters, which came into effect on 26TH August 2016.

In 2017 EASA published a “Charter to promote the safety of non-commercial General Aviation flights whith light aircraft by flight-sharing companies”.

Investigation body issues (in the interest of unification of common rules, promotion of passenger rights protection and control of flight activities) to EASA the following Safety recommendation:

No. SI-SR009-2020 **EASA – EASA member states should conduct coordinated activities, via national aviation authorities on yearly basis, with the goal of pointing out and increasing awearness about differences between criteria for flight execuition in the categories of commercial and non-commercial flight operations with light aircraft in general aviation category (based on above mentioned activities and content) as as a promotion of flight safety.**

The investigation did not reveal any deviations in ATC activities. From the time when N710CC entered Slovenian airspace, the controller constantly warned the pilot about deviations and issued correct instructions. Despite this, the Commission evaluates that in the interest of expeditious distribution of information on adverse weather (especially inflight icing), technical solutions which would provide automatic presentation of synchronised weather information on ATC working station radar display presentation. Investigation body issues the following Safety recommendation to Slovenia Control:

No. SI-SR010-2020

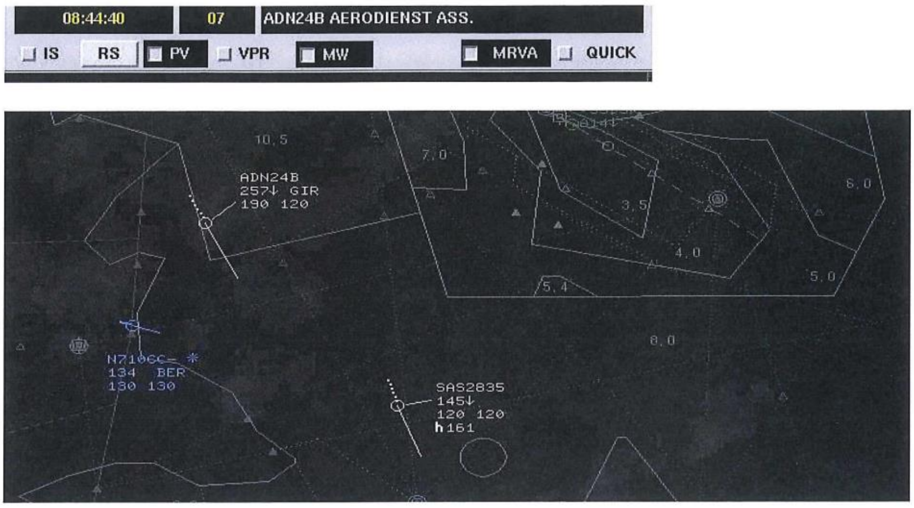
The provider of air navigation services (Slovenia Control) should evaluate the technical possibilities to provide generation of automatic warnings about dangerous weather phenomena on the displays of working stations of the air traffic controller.

APPENDICES

APPENDIX 1 SSR image of aircraft entering the Slovenian airspace

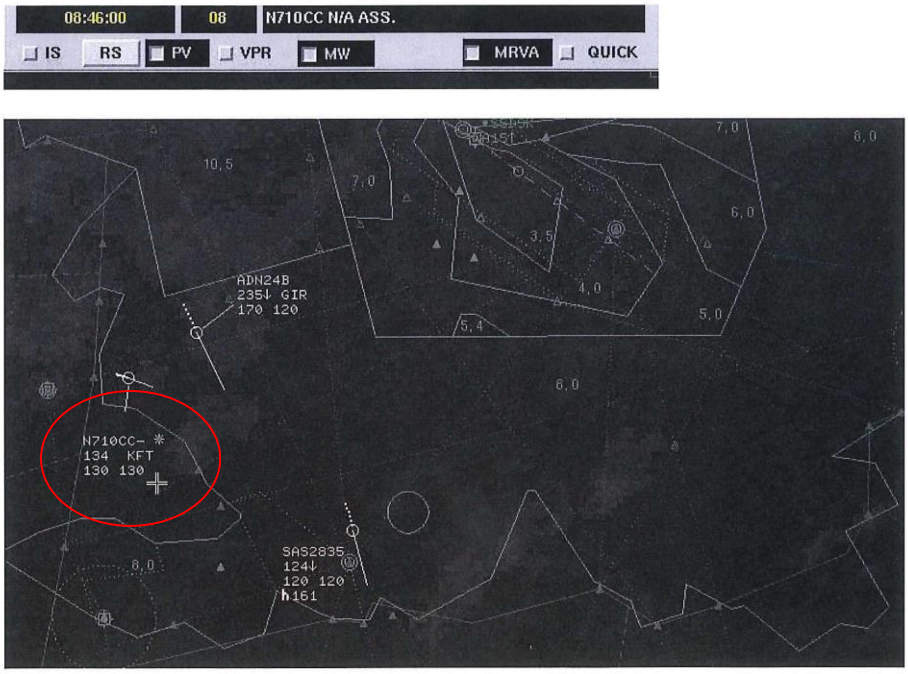
ČAS 08:44:40 UTC

N710CC vstop v FIR Ljubljana preko točke RIFEN na višini FL134 (13400 čevljev).



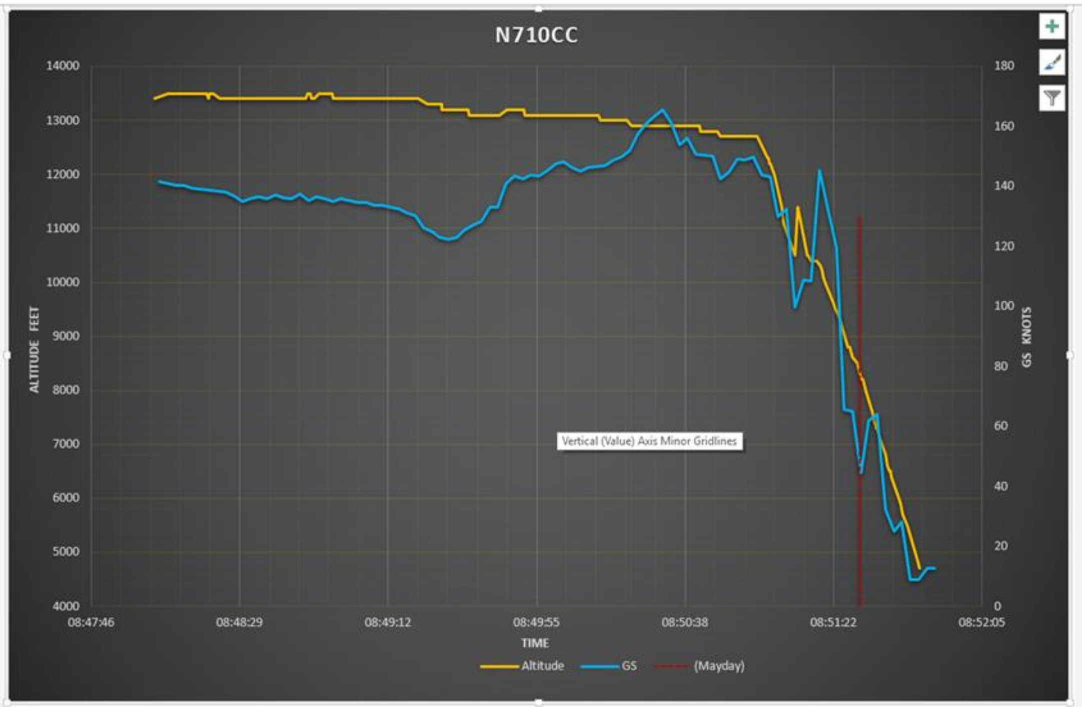
ČAS 08:46:00 UTC

N710CC v FIR Ljubljana na višini FL134 (13400 čevljev). Vzpostavljena glasovna komunikacija s kontrolo zračnega prometa. Izogibanje vplivom vremena.



2

APPENDIX 2 Flight elements before the accident (according to radar data)



NOTE:

- ALTITUDE – marked yellow
- GS – ground speed in knots – marked blue
- MAYDAY – time of distress call – red line

APPENDIX 3 FAA Registry printout

25. 5. 2020 FAA Registry - Aircraft - N-Number Inquiry

FAA REGISTRY
N-Number Inquiry Results

N710CC has Reserved/Multiple Records

Reserved N-Number

Type Reservation	Hold
Mode S Code	52276102
Reserved Date	09/13/2018
Renewal Date	None
Purge Date	09/13/2023
Pending Number Change	None
Date Change Authorized	None
Reserving Party Name	CANCELLED/NOT ASSIGNED
Street	None
City	None
State	
Zip Code	None
County	
Country	

Deregistered Aircraft

Deregistered Aircraft 1 of 1

Aircraft Description

Serial Number	3257358	**Certificate Issue Date**	04/17/2015
Manufacturer Name	PIPER	**Mode S Code (base 8 / oct)**	52276102
Model	PA-32R-301T	**Mode S Code (base 16 / hex)**	A97C42
Year Manufacturer	2004	**Cancel Date**	09/13/2018
Reason for Cancellation	Expiration	**Export To**	None
Type Registration	Corporation		

25. 5. 2020 FAA Registry - Aircraft - N-Number Inquiry

Aircraft Registration prior to Deregistration

Name	KUERTZ ENTERPRISE LTD		
Street	3511 SILVERSIDE RD STE 105		
City	WILMINGTON		
State	DELAWARE	**Zip Code**	19810-4902
County	NEW CASTLE		
Country	UNITED STATES		

Deregistered Airworthiness

Engine Manufacturer	LYCOMING	**Classification**	Standard
Engine Model	41569	**Category**	None
A/W Date	06/24/2004	**Exception Code**	No

Deregistered Other Owner Names

None

FAA REGISTRY
N-Number Inquiry Results

N710CC has Reserved/Multiple Records

Deregistered Aircraft			
Deregistered Aircraft 1 of 1			
Aircraft Description			
Serial Number	3257358	**Certificate Issue Date**	04/17/2015
Manufacturer Name	PIPER	**Mode S Code (base 8 / oct)**	52276102
Model	PA-32R-301T	**Mode S Code (base 16 / hex)**	A97C42
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Aircraft Registration prior to Deregistration			
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County	NEW CASTLE		
Country	UNITED STATES		
Deregistered Airworthiness			
Engine Manufacturer	LYCOMING	**Classification**	Standard
Engine Model	41569	**Category**	None
A/W Date	06/24/2004	**Exception Code**	No
Deregistered Other Owner Names			
None			

APPENDIX 4 HARDNESS MEASUREMENTS FROM "THE ANALYSIS OF THE HORIZONTAL STABILIZER" - ZAG

The results of Vickers hardness measurements

The measurements of hardness according to Vickers HV 1 (at a compressive load of 9.8 N) were made at the intersection of the broken longitudinal wing profile, wing profile stiffener and on skin plates on the metallographic specimens. In EN 485-2: 2016, Brinell hardness is given. The standard also provides for hardness measurements according to Vickers, where it is not possible to measure the hardness of Brinell. The thickness of the cross-section of the plates are too small to perform the Brinell hardness measurements.

Table 1: Results of HV hardness measurements. Longitudinal wing profile - (right wing, upper flange - longitudinal cross-section (sample 1), near the radius between the upper flange in the web (sample 2), both samples near the fracture surface to a distance of 23 mm from the fracture). The cross sections are indicated in Figure 63.

Sample	**Hardness HV**													
Distance from the fracture [mm]	0,1	0,5	1,0	2,5	3,0	4,0	5,0	6,0	7,0	8,0	20	21	22	23
1 – wing profile	142,7	154,7	152,2	147,1	148,3	154,4	151,6	144,2	144,1	141,7	139,0	139,8	154,0	142,1
2 – wing profile	163,6	158,0	152,7	153,3	157,3	155,7	157,1	157,0	155,1	157,0	158,6	149,7	150,3	152,6

Due to cold deformation, the hardness of the material of the longitudinal profile increased only in the immediate vicinity of the fracture on both samples. On the sample 2 (bent part of the longitudinal profile), the hardness is higher throughout the length due to the influence of the deformation in the manufacture of the profile. For this reason we measured the hardness of the material of the longitudinal profile in the transverse direction (see results in the table below).

Table 2: Results of HV hardness measurements. Longitudinal profile (right wing, upper flange - plane section, transverse cross-section), at a distance of about 80 mm from the fracture.

Location:	**Plane section – hardness HV**			**Radius cross-section – hardness HV**			
3V – **wing profile**	134,8	139,6	140,7	156,7	151,1	155,7	157,0

The hardness of the material of the longitudinal profile is higher in the area of the cold-shaped radius. On a flat section of the profile (flange), the hardness is between 135 and 140 HV (from 128 to 133 HB), and between 150 and 157 HV (143 to 148 HB) on a radius that was made by cold transformation. At a distance of about 80 mm from the fracture, the hardness is not increased due to deformations that may have been caused by alternating (reverse) bending prior to final failure.

Table 3: Results of HV hardness measurements. Longitudinal profile and wing profile stiffener next to it (right wing, upper flange (plane section) - longitudinal cross-section) - at a distance from 60 to 64 mm and from 280 to 284 mm from the fracture.

Sample	Hardness HV									
Distance from the fracture [mm]	60	61	62	63	64	280	281	282	283	284
3 – wing profile	139,5	141,5	138,8	134,9	136,9	-	-	-	-	
3A - wing profile stiffener	142,0	142,2	141,0	139,8	139,6	-	-	-	-	-
4 — wing profile	-	-	-	-	-	138,9	138,8	135,0	139,0	138,3
4A - wing profile stiffener	-	-	-	-	-	142,2	144,7	146,3	140,2	136,4

There is no apparent increase in hardness at any distance from the fracture site. Minor fluctuations in the measured values are mainly due to slightly different crystal grains in the alloy. The hardness of the wing spar stiffener is slightly higher than the hardness of the longitudinal wing profile.

Table 4: Results of HV hardness measurements. Hardness measurements near to the fracture on the front panel (skin) of the right wing (above and below - the places C and D, marked in Figure 12)

Sample	Hardness HV									
Distance from the fracture [mm]	0,1	0,5	1,0	2,5	3,0	10,0	11,0	12,0	13,0	14,0
C- top	158,2	146,8	143,1	143,0	144,2	146,8	144,2	136,9	136,2	137,5
D - bottom	158,7	168,1	148,8	144,5	140,5	138,6	138,8	132,9	134,3	135,6

The hardness of the material of the front panel, due to cold deformation, increased only in the immediate vicinity of the fracture on both samples.

Table 5: Results of HV hardness measurements. Hardness measurements near to the fracture on the middle plate of the right wing (back side of the plate, top side of the wing, place B with two fractures, indicated in Figure 12). The cross-sections are made in the longitudinal direction of the sheet at a distance of about 10 mm from the rivets.

Sample	Hardness HV									
Distance from the fracture [mm]	0,1	0,5	1,0	2,5	3,0	10,0	11,0	12,0	13,0	14,0
B 1 – top side	159,0	160,2	145,4	149,6	149,1	139,0	140,4	137,8	137,1	143,3
B 2 – top side	171,4	168,9	162,5	156,3	146,7	141,2	140,4	135,7	135,4	136,9

The hardness of the material of the middle plate increased due to cold deformation only in the immediate vicinity of the fracture on both samples.

3.4 Results of the chemical analysis

Table 6: Results of chemical analysis of aluminium parts (longitudinal wing profile, wing profile stiffener and skin plates). All sheets were removed from the right wing in addition to locations for other investigations. The results are given in weight %.

Vzorec	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	V	Ti	Al
wing spar	0,0505	0,111	4,51	0,591	1,53	0,0026	0,0081	0,0179	0,0065	0,0380	93,1
spar stiffener	0,0423	0,149	4,27	0,611	1,49	0,0018	0,0087	0,0121	0,0080	0,0332	93,3
front plate	0,0610	0,166	4,31	0,611	1,48	0,0041	0,0066	0,0612	0,0060	0,0350	93,2
middle plate	0,0672	0,162	4,25	0,610	1,36	0,0052	0,0068	0,0526	0,0065	0.0345	93,4

Table 7: The prescribed chemical composition for the qualities EN-AW-2024 and EN-AW-2124 according to standard EN573-3: 2004[5], given in weight %.

Quality	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	V	Ti	Al
EN-AW-2024	0,50	0,50	3,8 – 4,9	0,30 – 0,90	1,2 – 1,8	0,10	-	0,25	-	0,15	remainder
EN-AW-2124	0,20	0,30	3,8 – 4,9	0,30 – 0,90	1,2 – 1,8	0,10	-	0,25	-	0,15	remainder

Note: Both qualities are equivalent to Alloy 2024, Alloy 2124, Al Cu4Mg1, Al Cu4Mg1(A), which are used by different standards[13].
All tested samples of the horizontal stabilizer sheets in terms of chemical composition satisfies the requirements for the quality EN-AW-2024 as well as the quality of EN-AW-2124 (quality of higher purity).

3.5 Results of tensile test

Table 8: Results of the tensile test in accordance with the standard EN ISO 6892-1:2017[3]

ZAG identification No., thickness	Sheet, location	Yield strength $Rp_{0,2}$ [MPa]	Tensile strength Rm [MPa]	Elongation A_{50} [%]	Ratio $Rp_{0,2}/Rm$ [%]
Z/1886-1/17, 0.815 mm	Front plate, near the fracture	318	422	16,8	75,35
Z/1886-2/17, 0.815 mm	Front plate, 108 cm from the beginning of the plate by the hull	324	426	15,2	76,16
Z/1886-3/17, 1.57 mm	Longitudinal profile, near the fracture	320	441	17,9	72,61

Table 9: The prescribed minimum mechanical properties according to the standard EN 485-2: 2016 for the quality EN-AW-2024 with different processes of heat and other treatment:

Heat treatment (Temper)	Yield strength $Rp_{0,2}$ [MPa]	Tensile strength Rm [MPa]	Elongation A_{50} [%]	Harhness Brinell HBS
T4	275	425	12	120
T3, T351	290	435	12 (14)	123

The mechanical properties of the 0.815 mm thick sheets (the front plate of the wing) correspond to the prescribed properties for the quality EN-AW-2024 T4, and the mechanical properties of the of the longitudinal profile (thickness 1.57 mm) also correspond to the properties with the T3 and T351 treatments. The ratio $Rp_{0.2}$ / R_m is appropriate, there is no increase in the yield strength ($Rp_{0.2}$) and a reduction in elongation (A_{50}), which could result from the classical dynamic fatigue of the material.

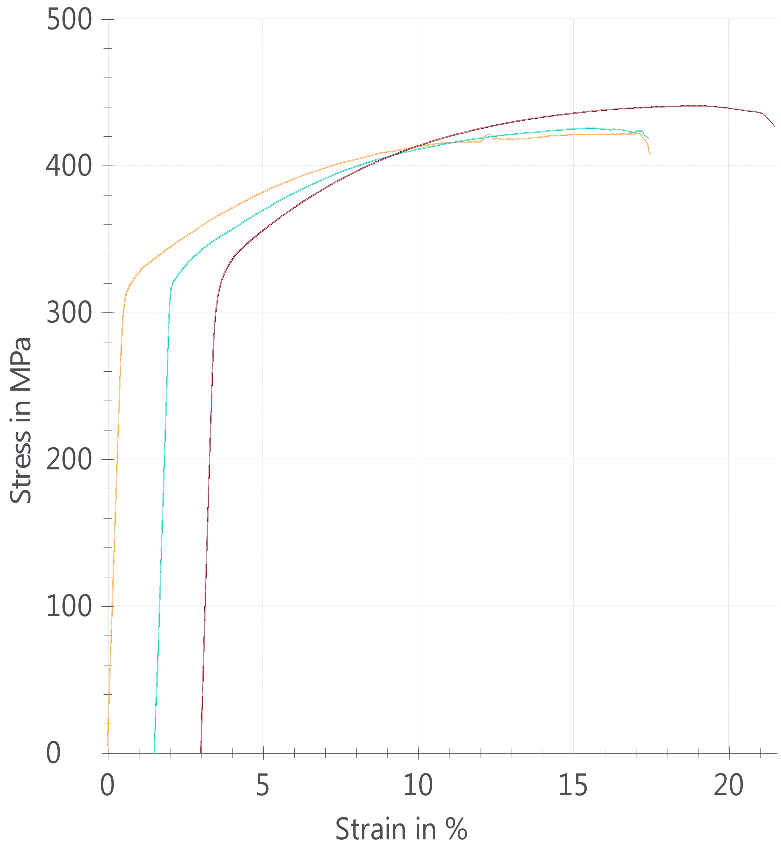


Figure 155: Serial graphs strees/elongation (from left to right samples: Z/1886-1/17, Z/1886-1/17 in Z/1886-1/17).

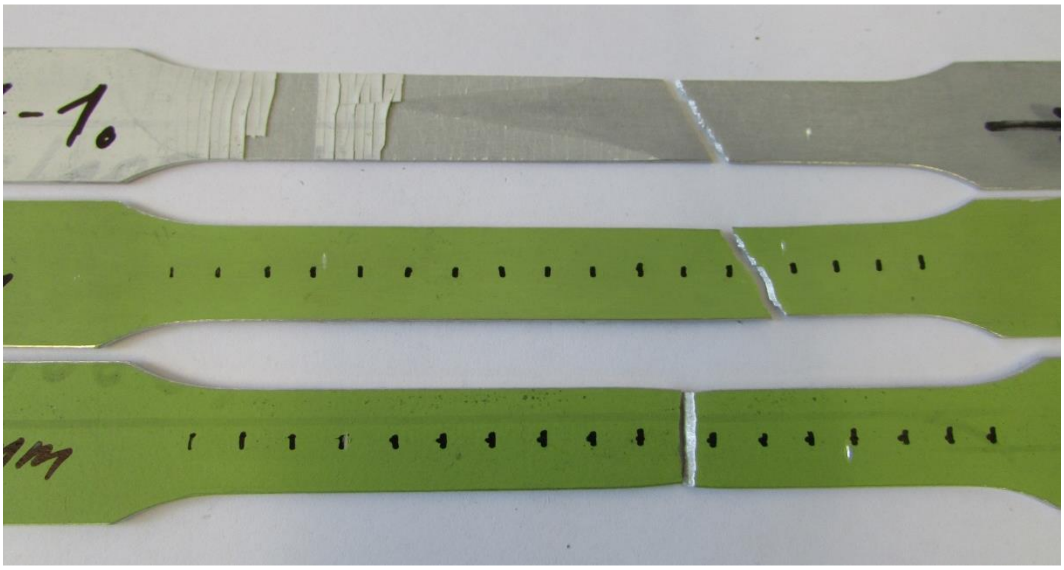


Figure 156: Tensile test pieces after tensile test. IMG-5667

4. CONCLUSIONS

A visual inspection of all the fracture surfaces of all metal plates (skin) and longitudinal horizontal stabilizer profile was carried out on the wreckage of the tail of the fuselage of the demolished aircraft and the wreckage of the horizontal stabilizer. We have not found anywhere "old" - fatigue cracks and no features of classic fatigue fracture. All sheets near the broken surfaces are plastic deformed. Most of the fracture surfaces and their surroundings have the characteristics of a relatively ductile and tough fracture. The fractures are consequence due to a few alternating (reverse) bending loads, in which the stress exceeded the yield strength of the material. In the vicinity of the fractures, the sheets are deformed in several directions. No corrosion or other mechanical damages were found in the fracture areas, which could represent the initial sites for the formation of fatigue cracks, or reduce the load capacity of the structural elements or the whole structure of the horizontal stabilizer.

All tested samples of the horizontal stabilizer sheets in terms of chemical composition satisfies the requirements for the quality EN-AW-2024 as well as the quality of EN-AW-2124 (quality of higher purity).

The microstructure of all tested metal samples of three different dimensions is completely conventional for sheet made of alloy EN-AW-2024 (or also EN-AW-2024), which is heat-treated, cold-formed and aged (Temper T3 or T4). It consists of various precipitates of intermetallic compounds of alloying and other elements dispersed by crystall grains α. A thin layer of aluminum alloy with a higher corrosion resistance is claded to the surface of both sides of the sheets ("Alclad").

In examining the cross sections at the points of fracture and their vicinity, we found the following: depending on the shape of the fracture and the contraction in the fracture area, it can be concluded that the fractures are the result of repeated overloads (alternating bending loads in which the yield strength of the metal was exceed). The shape of the fractures are also characteristic of a combination of bending and tensile loads. The breaks are tough, ductile. In the case of classical fatigue, there would be no contraction in the immediate vicinity of the fracture surfaces. The microstructure is in the vicinity of the fractures deformed in the direction of the load. We have not found any microstructure faults that could in any way affect the deterioration of the properties of the material.

The mechanical properties of the 0.815 mm thick sheets (front plate of the wing) correspond to the prescribed properties for the quality EN-AW-2024 T4. The results of the mechanical investigations are slightly "better" on the sample, which was cut out of the site near the site of the fracture. The differences are very small and are within the scope of measurement uncertainty. The mechanical properties of the of the longitudinal profile (thickness 1.57 mm) also correspond to the properties with the T3 and T351 treatments. The ratio $Rp_{0.2}$ / R_m is appropriate, there is no increase in the yield strength ($Rp_{0.2}$) and a reduction in elongation (A_{50}), which could result from the classical dynamic fatigue of the material.

The hardness of the material of the longitudinal profile and other sheets increases due to cold deformation only in the immediate vicinity of the fractures. The hardness of the material of the longitudinal wing profile is also higher in the area of the cold-shaped radio (due to the manufacturing process).

It can be concluded that the horizontal stabilizer has been disrupted in several successive cycles of alternating bending (in several directions), which is called "low cycle fatigue". The alternating swinging of the horizontal stabilizer is probably consequence of the dynamic aeroelastic phenomenon called the "flutter" [14].

APPENDIX 5 Report on sample examination for N710CC of the National forensic laboratory

only in Slovenian: *Findings (summary) in English are included in Analysis of colour traces on the horizontal stabilizer in the Final report.*

Nacionalni forenzični laboratorij (NFL)

POROČILO O PREISKAVI VZORCEV N710CC

Opis zadeve (dejanja):	Dne 14. 7. 2016 je v bližini kraja Predmeja, občina Ajdovščina, strmoglavilo 6 sedežno letalo Piper. Na kraju so umrli pilot in trije potniki. Dne 13. 10. 2016 so kriminalisti SKP NG skupaj s preiskovalci letalskih nesreč in strokovnjakoma NFL opravili ogled delov letala, ki so bila najdena v iskalni akciji dne 8. 10. 2016. Pri pregledu najdenih delov je bilo opaženih več sledi modre in rdeče barve. Na ogledu so zavarovali primerjalne in sporne vzorce barvnih sledi.
Vrsta preiskave:	primerjalna analiza barv
Podatki o zavarovanem materialu:	- primerjalni vzorci barv (2x) - sporni vzorci barvnih sledi (5x)
Datum prejema v NFL:	19. 10. 2016

Potrebno je bilo opraviti primerjalne preiskave spornih barvnih sledi s primerjalnimi vzorci.

Splošni podatki o preiskavi vzorcev

Preiskave in medsebojne primerjave materiala iz spornih in primerjalnih vzorcev (opis vzorcev, odvzem materiala za analizo, kemijske analize in interpretacija) smo izvedli v skladu z laboratorijskimi postopki za preiskavo barv[i].

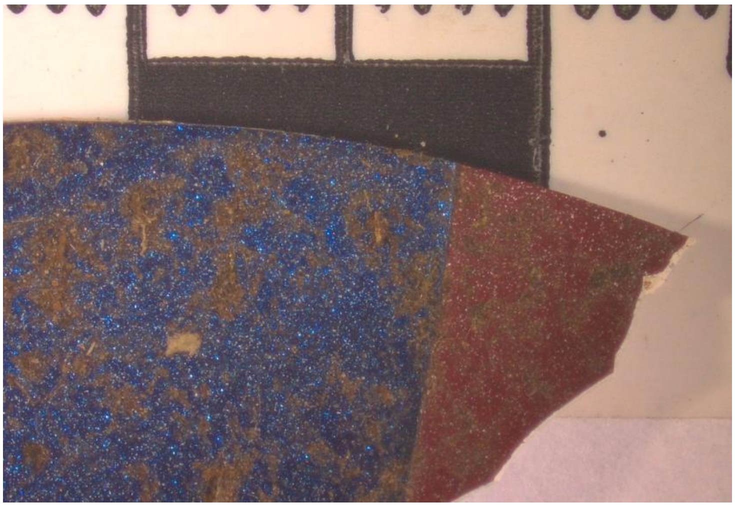
Datum preiskav: 21. 10. 2016 – 7. 11. 2016

Pregled in opis vzorcev

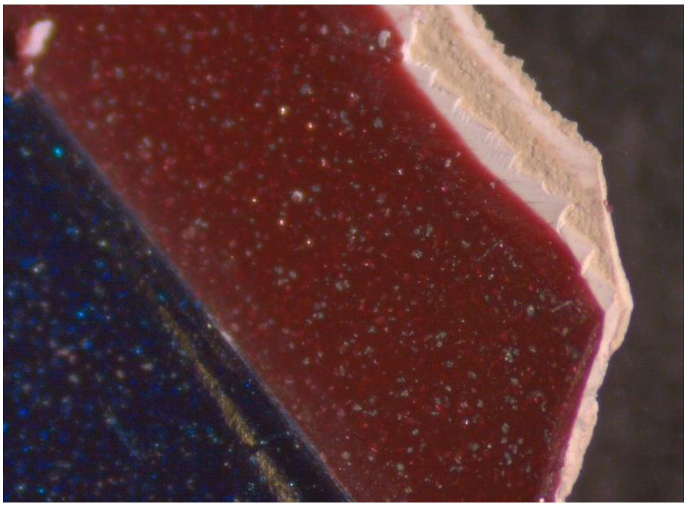
Laboratorijske (NFL) in originalne oznake vzorcev, opis zavarovanega materiala, embalaža in podatki o kraju odvzema so podani v Tabeli 1 in Tabeli 2. Material smo pregledali s prostim očesom in pod stereo mikroskopom. Vsi vzorci so bil zavarovani dne 13. 10. 2016, v hangarju MORS na letališču Brnik.

Tabela 1: Pregled in opis primerjalnih vzorcev

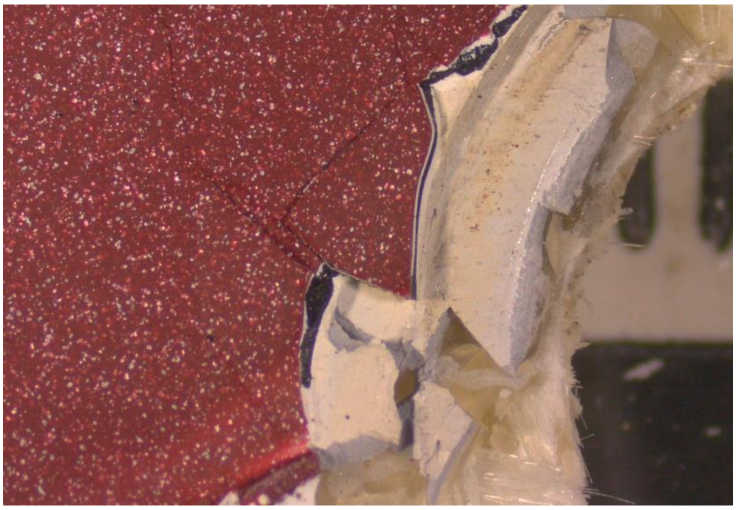
NFL ozn. vz.	orig. ozn. vz.	opis zavarovanega materiala	embalaža zavarovanja	kraj odvzema ali ime osebe, ki ji je bil vzorec odvzet
4	4	3 barvni delčki: delček modre barve, delček modre in rdeče barve ter delček modre, rdeče in bele barve; na njih nečistoče rjave barve od delčka modre in rdeče barve smo ločili manjši del, ga očistili z etanolom; delček ima več barvnih plasti: - modra plast s svetlečimi mikrodelci - rdeča plast s svetlečimi mikrodelci - bela plast - bež plast - bela plast - bež plast (Slika 1 in Slika 2)	pap. vrečka	prednji del ostankov letala
5	5	- 1 večji delček rdeče barve, večplasten (rdeča plast s svetlečimi mikrodelci, bela, črna plast s svetlečimi mikrodelci, bela, siva) - 1 večji delček modre barve, večplasten (modra plast svetlečimi mikrodelci, bela plast, rdeča plast s svetlečimi mikrodelci, bela, siva, rumena) - modri delčki, večplastni (modra plast svetlečimi mikrodelci, bela plast, rdeča plast s svetlečimi mikrodelci, bela plast) (Slika 3 in Slika 4)	pap. vrečka	rep letala



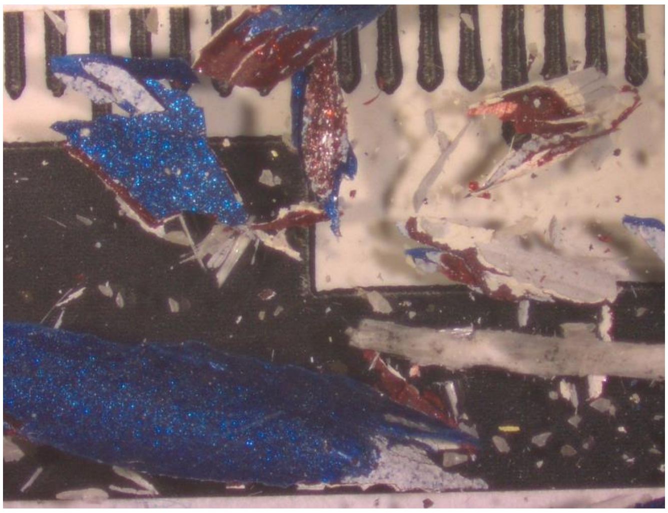
Slika 3: Vzorec št. 4



Slika 4: Vzorec št. 4



Slika 5: Vzorec št. 5

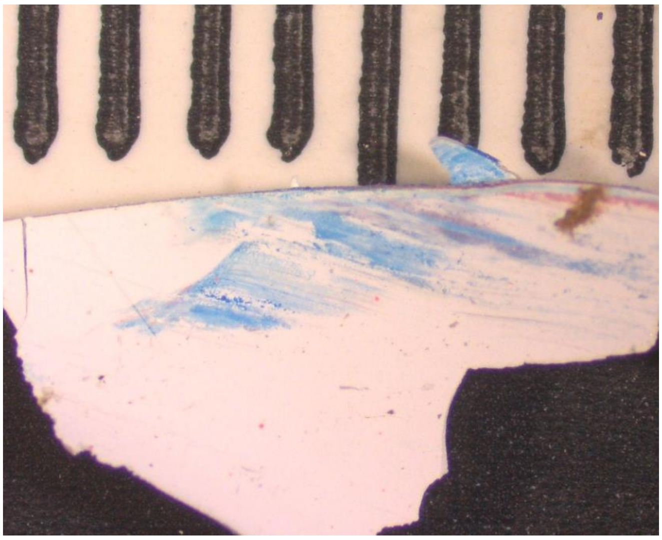


Slika 6: Vzorec št. 5

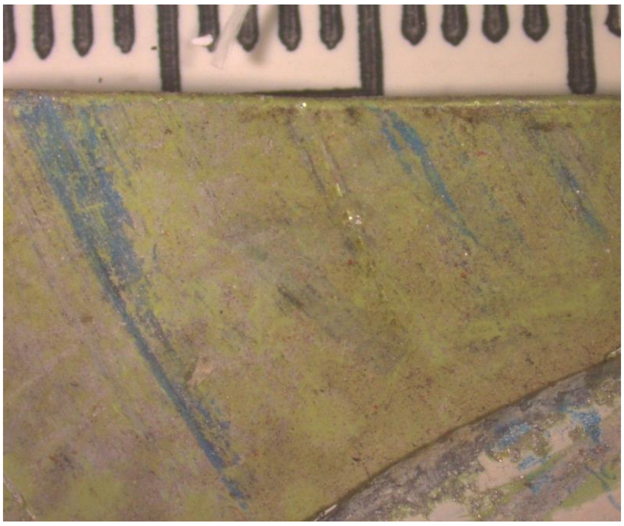
Tabela 2: Pregled in opis spornih vzorcev

NFL ozn. vz.	orig. ozn. vz.	opis zavarovanega materiala	embalaža zavarovanja	kraj odvzema ali ime osebe, ki ji je bil vzorec odvzet
1	1	- delci bele barve, na njih mikrozdrsnine modre barve in rdeče barve - kovinski delček, prebarvan s svetlo zeleno barvo, na njem bela barva in mikrozdrsnine modre barve (Slika 5 in Slika 6)	plastična škatlica	levo višinsko krmilo
2	2	- delci bele barve, na njih	plastična	levo višinsko krmilo

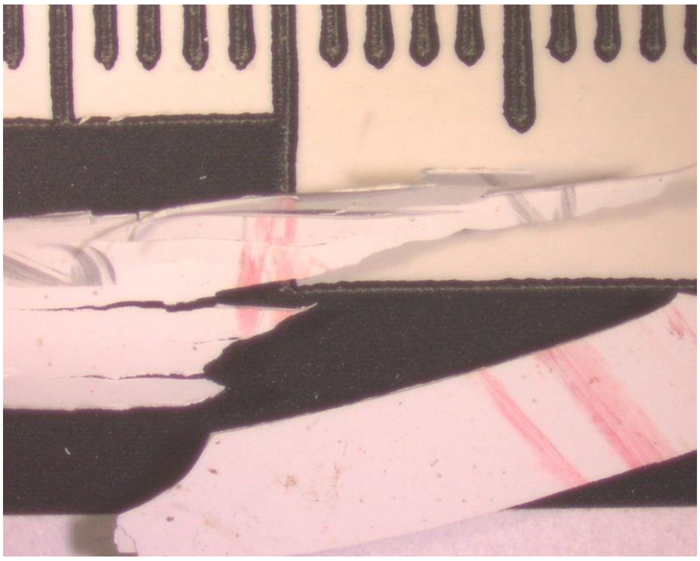
			mikrozdrsnine rdeče in temne barve (Slika 7)	škatlica	
3	3	-	delci bele barve, na njih mikrozdrsnine rdeče barve (Slika 8)	plastična škatlica	levo višinsko krmilo
6	6	-	kovinski delčki, na njih mikrozdsnine modre in sive barve (Slika 9)	plastična škatlica	desno višinsko krmilo
7	7	-	delci bele barve, na njih mikrozdrsnine rdeče in sive barve (Slika 10)	plastična posodica	leva stran letala ob identifikacijski ploščici



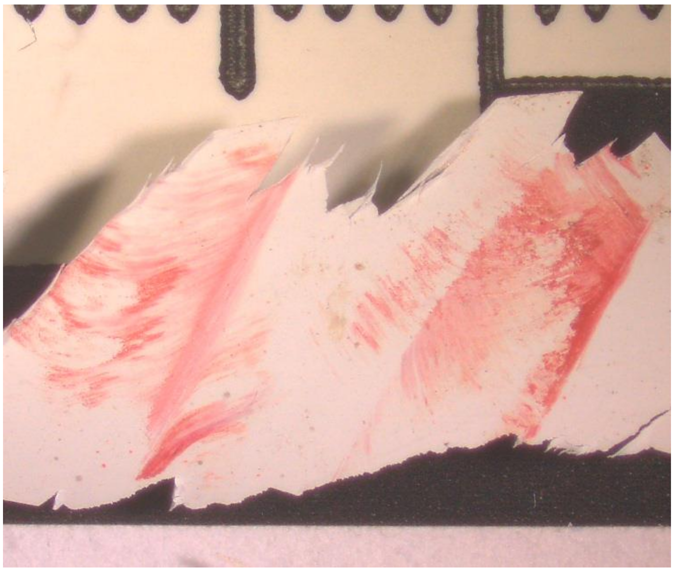
Slika 7: Vzorec št. 1



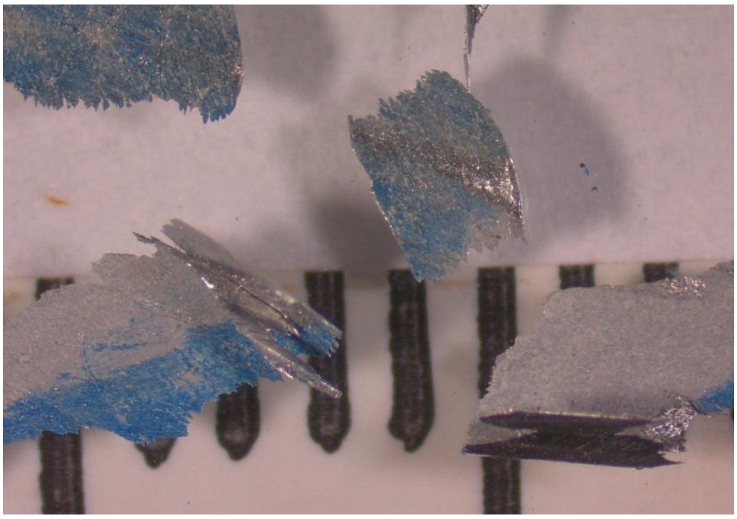
Slika 8: Vzorec št. 1



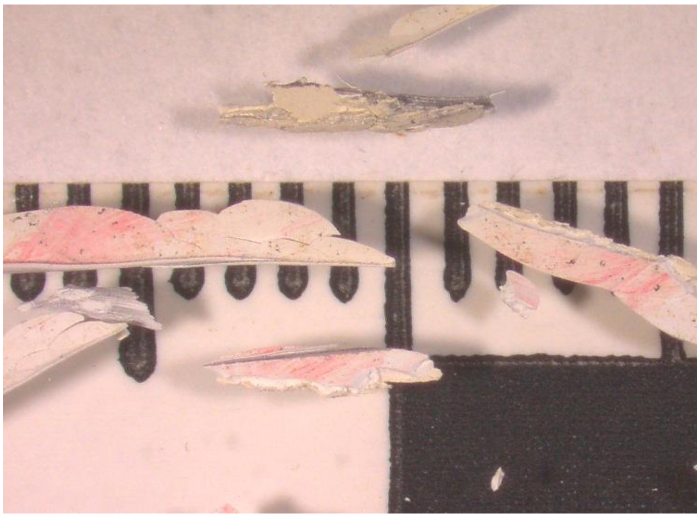
Slika 9: Vzorec št. 2



Slika 10: Vzorec št. 3



Slika 11: Vzorec št. 6



Slika 12: Vzorec št. 7

Izolacija in priprava vzorcev za analizo

Pred inštrumentalno analizo moramo vzorec ustrezno izolirati od podlage in ga pripraviti za analizo.

Pod mikroskopom z uporabo skalpela in/ali drugih pripomočkov ločimo sporno barvno sled od podlage (npr. sporno barvno sled s koščka lesa okenskega okvirja v katerega je bilo vlomljeno) ali pa ločimo posamezne barvne plasti med seboj (npr. večplasten avtomobilski lak). Le s popolno ločbo posamezne barvne plasti lahko dobimo IR spekter, ki ga kasneje uporabimo za primerjalno analizo.

Izolirano barvno plast odložimo na diamantno stekelce, jo prekrijemo z drugim diamantnim stekelcem in jo, v posebnem nastavku z navojem, stisnemo na ustrezno debelino.

Analiza z infrardečim spektrometrom (FTIR) s pomočjo IR mikroskopa

Na osnovi FTIR meritev lahko sklepamo na kemijsko sestavo snovi ali pa snovi samo medsebojno primerjamo. Medsebojno je smiselno primerjati le tiste materiale (plasti) primerjalnih in/ali spornih vzorcev, ki so pri opazovanju s prostim očesom oz. pod mikroskopom videti enakega barvnega odtenka.

V konkretnem primeru smo opravili primerjalne preiskave spornih sledi rdeče in modre barve ter rdeče in modre barve s primerjalnih vzorcev.

IR spektre barv iz preiskovanih vzorcev smo medsebojno primerjali na osnovi ujemanja položaja in intenzitete absorbcijskih vrhov. Primerjavo smo opravili z vizualnim pregledom parov spektrov (na primer: barva spornega vzorca »X« : barva primerjalnega vzorca »Y«).

V Tabeli 3 in v Tabeli 4 so navedeni materiali (barve), ki smo jih analizirali, v Tabeli 5 pa rezultati analiz, oziroma medsebojne primerjave posnetih IR spektrov.

Tabela 3: Analiziran material – primerjalna vzorca

NFL oznaka vzorca	analiziran material
4	- modra barva - rdeča barva - material bele barve - material bež barve
5	- modra barva - rdeča barva

Tabela 4: Analiziran material – sporni vzorci

NFL oznaka vzorca	analiziran material
1	- modre mikrozdrsine - material bele barve (nosilec)
2	- izolacija (in analiza) rdečih mikrozdrsnin ni možna, saj količina spornih zdrsnin ni zadostna
3	- rdeče mikrozdrsine - material bele barve (nosilec)
6	- modre mikrozdrsnine - sive mikrozdrsnine
7	- izolacija (in analiza) rdečih mikrozdrsnin ni možna, saj količina spornih zdrsnin ni zadostna

Tabela 5: Rezultati analiz

NFL oznaka vzorca	medsebojna primerjava IR spektrov
4 in 5	IR spektra modre barve vzorca št. 4 in modre barve vzorca št. 5 imata medsebojno enake karakteristike
4 in 5	IR spektra rdeče barve vzorca št. 4 in rdeče barve vzorca št. 5 imata medsebojno enake karakteristike
1 in 4, 5	IR spekter modrih zdrsnin z vzorca št. 1 ima enake karakteristike kot IR spektri modre barve vzorcev št. 4 in št. 5
3 in 4, 5	IR spekter rdečih zdrsnin z vzorca št. 3 ima enake karakteristike kot IR spektri rdeče barve vzorcev št. 4 in št. 5
6 in 4, 5	IR spekter modrih zdrsnin z vzorca št. 6 ima enake karakteristike kot IR spektri modre barve vzorcev št. 4 in št. 5

Ugotovitve

Z opravljenimi preiskavami nismo ugotovili razlik v kemijski sestavi spornih zdrsnin modre barve z delov letala, zavarovanih dne 13. 10. 2016 v hangarju MORS na letališču Brnik, označena kot vzorec št. 1 (levo višinsko krmilo) in kot vzorec št. 6 (desno višinsko krmilo), in primerjalnih vzorcev modre barve z delov letala, strmoglavljenega dne 14. 7. 2016 v bližini kraja Predmeja, označena kot vzorec št. 4 (prednji del ostankov letala) in kot vzorec št. 5 (rep letala).

Prav tako nismo našli razlik v kemijski sestavi spornih rdečih zdrsnin z vzorca št. 3 (levo višinsko krmilo) in rdečo barvo primerjalnih vzorcev št. 4 in št. 5.

Mnenje

Rezultati kemijskih analiz podpirajo hipotezo, da sporne zdrsnine modre barve z delov letala, ki so bili najdeni v iskalni akciji dne 8. 10. 2016 (vzorec št. 1 in vzorec št. 6) izvirajo iz modre barve delov letala, ki je dne 14. 7. 2016 strmoglavilo v bližini kraja Predmeja, občina Ajdovščina, sporne zdrsnine rdeče barve z najdenega dela (vzorec št. 3) pa imajo izvor v rdeči barvi delov strmoglavljenega letala.