

# FINAL REPORT

from

**Investigation of an aviation accident, carried out on April 20, 2019 by aircraft ZODIAC CH 601, registration marks LZ-ASN, in a demonstration flight over the stadium of the village of Orizari, Plovdiv District**



2020 г.

## **Purpose of this report and level of responsibility**

In accordance with Annex 13 of Chicago Civil Aviation Convention from December 7,1944, Regulation 996 / October 20, 2010 of European Parliament and of Council for Investigation and Prevention of Accidents and Incidents in Civil Aviation and Ordinance No. 13 from January 27, 1999 of MT (last edition from January 22,2016), the purpose of this incident investigation is to identify the reasons which have led to its implementation in order to be eliminated and prevented in the future **without identifying any guilty or responsibility**

## CONTENTS

<b>01. LIST OF ABBREVIATIONS</b> .....	4
1. Introduction .....	5
2. Factual information.....	5
2.1. Flight History .....	5
2.1.1. Flight number and type, the last point of departure and time, and planned destination point	5
<b>2.1.2. Flight preparation and description of the flight</b> .....	5
2.1.3. Location of aviation occurrence .....	6
2.2. Injuries to persons .....	6
2.3. Damage to aircraft.....	6
2.4. Other damages.....	6
2.5. Personnel information: .....	7
2.5.1. Commander .....	7
2.6. Aircraft Information .....	7
2.6.1. Airworthiness Information .....	7
2.6.2. Aircraft characteristics .....	9
2.6.3. Information on the used fuel. ....	<b>Error! Bookmark not defined.</b>
2.7. Meteorological information .....	9
2.8. Navigation systems.....	10
2.9. Communication systems.....	10
2.10. Airdrome information.....	10
2.11. Flight recorders .....	10
2.12. Information about the impact and the debris .....	10
2.13. Medical and pathological information.....	11
2.14. Fire.....	12
2.15. Factors for Survival .....	12
2.16. Testing and research.....	12
3. Analysis.....	14
4. Conclusion.....	15
4.1. Findings .....	15
4.2. Causes.....	16
5. Safety Recommendations:.....	17
APPENDIX 1 .....	18
APPENDIX 2.....	27

**01. LIST OF ABBREVIATIONS**

AO	-Aviation operator;
BAS	- Bulgarian Academy of Sciences;
AS	-Airspace;
A/C	-Aircraft;
DG CAA	-Directorate Generale "Civil Aviation Administration“
SG	- State Gazette;
SE ATC	-State Enterprise "Air Traffic Control";
AC	-Aircraft crew;
RT	- Railway transport;
CAL	-Civil Aviation Law;
AIUAWRT	-Accident Investigation Unit for Air, Water and Rail Transport;
A/F	- Airfield;
O	- Overhaul;
MoI	- Ministry of Interior;
MoT	- Ministry of Transport;
MTITC	- Ministry of Transport, Information Technologies and Communications;
SO	- Start of Operation;
ATS	- Air Traffic Service;
TSO	- Technical Service Organization;
RWY	- Runway;
MP	- Maintenance Program;
FOM	- Flight Operation Manual;
MM	- Maintenance Manual;
USA	- United States of America;
SAAIU	- Specialized Aviation Accident Investigation Unit;
SOP	- Standard Operating Procedures;
p.	- page;
TL	- Technical logbook;
SRS	- Certificate of release to service;
AMD	- Aircraft manufacturer and designer;
ASTM	- American Society for Testing and Materials;
CAA	- Civil Aviation Authorities;
EASA	- European Aviation Safety Agency;
FAA	- Federal Aviation Administration;
ICAO	- International Civil Aviation Organization;
POH	- Pilot-Operating Handbook;
UTC	- Universal coordinated time;

## 1. Introduction

Date and time of this aviation event:

April 20, 2019, 10:11 hrs local time (07:11 h UTC).

Notified:

Directorate AIUAWRT, DG CAA at MTITC of the Republic of Bulgaria, European Commission (EC), International Civil Aviation Organization (ICAO), the European Aviation Safety Agency (EASA), US National Transportation Safety Board (NTSB), Canada's Transportation Safety Board and the Aviation Safety and Analysis Bureau of the Republic of France.

Pursuant to Art. 9 para. 1 from Ordinance No. 13 / January 27, 1999 for investigation of aviation accidents, the event is classified by SAAIU ( at Directorate AIUAWRT of MTITC ) as an aviation accident. The materials about the event are filed in case No 02/April 20, 2019 in the archives of SAAIU.

Pursuant to Art. 5, para. 1 of Regulation (EC) No 996 / October 20, 2010 about investigation and prevention from accidents and incidents in civil aviation, Art. 142 para. 2 of CAL from December 01, 1972, Art. 10, para. 1 of Ordinance No 13 of the Ministry of Transport from January 27, 1999 for investigating aviation accidents, with Order № RD-08 -244/May 17, 2019 of the head of AIUAWRT at MTITC a Commission to investigate the aviation accident is appointed.

The difference between local and universal coordinated time is +3 h. All times in the report are local time.

On April 20, 2019, a ZODIAC CH 601 aircraft, registration plates LZ-ASN, performs a demonstration flight over the stadium of Orizari village, Plovdiv district, upon the opening of a radio-controlled drones competition. At about 10:11 hrs, the plane flies over in a horizontal flight, at an altitude of about 10 m above the stadium, and begins climbing. The left wing detaches from the body of the aircraft. It rotates to the left around its longitudinal axis, flies at about 100 m, hits trees and falls on the right bank of the Maritza River. When hit on the ground, PIC and a passenger aboard die. The plane is completely destroyed.

The Safety Investigation Commission accepts as a major reason for the occurrence of this aviation accident excessive operational overload, a result of an aircraft piloting technology breach at a balance near the maximal rear limit and a breach of flying at safety altitude rules, and above settlements by the piloting pilot.

## 2. Factual information

The factual background information on the flight history, its preparation and execution, as well as the occurrence of the aviation event itself, was obtained by the Commission from interviews and written evidence from witnesses and data from DG CAA.

The aircraft does not have a system for recording flight parameters.

### 2.1. Flight History

#### 2.1.1. Flight number and type, the last point of departure and time, and planned destination point

**Flight Number:** LZ- ASN.

**Type of flight:** private flight.

**Last point of departure:** non-certified airfield Belozem.

**Take-off time:** 09:50 h.

**Planned destination point:** non-certified airfield Belozem.

#### 2.1.2. Flight preparation and description of the flight

On April 20, 2019, shortly after 9:00 hrs, the owner of the ZODIAC CH 601 aircraft, registration plates LZ-ASN, arrives at the non-certified Belozem landing site, Belozem village, Rakovski municipality, Plovdiv district and after a brief conversation with acquaintances using the airfield as a base for their own aircraft, he performs a flight along a route close to the circle of the airfield. There is no information from eyewitnesses about the actions involved in preparing the aircraft for flight. There are no records in the available aircraft's technical documentation for such preparation. After landing, he takes on board a passenger who sits on the left seat, which is usually the place for the pilot or trainee. The owner and PIC have no instructor rights, but sits on the right seat. Although the passenger is under 18, there is non-official information that he has been trained as a pilot and has

piloted well, piloting also the A/C which has implemented the event. The plane takes off with both persons on board along a route, the final destination of which is the stadium of Orizari village, Rodopi municipality, Plovdiv district.

On this day, at the stadium, "Model Club Plovdiv", which deals with the piloting of radio-controlled models of planes and helicopters, is organized a competition in memory of a deceased member of the club. The owner of the aircraft, which has realized the event, has announced that he had provided a free flight with the plane, as a reward to the winner in the competition. It has been planned that the opening of the competition to be preceded by a demo flight of the aircraft that will realize the prize. Aviation authorities in the person of DG CAA have not been notified of the event and the demonstrations.

The flight implementation shows that it is envisaged to fly over the stadium at an altitude of about 10 m with a subsequent climb. At 10:11 hrs (according to eyewitnesses), the plane approaches the stadium from the southeast and smoothly manoeuvres for a low flight-over. At the beginning of the stadium the plane is in a horizontal flight and at the moment when it begins to climb the left wing detaches from the body of the aircraft and hits the canopy. As a result of the impact, the canopy is destroyed and scattered throughout the southern half of the stadium. The detached left wing falls on the ground of the stadium, Fig. 7 of Appendix 1. The aircraft begins to rotate along its longitudinal axis to the left and after 100...150 m it crashes into trees on the bank of the Maritza River, where it collapses; Fig. 1 to 3, Appendix 1. Witnesses of the event quickly go to the place where the aircraft is down and faces the cabin down. Several people turn the plane over and cut the belts to release the crew, which shows no signs of life. One of the eyewitnesses has called 112 and an ambulance has arrived shortly after the accident, finding the death of the owner and the other person on board. A fire brigade arrives, which does not fight a fire because, despite the presence of petrol vapors at the point of contact of the aircraft with the ground, no fire has occurred.

### 2.1.3. Location of aviation occurrence

The aviation accident occurs on April 20, 2019 at 10:11 hrs above the stadium of Orizari village, Plovdiv district, in the light part of the day.

The left wing falls in the northern half of the stadium with GPS coordinates 42° 1562.35' N 24° 6328.64' E and at altitude of 170 m.

The body of the aircraft falls on the right bank of Maritza River in a location with GPS coordinates 42° 1510.34' N 24° 6330.58' E.

## 2.2. Injuries to persons

Injuries	Crew	Passengers	Total persons on board	Other persons
Fatal	1	1	2	0
Serious	0	0	0	0
Absent	0	0	0	0
Total	1	1	2	0

## 2.3. Damage to aircraft

The inspection of the aircraft at the scene of the accident reveals that its destruction has begun in the air above the soccer field, where the left wing is torn off without the flap which remains attached to the body of the aircraft. After being torn off, the wing hits the canopy of the cabin and destroys it. The rest of the airplane flies a certain distance, rotating to the left around its longitudinal axis and after a collision with a willow-tree on the right bank of the Maritza River, collapses on the ground, being completely destroyed and not recoverable, Fig. 1 to 3 of Appendix 1.

## 2.4. Other damages

None.

## 2.5. Personnel information:

### 2.5.1. Commander

Man of 45.

License: BGR. FCL.PPA – 0023-11595 issued on November 21, 2013 by DG CAA, attested on October 21, 2017 valid through October 31, 2019.

Qualifying bookmarks: SEP (land).

National ULA PPL № BGR.NPPL-0064-11595, issued on October 27, 2017.

Qualifying bookmarks: A, valid through October 12, 2019.

Medical certificate: Class 2 / LAPL, valid through February 11, 2021, issued by CAA of Romania.

Medical restrictions: none.

The Commission does not have accurate flight experience data, as the pilot's flight book was not found.

The initial flight training of the same has been carried out by the training base for private pilots "Olympia Air" Ltd. in 2013 and includes 49:21 flying hours, of which 20:51 are self-contained.

There is no information about breached rest on the day preceding the flight at which the accident has occurred.

The Commission accepts that PIC has the appropriate rights to pilot an aircraft such as the one in which the accident has occurred. PIC possesses good technical skills and participates in the assembly of the aircraft with which the event is realized.

According to witnesses of the event, the plane may have been piloted by the passenger, a man over 17, during the event, but there is no evidence of this.

## 2.6. Aircraft Information

### 2.6.1. Airworthiness Information

An airplane, in accordance with a certificate of registration No. 2479, issued on March 07, 2014 by DG CAA of the Republic of Bulgaria, ZODIAC CH 601, registration marks LZ-ASN, serial number 606-025 is a category of Experimental-Amateur built aircraft. The ZODIAC CH 601 XL-ULM glider kit purchased from Zenair Ltd, Canada's French office with invoice No. Z-1345 has been used to build the same. When asked, the manufacturer of the kit responds that the aircraft kit includes, in addition to the glider, an engine kit and avionics which are not purchased from them and therefore they are not responsible for the aircraft type.

The owner buys the parts and assembles the aircraft. He is a manufacturer. Therefore, the committee accepts that the type of airplane and the manufacturer were incorrectly recorded in the registration certificate.

When assembling the glider kit, structural changes have been made that are not recorded in the aircraft's documentation, such as replacing the flexible control of the ailerons with a tubular, installing reinforcing bars on the wing attachment unit to the body. The beam in the body to which the wing is mounted does not correspond to the construction of the beam described in the manufacturer's documents. A logbook is kept when constructing the aircraft.

The original of this diary was not found by the investigation commission and the copy made by DG CAA is of such quality that it cannot be used for anything other than to trace over time the sequence of activities carried out. It does not appear from the diary that DG CAA inspectors have controlled the important assembly operations, such as the attachment of the wing to the body. The inspection card examining the airplane for its admission to flight testing does not include a check of the wing attachment unit to the body.

When registering the airplane in DG CAA, an Aircraft Flight Operations Manual (FOM) should be presented and approved. There is no copy of such a document in DG CAA. No FOM was found onboard the crashed plane, there is no such document in the bag with documents of the deceased pilot, handed over by his wife after the event, the co-owners of the aircraft have no such document too. In FOM should be recorded all restrictions that must be observed in the operation of the airplane and normal and emergency operating procedures.

When registered the aircraft has an EJ22 SUBARU engine and a maximum take-off mass of 650

kg. On November 21, 2017 the aircraft engine is replaced by a Rotax 912 ULS engine and its maximum take-off mass is limited to 450 kg. These reconstructions are related to significant changes in the characteristics of the aircraft. In connection with these reconstructions, when conducting an inspection for the issuance of the Special Certificate of Airworthiness of the Airplane, DG CAA requires an adjustment of MM in relation to the changes made, but does not require modification of the Flight manual.

DG CAA issues a special certificate of airworthiness for aircraft No 2479 valid for the period from December 03, 2018 to December 02, 2019. During this period the investigated event is realized. In the certificate, in the column "Manufacturer and name of the aircraft" improperly is recorded "Zenair Ltd, Canada ZODIAC CH 601".

On October 24, 2018, the aircraft is provided with an annual and 100-hours service in accordance with the approved maintenance plan of the aircraft. The one-hundred-hours inspection is performed 126 hours after the previous one, which violates the schedule for 100-hours inspections with 26 hours. At that moment, the aircraft has 220: 55 flying hours since the commencement of operation. Due to the destruction of the dashboard, the engine clock has not been detected and there is no record of the flying hours until the event.

Until the occurrence of the accident, the maintenance of the aircraft is carried out in accordance with the requirements of the LZ-ASN registration marks ZODIAC CH 601 aircraft maintenance plan, approved by DG CAA on November 22, 2018. Section 6 of this plan is entitled "Limited maintenance tasks performed by the Owner-Pilot." In the penultimate paragraph of the page on which the title of the section (lack of page numbering in the sections of the plan, which makes it difficult to trace the citation) is written:

"Maintenance tasks shall not be performed by the Owner Pilot when they are linked:

1) Directly with safety where improper performance would adversely affect the airworthiness of the airplane or the maintenance task would significantly affect flight safety or

...

3) With the implementation of the Airworthiness Directive, unless it states that it can be performed by the Owner-Pilot..."

The limited maintenance tasks performed by the Owner-Pilot are set out in the table on pages 2 and 3 of this section. Line 3 of this table lists items 10 to 76 of paragraph 8.2 of this Plan that meet the above conditions and therefore should not be performed by the Owner-Pilot. There is a difference between the Bulgarian and English texts when drafting item 62. The Bulgarian text contains "external bearing elements" and the English text contains "internal structure". An internal structural bearing element is also the one that has been destroyed and has caused the aviation accident.

In paragraph 3.2. 4 of the maintenance plan is written: "Upon completion of the first flight of the day and pre-flight inspection before each subsequent flight within the flying day ..., no certificate of release to service shall be issued."

In section 8 of the Maintenance Plan entitled "Tasks for Scheduled Maintenance", the following types of maintenance are recorded:

- Pre-flight inspection by the pilot;
- Inspection A, before the first flight of the day;

...

The absence of a recording requirement for those activities that are part of the aircraft maintenance contradicts the requirement of Art. 84 of Ordinance H-1 from January 09, 2014 and causes difficulties in the investigation of aviation events in connection with the assessment of the readiness of the aircraft to perform the specific flight.

There is a difference between the scheduled maintenance tasks outlined in paragraph 8.5 of the maintenance program and the maintenance schedule performed on October 24, 2018. The difference is due to the fact that the review has been performed on the basis of the Maintenance Manual approved on October 12, 2015. Upon completion of the annual inspection by DG CAA, the new Airplane Maintenance Plan has already been approved and the work performed on the airplane should be consistent with that new plan.



There is no plan to remedy inconsistencies in the transition of maintenance from the implementation of the Maintenance Manual to the implementation of the Maintenance Plan.

There is no record of the design changes made and their approval by DG CAA when replacing the EJ22 SUBARU engine with a Rotax 912 ULS engine.

The engine Rotax 912 ULS, serial №5644286, which is installed on November 21, 2017, has 251 hours flown till October 24, 2018, with a resource of 1500 hours till the next repair and 12 years in calendar period.

A three-blade propeller manufactured by IVOPROP model MEDIUM, type IVOPROP 1-800, is mounted on the aircraft. The propeller form does not contain the serial number of the propeller.

The aviation accident is not related to a disturbance of the normal operation of the power-plant.

On the basis of the foregoing in this paragraph, the Investigation Commission in relation with Safety accepts that at the time of the event the aircraft has had the documented required flight execution resources, but upon its registration, maintenance and control of continuing airworthiness deviations from normal procedures are allowed.

### 2.6.2. Aircraft characteristics

The LZ-ASN registration mark ZODIAC CH 601 aircraft, is a two-seat, single-engine, piston-engine, low-wing and non-retractable, three-wheel landing gear, with a nose wheel. The aircraft is a category of experimental-amateur-built, metal construction.

The maximum take-off mass of the airplane in accordance with Special Airworthiness Certificate No. 2479 issued on December 03, 2018 is 450 kg. The aircraft does not have a noise requirements compliance certificate. According to the airplane mass measurement protocol from October 20, 2018, the unladen mass is 243,2 kg. At the time of the event, there was a pilot on board the aircraft with a mass of 130 kg, a passenger with a mass of 80 kg and fuel with an unspecified mass, but not more than 67 kg in take-off. Under these conditions, the take-off mass of the aircraft is 520.8 kg and it can be assumed that the aircraft has been overloaded during the flight during which the event has occurred.

As the Flight Operations Manual approved by DG CAA has not been found, the following data related to the flight performance of the aircraft are taken from an example manual obtained from ATO "Olympia Air" Ltd, which has performed one of the 100-hours airplane inspections and the replacements of EJ22 SUBARU aircraft engine with Rotax 912 ULS engine.

The speeds are given as calibrated airspeed (CAS) in miles per hour (mph), in the cockpit of the aircraft the speedometer shows km/h.

Collapse speed  $V_s$  - 44 mph, 70.8 km/h;

Normal operational speeds - 44... 125 mph, 70.8... 201 km/h;

Manoeuvring Speed - 97 mph, 156 km/h;

Attention Zone - 112... 150 mph, 180.2... 241.4 km/h;

VNE - 150 mph, 241.4 km/h.

Overload:

-positive 4;

-negative 2.

In accordance with the above-mentioned FOM, the amount of fuel on board in the standard version is 16 US GAL, and in the optimal variant there are two more wing tanks with a total capacity of 15 US GAL.

In the questionnaire card, attached to the aircraft registration documentation, a fuel mass of 67 kg, which corresponds to a volume of 90 liters, with a fuel density of 740 kg/m<sup>3</sup>, is enclosed.

The cabin has inscriptions in Russian, Bulgarian and English.

Under certain flight conditions, a phenomenon known in aerodynamics called "flutter" can occur.

The flutter is a dynamic body instability in the airflow. The flutter can spread to the wing, tail panels, casing, propeller and other parts of the aircraft. It represents the self-excited undamped oscillations of parts of the structure that occur when interacting with aerodynamic forces. The energy required to sustain these vibrations is derived from the counter-airflow. The flutter is an extremely fast-moving and dangerous phenomenon that usually ends with the destruction of the aircraft.

Let the wing deviate from its neutral position for some reason (Fig. 2.1, item 1 of Appendix 2). Upon termination of the external force, the section begins to move upwards under the action of the elastic force. Because the aileron control system is not perfectly rigid, deformations occur in it, there are also

gaps, so that, under the action of the inertial force of the aileron  $l^{m_s}$  it deflects downwards. This leads to an increase in the lifting force by  $l^{\delta_i}$ , i.e. the force  $l^{\delta_i}$  is an initiating one. The section is also affected by the force  $l^h$ , which is again damping (Fig. 2.1, item 2 of Appendix 2).

After reaching the uppermost point (Fig. 1, item 5 of Appendix 2), the section begins to move downwards, with the aileron deflecting upwards. Again, the force  $l^{\delta_i}$  is initiating and  $l^h$  - damping (Fig. 2.1, item 6 of Appendix 2). After reaching the lowest position, the phenomena are repeated.

The force  $l^{\delta_i}$  depends on the squared value of the airflow velocity (velocity of flight)  $V$  and existing velocity  $V_F$ , over which the force  $l^{\delta_i}$  is greater than  $l^h$  and the amplitude of the oscillations can increase indefinitely.

The critical velocity of the flutter  $V_F$  is influenced by the stiffness of the control of the aileron (including the slack) and the location of its center of gravity. As the steering stiffness increases, the critical speed of the flutter also increases. In the assembled aircraft, the rope control of the ailerons is replaced by levers, which increases the rigidity of control and makes the flutter less likely.

A more radical solution is to move the center of gravity in front of the axis of rotation of the aileron. Then, due to the inertial force, the aileron rotates to create damping rather than an initiating force. Anti-flare weights are placed in the bow of the aileron to shift the center of gravity.

## 2.7. Meteorological information

The flight is performed in the light part of the day VFR.

There are no data on dangerous meteorological phenomena that have influenced the flight.

## 2.8. Navigation systems

ULA standard navigation equipment.

## 2.9. Communication systems

ULA standard communication equipment.

## 2.10. Airdrome information

The plane takes off and plans to land on an uncertified airfield, levels in the land of Belozem village, Rakovski municipality, Plovdiv district, next to the "Lukoil" gas station on the "Trakia" highway to the Burgas - Sofia road. The west end of the runway has the coordinates N 42°13'02.46", E 025°03'41.66" and an elevation of 149 m. Using the site as a base predetermines increased vibration loads during take-off and landing on the ground.

## 2.11. Flight recorders

The plane has no flight recorders.

## 2.12. Information about the impact and the debris

Upon inspection of the scene, it was found that the ZODIAC CH 601 aircraft with registration plates LZ-ASN has begun to be destroyed in the air when a demonstration flight has been conducted over the stadium of Orizari village. The left half-wing bends into the canopy destroys it and is torn off, leaving the flap attached to the body. The plane turns to the left, around its longitudinal axis, flies about 100 m, crashes into a tree and falls on its back on the right bank of the Maritza River in a place overgrown with trees and thick bushes. The location of the fall is shown in the pictures marked as Fig. 1 and Fig. 2 of Appendix 1. GPS coordinates of the fall point of the body are indicated in paragraph 2.1.3.

The aircraft has fallen between the trees, with the three-blade propeller separated from the engine and located about 2 m away from the body of the aircraft.

The cabin is completely destroyed. As a result of the impact, the engine is detached from the motor frame, Fig. 3 Appendix 1. The motor frame is torn off by the fuselage fireboard. The body is deformed and has a broken geometry from the nodes to attach the wings to the tail of the aircraft. The main

landing gear has no damages but the nose one, because of the impact is twisted into the shock absorber stand.

The right half-wing is deformed as a result of the impact, and traces of slippage can be seen on it. The left half-wing is torn off as the plane flies over the stadium, with the left half-wing flap hanging on the body of the aircraft, which is held on the flaps' synchronizer lever. The tail of the airplane and the vertical rudder are deformed, Fig. 4 of Appendix 1

The left half-wing falls in the northern half of the stadium; Fig. 7 of Appendix 1. The GPS coordinates of the location of the left half-wing fall are given in paragraph 2.1.3. The detachment of the wing is due to the destruction of the knot for securing the central longitudinal beam to the transverse beam in the body, Fig. 8 of Appendix 1. The half-wing casing is probably deformed by the impact to the ground, completely crushing the end fairing and destroying the navigation lights.

As a result of the blow from the half-wing, the canopy is destroyed and scattered throughout the southern half of the stadium.

The wreckage of the aircraft is collected and stored in a warehouse controlled by the Plovdiv Regional Prosecutor's Office.

The components initially destroyed in flight serve to attach the wing to the body and to transmit the corresponding effort from the wing to the body - Fig. 2.3 of Appendix 2.

In the wing, these efforts are mainly borne by the longitudinal beam - Fig. 2.4 of Appendix 2. The destruction of the longitudinal is a catastrophic event.

The forces in the anchorage zone that are transmitted to the body are: a bending moment, a twisting moment and shearing force - Fig. 2.13 of Appendix 2. They are transmitted as forces through the mounting nodes (Fig. 2.3 of Appendix 2) to the body where they balance.

On November 7, 2009, the manufacturer of the kit (and similar aircraft) AMD issues Security Alerts, which is mandatory for immediate implementation. It prescribes an immediate reinforcement of the mounting nodes (Figs. 2.4 and 2.5). The main reinforcing element is a plate (pos.1 in Fig. 2.4 of Appendix 2) with a thickness of 0.125 "(≈3.2 mm). Figures 2.3, 2.4 and 2.5 of Appendix 2 show diagrams of the right half-wing, the left is symmetrical. The real bar (Fig. 2.7 of Appendix 2) is 6.5 mm thick, has a different shape and is of aluminium alloy with unknown heat treatment. Increased thickness does not provide greater strength, even on the contrary: it changes the distribution of forces between the bolts and can reduce the strength of the assembly.

As the thickness of the assembly has increased significantly, the lengths of the original bolts, which are inch-sized and have a suitable anti-corrosion coating, are insufficient and have been replaced by others. The new bolts are larger in diameter, have a larger diameter and do not have a suitable anti-corrosion coating. The increased diameter of the new bolts necessitates the drilling of the original openings (Fig. 2.12 of Appendix 2). The lack of a suitable anti-corrosion coating on the steel bolts in contact with the aluminium rails and plates creates conditions for electrochemical corrosion. This is observed on all new bolts - fig. 2.6, 2.7, 2.9, 2.10 and 2.11 of Appendix 2. Their condition can be compared to that of the original bolt of Fig. 2.8 of Appendix 2 with a similar function.

### **2.13. Medical and pathological information**

An expert forensic report of the pilot's corpse and forensic chemical expertise of a blood sample taken from the pilot's corpse has been performed. The expertise's are attached to the case with investigation materials.

The expert forensic report of the pilot's corpse outlines the results of an external and internal examination and indicates the cause of death:

"A severe combined open traumatic skull injury, thoracic trauma and abdominal trauma with life incompatible injuries - interruption of the brainstem at the bridge level, tearing of the heart from the vascular bundle with rupture of the wall of the left ventricle and pericardium and rupture of the spleen and liver.

The traumatic injuries described are directly related to the incident and to the death. "

Ethyl alcohol was not detected in the pilot blood tests and the presence of drugs or their analogs was not demonstrated within the sensitivity of the methods used.

An expert forensic report of the passenger's body and forensic chemical expertise of blood taken from the passenger's body were performed. Expertise is attached to the case with investigation materials. The expert forensic report of the passenger's corpse outlines the results of an external and internal examination and indicates the cause of death:

"Acute blood loss is judged by the pericardial ruptures and tearing of the left ventricle wall, 2500ml of blood and blood clots in the left half of the chest cavity, 500ml of blood in the abdomen, liver rupture, expressed pallor of internal organs.

The traumatic injuries described are directly related to the incident and to the death. " Ethyl alcohol was not detected in the passenger blood tests and the presence of drugs or their analogues was not demonstrated within the sensitivity of the methods used. In the necropsy, no diseases of the organs and systems of the organism were found which could be causally related to the incident or would lead to it.

#### **2.14. Fire**

None..

#### **2.15. Factors for Survival**

During the flight, the pilot and passenger were wearing seat belts, which were cut off by witnesses of the incident when they arrived at the scene of the collision with the ground..

#### **2.16. Testing and research**

For the purpose of the investigation, the investigation commission in relation to safety conducted and carried out:

1. An inspection of the collision site at the site of the left half-wing fall
2. Inspections of ZODIAC CH 601 aircraft, registration marks LZ-ASN, after the event.
3. Interviews with witnesses of the accident;
4. Study and analysis of aircraft operational and technological documentation;
5. Assessment of the performance of the airplane;
6. Laboratory analysis of the fuel used for refuelling the aircraft;
7. Inspection of the condition of the mounting unit for securing the left wing to the body of the aircraft and application of microscopic methods for analysing the structure of the material at the site of destruction.
8. Study and analysis of pilot training.
9. Pilot and passenger medical and pathological examination.
10. Logical-probabilistic analysis of possible causes of the aviation accident.

Under the first point, the results of the inspection of the accident site are reflected in paragraphs 2.1.2, 2.1.3, 2.4 and 2.12.

Under the second point, the results of the inspections of the airplane after the event are reflected in paragraphs 2.3 and 2.12.

Under the third point, the results of the interviews with witnesses of the accident and persons involved in the construction of the aircraft are reflected in paragraphs 2.1.2, 2.6.1, 2.6.2 and 2.12.

Under the fourth point, the results of the study and analysis of operational and technological information on the airplane are reflected in paragraphs 2.6.1 and 2.6.2.

Under the fifth point, the assessment and analysis of aircraft flight performance is made in paragraphs 2.6.2, 2.6.3 and 2.17.

Under the sixth point, the results of the laboratory analysis of the fuel with which the airplane is loaded are set out in paragraph 2.6.3.

Under point seven, an examination of the condition of the assembly unit for securing the left half-wing to the body and applying microscopic methods for analyzing the structure of the material at the site of destruction is made in paragraphs 2.6.2 and 2.17.

Under point eight, the materials of pilot preparation study and analysis, are set out in paragraph 2.5.

Under item nine, medical and pathological examination of the pilot and passenger, the materials are set out in paragraph 2.13.

Under point 10, a logical-probabilistic analysis of the possible causes of the aviation accident is made in Chapter 3 of this report.

### **2.17. Additional information**

Six cases of ZODIAC CH 601 destruction in flight have forced the FAA to Issue in November 2009 "SAIB Airworthiness Special Bulletin: CE – 10 – 08 from November 7, 2009" informing about the airworthiness issues of ZODIAC CH 601XL and CH650 aircraft all serial numbers, including special light sports aircraft category (S-LSA), experimental light sports aircraft (E-LSA) and experimental amateur-built aircraft.

The FAA analysis reveals several problem areas with respect to the construction of ZODIAC CH 601XL that may have an impact on flight safety. These problem areas are related to:

Wing construction: FAA analyzes show that the bending loads used in the design of the wing structure are not conservative and the basic static strength does not meet ASTM aircraft standards.

Stability of the structure: Other aviation authorities note the presence of bending in the wing structure, including in the center section. Such structural instability can have a significant effect on static strength and flutter performance.

Flutter: The thorough review by the FAA of available flutter analysis reports is unconvincing. Pictures of aviation accidents clearly show the appearance of a flutter in the event of a flight failure. The FAA suggests that the flutter may be either the first major cause of structural failure in flight or a secondary cause after some initial structural deformation or wing torsion.

Airspeed Calibration: The calibration procedures do not seem to adequately account for the main error at the source of static pressure due to the location of the openings. This can lead to inconsistencies in the airspeed readings, especially since the CH 601XL can be supplied with different airspeed indicators or without an indicator. The situation may result in the operation of the aircraft at speeds above maneuvers and or above design cruising speed, potentially resulting in constructive failures.

Control lever characteristics: Data from flight tests by foreign aviation authorities indicate that at a rear center of gravity, the forces on the control lever become very small. FAA suggests that this could be a contributing factor to aviation accidents due to structural failure if combined with an operating exceedance of maximum take-off mass at speeds higher than VA and/or improperly loaded aircraft. Under such conditions, the dynamic load on CH 601XL's wing can very easily exceed its design limit value.

Further, CE - 10 - 08 strongly recommends that all owners and operators of experimental amateur-built aircraft and E-LSA comply with the drawings and instructions contained in the manufacturer's and aircraft designer's (AMD) safety directives.

On November 23, 2009, AMD has issued "Mandatory Action - Safety Alert" newsletter for immediate implementation, which requires the correction and improvement of the kit and, in addition, the completion of mandatory 7 points before each flight.

The kit assembly work, in accordance with the record in the aircraft construction logbook, begins on November 20, 2008, and ends on April 05, 2011. This period includes the time during which the documents mentioned above in this paragraph are published, but in the technical documentation of the airplane has no record of performance of the mandatory work specified by the document issued on November 23, 2009.

A testing using microscopic methods for the analysis of the structure of the material at the site of destruction is performed at the Laboratory for Analysis and Testing of Materials and Calibration of Measuring Instruments (LATMC) of the Institute of Metal Science, Facilities and Technologies with a Center for Hydro and Aerodynamics "Academician A. Balevski" - BAS. The test results are recorded in Test Report No. 91 / October 03, 2019. A copy of this protocol is attached to the case with the investigation materials. For testing, 6 metal specimens are provided, shattered plates removed from the indications in Fig. 8, Appendix 1, a broken unit for attaching the main beam of the left half-wing to the fuselage. In Appendix 1, Fig.11 and 12 show photographs of Appendix 1 of Test Report No. 91 /October 03, 2019. These pictures show the general appearance of the specimens examined and the

destroyed areas. Fig. 13 and 14 show photographs of Appendix 2 of Test Report No. 91 /October 03, 2019. These photographs show microphotographs of characteristic sections of the breakage of the samples. Generally, plastic burstings are observed in all specimens.

The expert opinion on the tests carried out states that all the bolts with which the plates have been fastened had corroded. Small, unevenly located, shallow corrosion pits can be seen on the surfaces of the straps, where the paint is scraped. The opinion concludes that the corrosion damage found are surface and could not be the cause of the destruction. However, the corrosion-released products on the bolts disrupt the adhesion between the nut and the bolt, which in operational conditions can lead to loosening of the connection and disruption (unscrewing) of the bolt connection.

A chemical analysis of the composition of the straps is made in which it is found that the material of the straps P3 and P6 differs from the material of the others. Aluminum is the main constituent of the material in all straps. A copy of Technical Protocol No. TR 560-0116 /September 27, 2019, defining the chemical composition of the straps is attached to the investigation materials.

When reading data from GPS memory "GARMIN", model "GPS 72", Serial No. 82392755, which is on board the aircraft at the time of the event, no record is found for the flight in which the accident takes place. The memory is read at the Center for Experimental Forensic Research at the Ministry of Interior Research Institute of Forensics. Expert Information №2019 / ICU - 214 is issued for the purpose of reading. A copy of this information is kept in the case with the investigation materials.

### 3. Analysis

Considering the abovementioned, it can be stated that the aviation accident is a result of the destruction of the attaching unit of the left half-wing main bearing beam to the beam of the fuselage located in the body of the aircraft. Fig. 8 of Appendix 1 shows that the bearing beam of the fuselage is destroyed, and part of it, together with the mounting bolts, is detached and has remained attached to the main bearing beam of the half-wing. What could be the cause of this destruction.

The Commission examined three main hypotheses for this destruction:

1. The first hypothesis is that the destruction occurs as a result of fatigue of the material as a result of cyclic loads during the operation of the aircraft.
2. The second hypothesis is that the destruction is caused by excessive operational overload during the flight with the accident.
3. The third hypothesis is that, as a result of the corrosion of the materials of the assembly unit, their bearing capacity has decreased and this has led to the destruction of the assembly at acceptable operational loads.

In considering the hypotheses, account was taken of: flight-related circumstances, results of inspections of the damaged surfaces at the accident scene and subsequently at the place of storage of remains, the manufacturer's and FAA's experience of investigating similar events, the results of studying damaged element samples at the Laboratory for Analysis and Testing of Materials and Calibration of Measuring Instruments (LATMC) of the Institute of Metal Science, Equipment and Technologies with a Center for Hydro and Aerodynamics "Academician A. Balevski" - BAS.

Under Hypothesis No. 1. In support of this hypothesis, facts may be cited that the operation of the aircraft is carried out by a non-certified ground airfield, that the requirements related to the operation of aircraft of such type are violated, such as a ban on the performance of aerobatic figures. Not very clear operational restrictions in the document issued for this purpose by DG CAA, which also leads to its use as a training plane. Insufficient and incomplete technical documentation preventing the assessment of compliance with the recommendations of the manufacturer of the kit classified as airworthiness directives.

In spite of the above mentioned, no fatigue cracks are found in the study of the scrapes at the LATMC of BAS, which makes this hypothesis untenable.

Under Hypothesis 2. The following may be cited in support of this hypothesis:

It is clear from paragraph 2.6.2 that one of the basic requirements related to the airworthiness of the aircraft is violated at the beginning of the flight - the maximum take-off mass is exceeded due to the large mass of the two pilots. The excess weight of the pilots changes the position of the center of gravity of the airplane and makes it close to the limit rear balance. Paragraph 2.17 states that flight

tests of the airplane indicate that at a rear balance, the efforts on the control lever become very small. In such a situation it is easy to cause excessive steering deviations which can lead to excessive overloads which to exceed the design allowances. The smaller the pilot's experience, the more likely it is to cause the steering surfaces to deviate too much.

Paragraph 2.1.2 states that in the left seat, the seat of the pilot has been occupied by the passenger who has piloted the aircraft not for the first time without the relevant rights. The aircraft flies over the stadium at an unacceptably low altitude and above an object with a significant number of people, for which the commander of the aircraft is responsible and which is unacceptable in terms of flight safety. This situation inevitably is connected with the increased tension of the piloting person and it is likely at the moment he or she going from horizontal flight to climbing to have pulled in excess the control lever. This excessive pull, at speeds close to the maximum permissible, probably has led to the load exceeding the permissible one and to the destruction of the fuselage mounting unit for the left half-wing. The study of the scrapes in LATMC of BAS indicates the presence of plastic deformation in the destroyed scrapes. Such plastic deformation occurs when the maximum allowable load is exceeded. Additional contributory factors in the destruction of the half-wing assembly to the body of the airplane may include:

- The power beam in the body (fuselage beam) on which the wing is mounted does not correspond to the design of the bearing beam described in the manufacturer's documents, a finding noted in paragraph 2.6.1. The inconsistency is in the direction of reducing its carrying capacity.

- The presence of corrosive cores, identified in the study at LATMC of BAS, which reduce the bearing capacity of the materials. The foregoing makes it probable that the occurrence of the aviation accident may be related to the second hypothesis.

Under hypothesis No. 3. The presence of visible corrosion marks on the destroyed assembly unit for the main bearing beam of the left half-wing to the beam of the fuselage located in the body of the aircraft shown in Fig. 8 of Appendix 1 also makes it relevant to consider such a hypothesis. In the study performed at the LATMC of BAS, a conclusion is made and recorded in paragraph 2.17, that the corrosion damage found are on the surface and could not be the cause of the catastrophic destruction. Having in mind the above mentioned, the investigation commission in relation with safety, dismisses the third hypothesis as a possible cause of the aviation accident, but accepts that corrosion can serve as an additional contributing factor to the event.

In view of the foregoing, the Commission considers as a main reason for the occurrence of an aviation accident an excessive operational overload, a result of a breach of the piloting technics of the aircraft at balance close to the rear limit and a violation of the rules for conducting flights at safe altitudes and above settlements by the piloting pilot.

## **4. Conclusion**

### **4.1. Findings**

As a result of the investigation, the commission reached the following conclusions:

1. ZODIAC CH 601 aircraft, registration marks LZ-ASN, is an experimental amateur-built aircraft.
2. A ZODIAC CH 601 XL-ULM glider kit purchased from Zenair Ltd, Canada, invoice No. Z-1345 is used to build the same.
3. The airplane holds a certificate of registration No. 2479 issued on March 07, 2014 by DG CAA of the Republic of Bulgaria, where the type of the airplane, ZODIAC CH 601, serial number 606-025 and manufacturer has been incorrectly enrolled.
4. The aircraft manufacturer is the owner.
5. The aircraft is owned by a private individual and operates as a private aircraft.
6. When assembling the glider kit, structural changes are made that are not recorded in the aircraft documentation.
7. The beam in the fuselage to which the wing is mounted does not correspond to the construction of the beam described in the documents of the manufacturer of the glider kit.
8. A logbook is kept of the construction of the airplane and its stored copy is not of good quality.
9. It is not apparent from the diary records that DG CAA inspectors have supervised the execution of the important assembly operations, such as the attachment of the wing to the fuselage.

10. The inspection card examining the airplane for its admission to flight testing does not include a check of the mounting unit for the wing to the fuselage.
11. No Flight Operations Manual certified by DG CAA has been found.
12. No restrictions, approved by DG CAA, have been found to be respected in the airplane flight operation.
13. The aircraft has been issued a special airworthiness Certificate No 2479 by DG CAA valid for the period from December 03, 2018 till December 02, 2019. In the certificate, under the column "Manufacturer and name of the aircraft", incorrectly is recorded "Zenair Ltd, Canada ZODIDC CH 601".
14. On October 24, 2018, the aircraft was provided with an annual and a 100-hour service in accordance with the approved maintenance plan of the aircraft. The one-hundred-hour review is performed 126 hours after the previous one, which violates the schedule for 100-hour examinations by 26 hours.
15. There is no record of the flight hours since the last maintenance up to the time of the accident.
16. Aircraft maintenance is carried out in accordance with the requirements of the ZODIDC CH 601 Aircraft Maintenance Plan, LZ-ASN Registration Marks, approved by DG CAA on November 22, 2018.
17. There is no record of linear maintenance performed under this plan.
18. There is no plan to remedy inconsistencies in the transition of maintenance from the implementation of the Maintenance Manual to the implementation of the Maintenance Plan.
19. There is no record of the reconstructions made and their approval by DG CAA when replacing the EJ22 SUBARU engine with a Rotax 912 ULS engine.
20. The aviation accident is not related to a disturbance of the normal operation of the power plant.
21. In the propeller form, it is not written the serial number of the propeller.
22. For the performance of the flight, the aircraft is fueled with A95H motor gasoline, which complies with the technical requirements.
23. There is no indication that the event is related to the consumption of the available fuel onboard.
24. During the flight in which the event takes place, the aircraft has a larger take-off mass than the maximum permitted.
25. In the applicable FOM, speeds are given as calibrated airspeed (CAS) in miles per hour (mph), in the airplane cockpit the speedometer shows km/h.
26. During the flight, when transiting from horizontal flight to climbing, the assembly unit of the left half-wing to the fuselage is destroyed.
27. The aircraft rotates to the left, about its longitudinal axis, flies about 100 m, crashes into a tree and falls on its back on the right bank of the Maritza River in a place overgrown with trees and thick bushes.
28. The collision of the airplane with the ground causes the death of both persons on board, the owner of the airplane and the passenger.
29. The aircraft is completely destroyed.
30. No fire has occurred during the event.
31. The owner has the appropriate rights and a valid medical certificate for piloting the aircraft.
32. The owner possesses good technical skills and participates in the assembly of the crashed aircraft.
33. The passenger sitting on the left seat, the pilot's seat, has not had pilot rights but has piloted this aircraft.
34. Forensic expertise does not establish the use of alcohol, drugs and narcotics by both persons on board the aircraft.
35. At the autopsy of the bodies of both persons on board the aircraft, no diseases of organs and systems of the bodies are found which are in causal relation to the incident.
36. Meteorological conditions do not directly affect the happening of the event.

#### 4.2. Causes

On the basis of the circumstances set out in this report and the analysis made by the Commission, the Commission considers as the main reason for the occurrence of the aviation accident an excessive operational overload, a result of a violation of the piloting technics of the aircraft at



balance value close to the rear limit and a violation of the rules for conducting flights at safe altitudes and above settlements by the piloting pilot.

## 5. Safety Recommendations:

Immediately after the occurrence of the event, AMRAIU Directorate at MTITC makes the following recommendation regarding the safety of flights to DG CAA:

To check the units for mounting the wing, according to the manufacturer's instructions of all experimental aircraft, enrolled in the Register of Civil Aircraft of the Republic of Bulgaria. Deadline the next flight. The verification should be recorded in the aircraft technical documentation.

In connection with this recommendation, DG CAA issues a Flight Safety Bulletin with control No 02/2019 from April 22, 2019.

In view of the causes of the aviation accident and the shortcomings identified in the investigation, the Commission recommends the following flight safety measures to be implemented:

**BG.SIA-2019/02/01.** The Association of Ultralight Aviation in Bulgaria to arrange for its members to be acquainted with the main circumstances, conclusions, contributing factors and causes in connection with the aviation accident which is the subject of this report.

**BG.SIA-2019/02/02.** When assembling amateur-built aircraft, DG CAA will supervise the whole process from the moment of declaring the intention to the completion of the flight tests by keeping a logbook and recording in that log the control of key stages of this assembly, based on world experience and good practices.

**BG.SIA-2019/02/03.** DG CAA to ignore the possibility of factual errors in the issue of aircraft registration and airworthiness documents by developing procedures and providing multi-level controls for the implementation of these procedures.

**BG.SIA-2019/02/04.** When registering amateur-built aircraft, DG CAA shall require and approve a Flight Manual, a copy of which shall remain in DG CAA's archive.

**BG.SIA-2019/02/05.** When making structural changes to an amateur-built aircraft, DG CAA will require a project including detailed drawings and an explanatory note to them that must be approved prior to its implementation.

**BG.SIA-2019/02/06.** DG CAA to strengthen the control over the provision of private ultralight aircraft for operation by persons who are not owners and persons who haven't pilot rights.

**BG.SIA-2019/02/07.** DG CAA should provide, through guidance and control, recording of maintenance activities and the flight hours of the aircraft owners.

**BG.SIA-2019/02/08.** When replacing a maintenance program with a maintenance plan, DG CAA will monitor the compatibility of both programs by making a written assessment of its compatibility.

Appendix 1 and Appendix 2 follow. They are an integral part of this report.

On the grounds of Article 18, §5 of Regulation (EU) 996/2010, the safety recommendation issued will be recorded in the centralized European system SRIS (Safety Recommendations Information System).

*The Investigation Commission reminds all organizations, to which flight safety recommendations are sent that, on the grounds of Article 18 of Regulation (EU) 996/2010 on Investigation and Prevention of Accidents and Incidents in Civil Aviation and Article 19, paragraph 7 of Ordinance No. 13 on the Investigation of Aviation Accidents are obliged to notify the Directorate of the AAIU to the MTITC in writing of the action taken on the recommendations made.*

**Chairman of the Commission:**

**Stefan Petrov**

APPENDIX 1



Fig. 1



Fig.2



Fig.3



Fig.4



Fig. 5



Fig. 6



Fig. 7



Fig. 8



Fig. 9



Fig. 10.

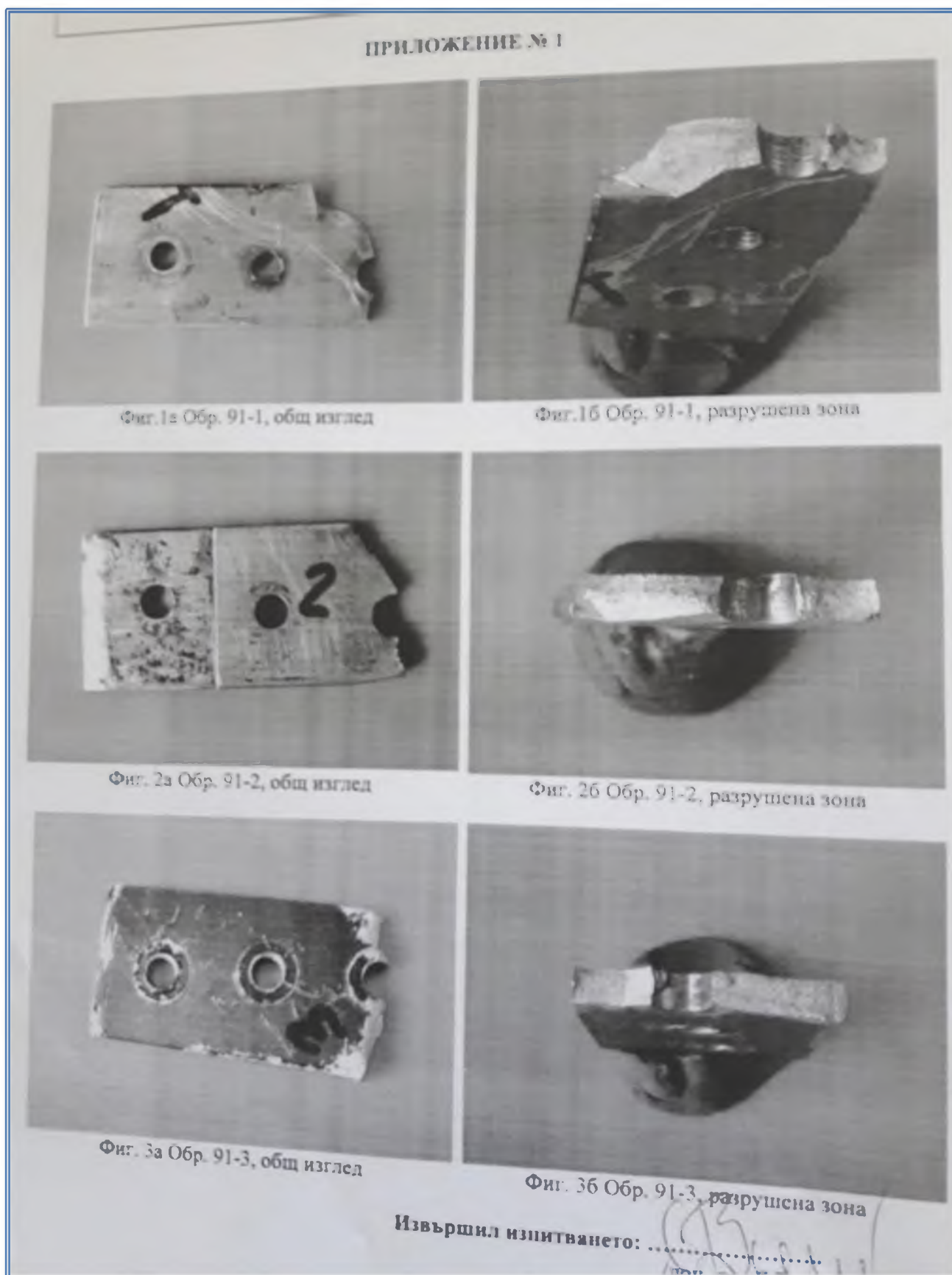


Fig. 11.

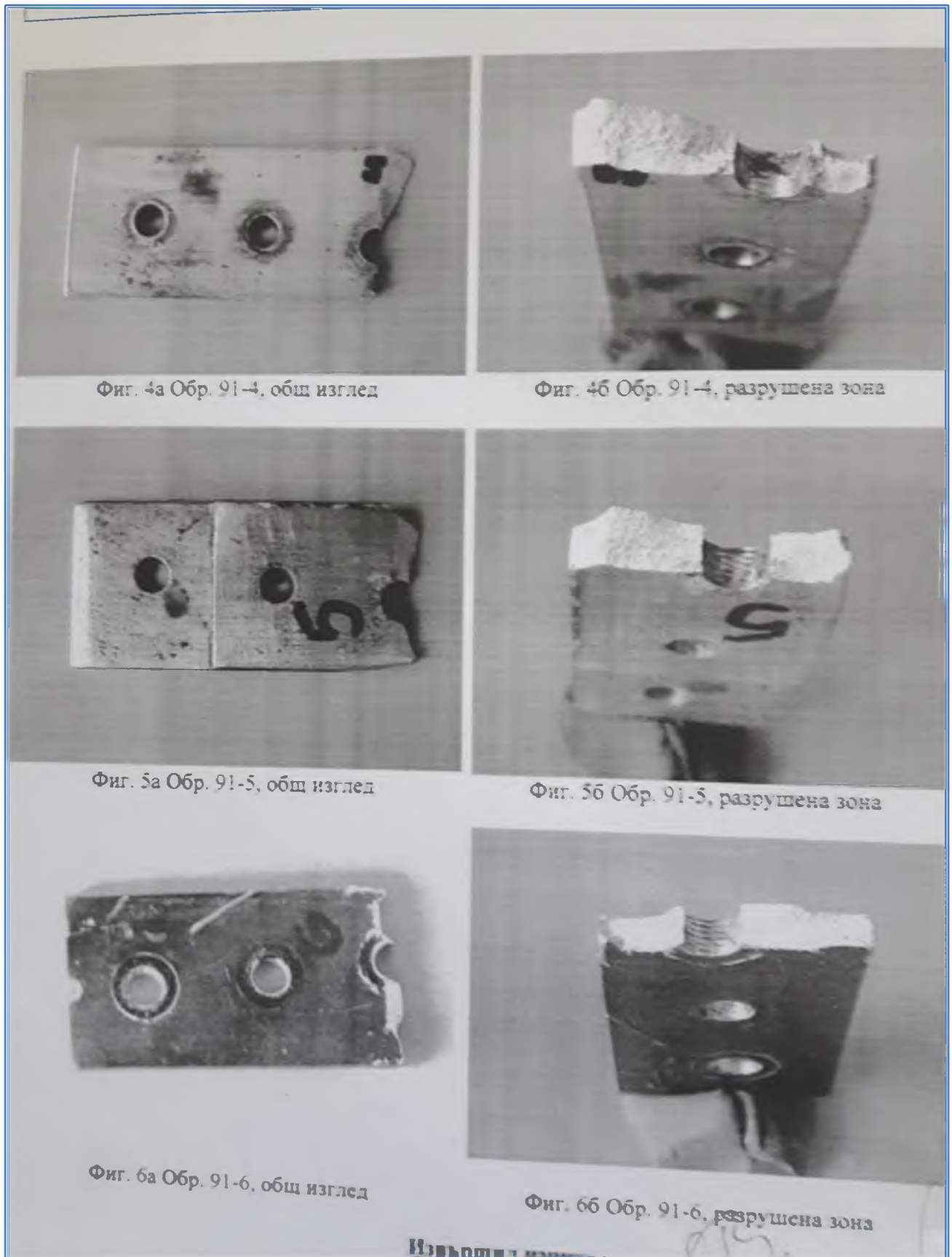


Fig. 12.



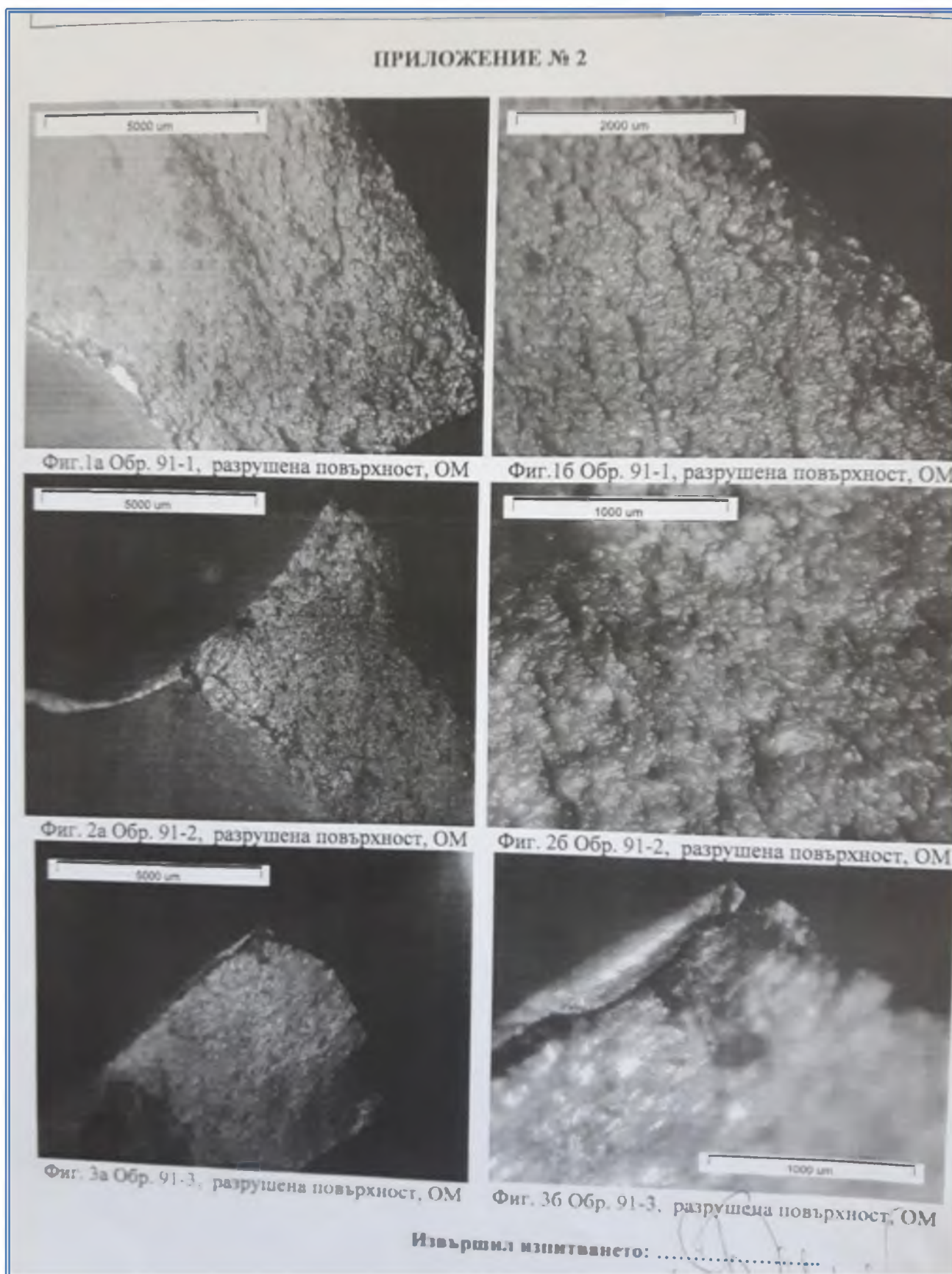


Fig. 13.

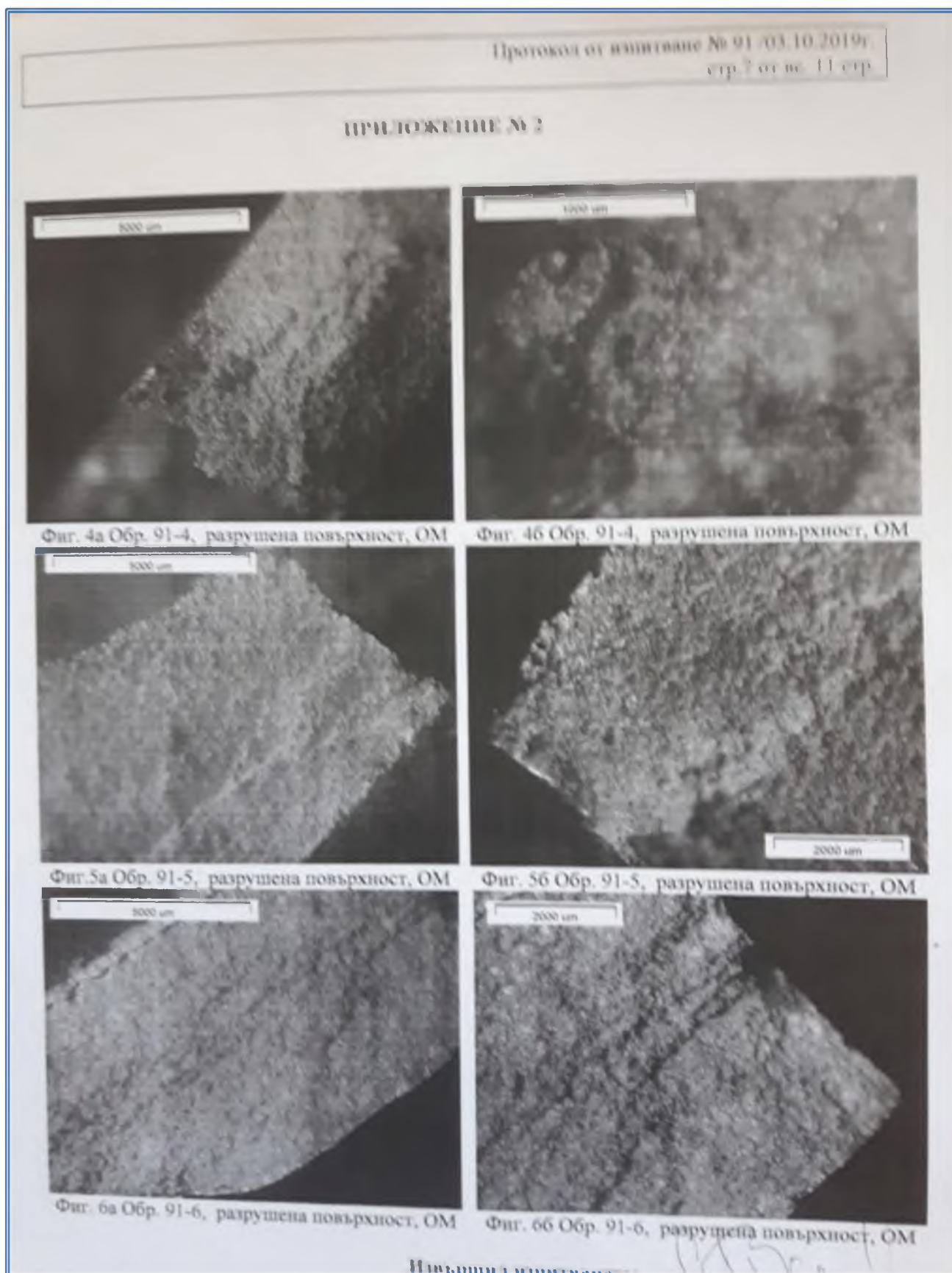


Fig. 14.

APPENDIX 2

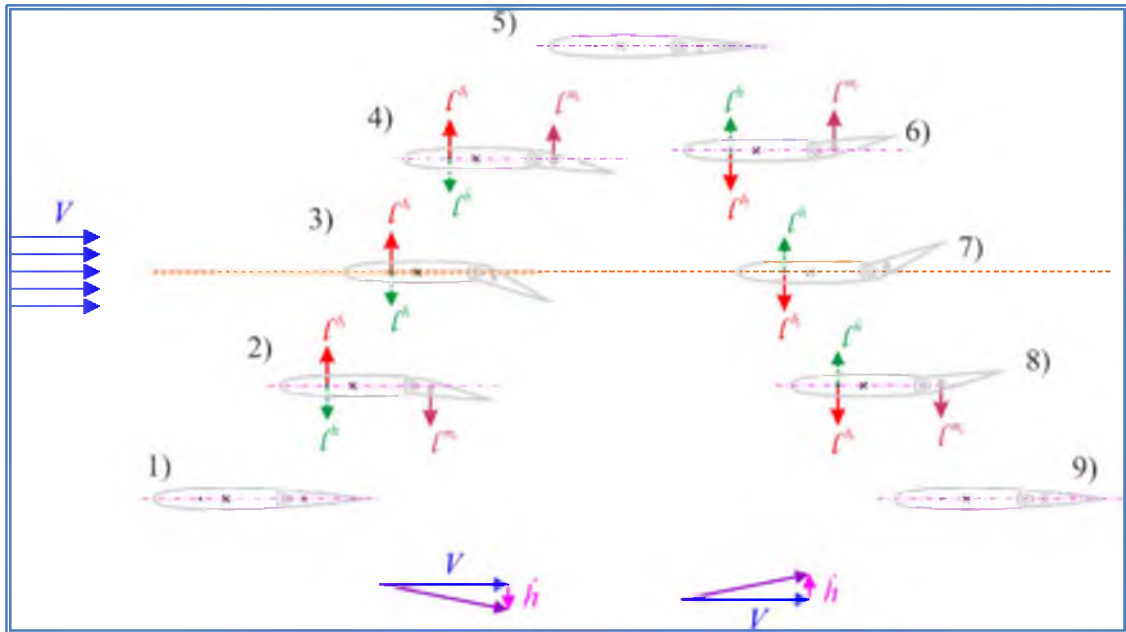


Fig. 2.1

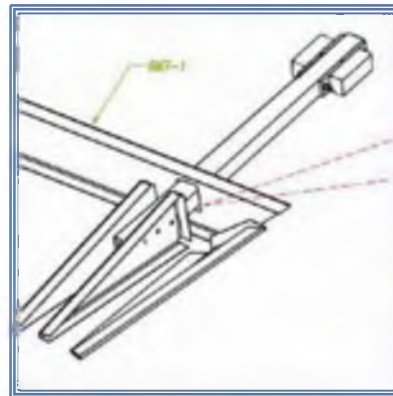
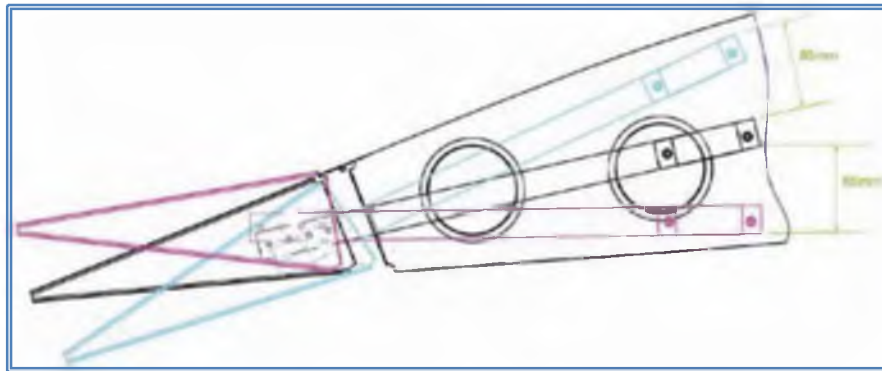


Fig. 2.2

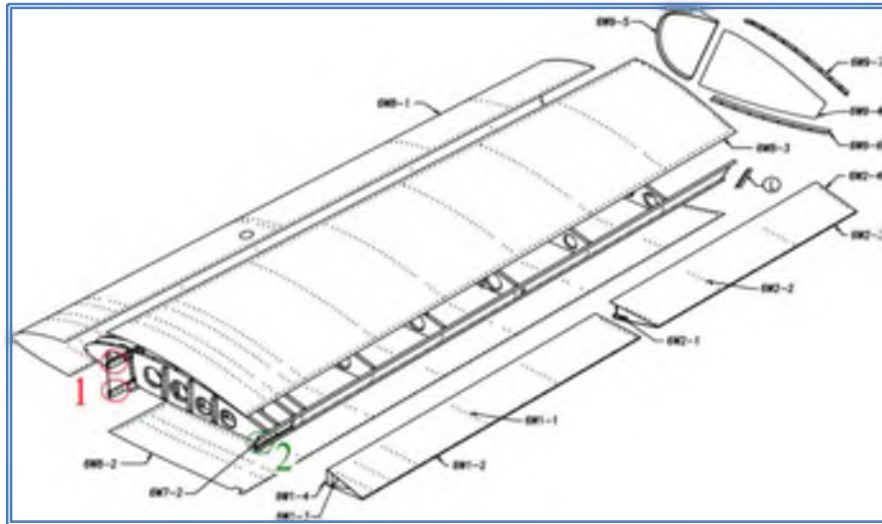


Fig.2.3

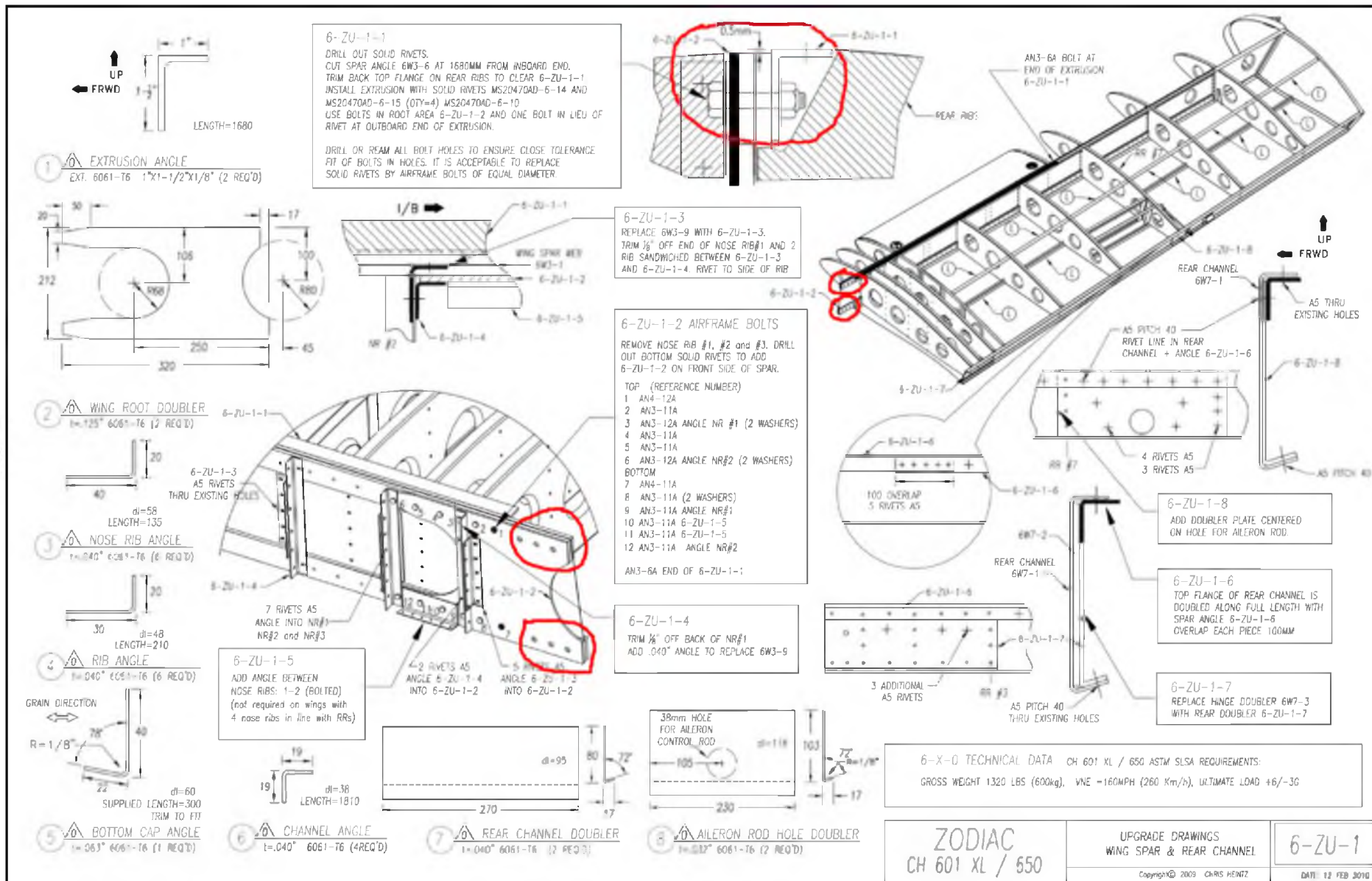


Fig.2.4

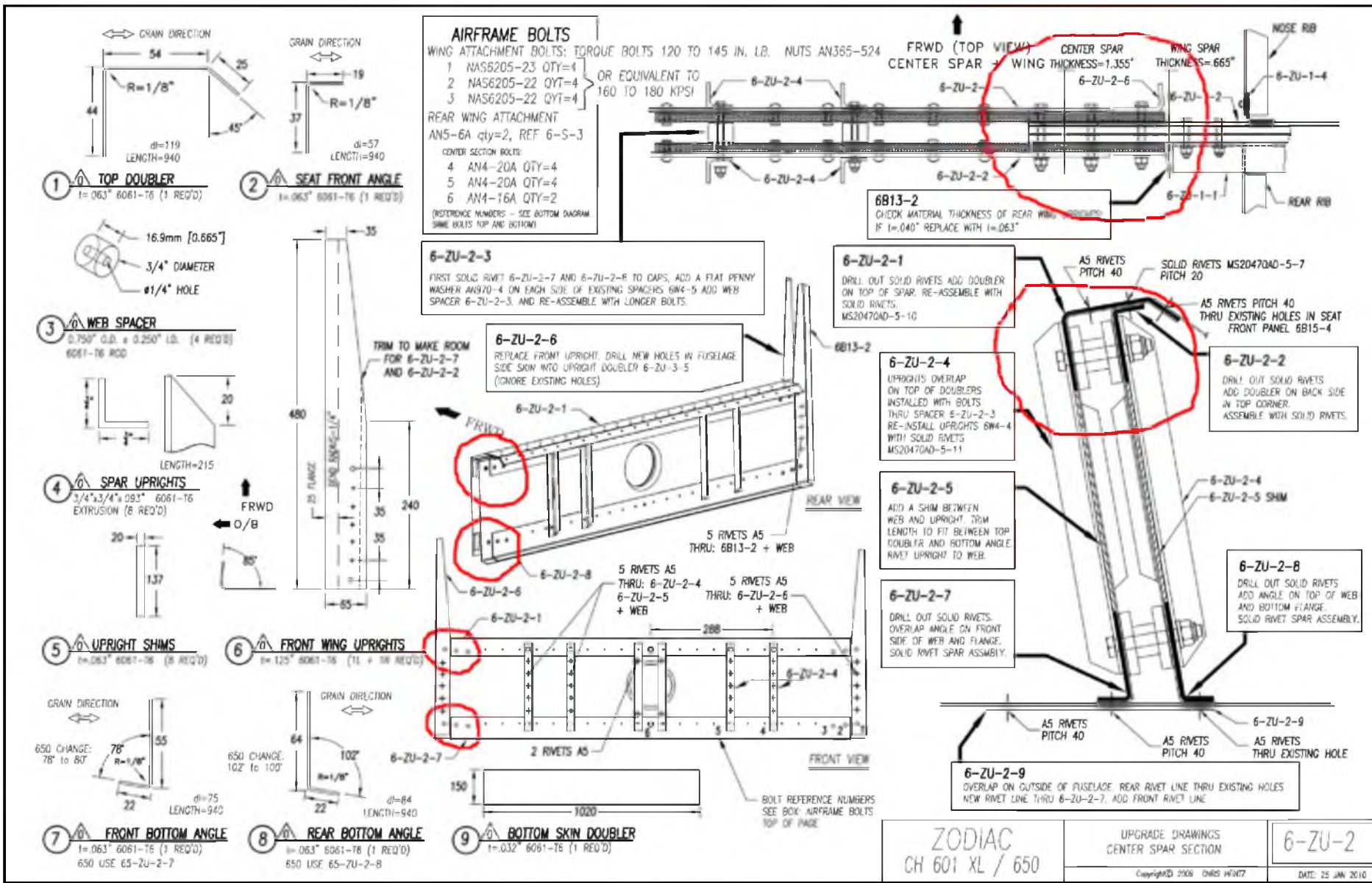


Fig.2.5



Fig. 2.6



Fig. 2.7



Fig.2.8



Fig.2.9





Fig.2.10



Fig.2.11



Fig.2.12

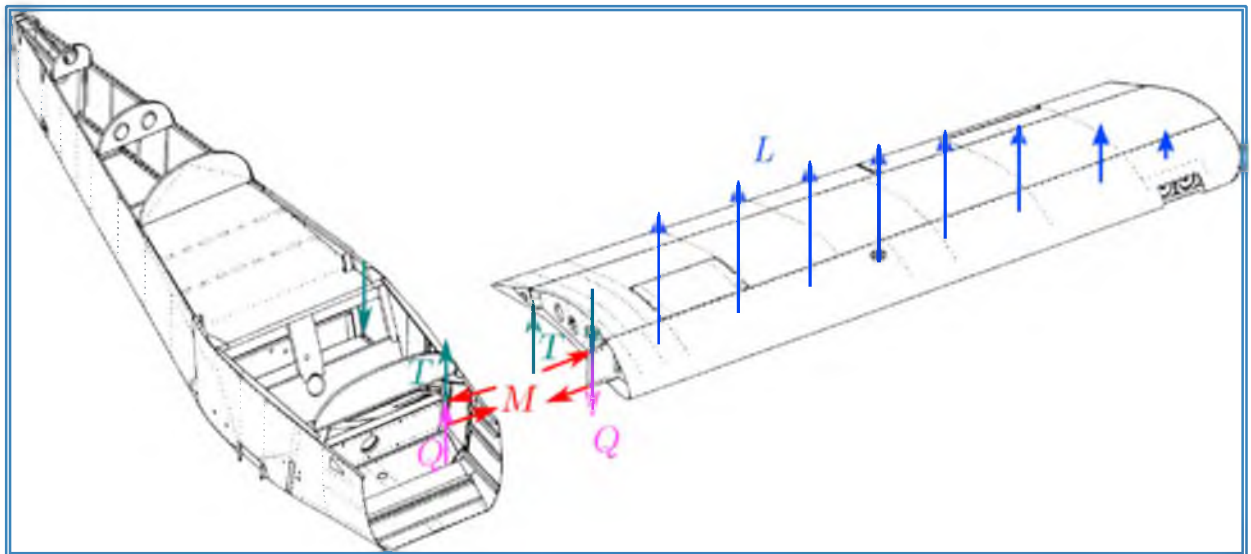


Fig.2.13