MINISTRY OF INFRASTRUCTURE
STATE COMMISSION ON AIRCRAFT ACCIDENT INVESTIGATION

FINAL REPORT

ACCIDENT

Occurrence No: 562/09

Aircraft: Parachute Black Hawk 265

25 July 2009 – Chrcynno near Nasielsk

This report is a document presenting the position of the State Commission on Aircraft Accident Investigation concerning circumstances of the air occurrence, its causes and safety recommendations.

The report is the result of the investigation carried out in accordance with the applicable domestic and international legal provisions for prevention purposes only. The investigation was conducted without the need of application of legal evidential procedure.

In connection with the Article 134 of the "Aviation Law" Act (Journal of Laws 2006, No. 100, item. 696 with amendments), the wording used in this report may not be considered as an indication of the person guilty or responsible for the occurrence.

The Commission makes no judgments about fault and responsibility.

In connection with the above, any form of use of this report for any purpose other than air accidents and serious incidents prevention, can lead to wrong conclusions and interpretations.

This report was drawn up in Polish. Other language versions may be drawn up for information purposes only.

Warsaw 2011

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GENERAL INFORMATION

Occurrence :	**ACCIDENT**
Type and model of aircraft :	**Parachute Black Hawk 265**
Aircraft registration marks:	**Not applicable**
Aircraft commander :	**Student skydiver**
Flight organizer :	**Aeroklub Warszawski**
Aircraft user :	**Aeroklub Warszawski**
Aircraft owner :	**Aeroklub Warszawski**
Place of the incident :	**Chrcynno near Nasielsk**
Date of the incident :	**25 June 2009; 14:22 hrs LMT**
Damage to the aircraft :	**minor**
Injuries to persons :	**fatal**

SYNOPSIS

On 25 July 2009, a student skydiver left Cessna 208B airplane at FL 133. It was her 21st parachute jump in life. After separation from the airplane at estimated altitude about 300 - 200 meters she was observed by several persons present in the area. She was seen as falling down with a closed parachute. Nobody noticed opening a parachute during the observed portion of the fall. Observation of the final portion of the student fall (approximately below 100 m) was obstructed by trees. The student skydiver collided with the ground about 850 meters from the manifest, suffering death on the spot.

Investigation of the occurrence was conducted by the SCAAI Investigating Team in the following composition:

Tomasz Kuchciński	- Investigator-in-Charge;
Agata Kaczyńska	-Team Member;
Bogdan Fydrych	-Team Member;
Jacek Rożyński	-Team Member;
Ryszard Rutkowski	-Team Member;
Stanisław Żurkowski	-Team Member;

During the investigation, the SCAAI determined the following causes of the air accident:

1. Failure to open main canopy by the student skydiver because of unknown reasons;
2. Failure to open reserve canopy by the student skydiver because of unknown reasons.

3. Malfunction of AAD which resulted in failure to cut the closing loop of the reserve canopy container.

The State Commission on Aircraft Accident Investigation, taking into account the evidence gathered during the investigation, the fact of publishing Service Bulletin SB AMMO050910/4 by the „Argus" AAD manufacturer, and information of the manufacturer concerning quality improvement of the cutters, have made one safety recommendation.

Commission Comment:

Taking into account the findings contained in this report, it should be noted that persons practicing parachute jumps should, in accordance with applicable procedures open main canopy, or if necessary reserve canopy at appropriate altitude, and AAD should be treated only as a back up device.

1. FACTUAL INFORMATION.

1.1. History of the occurrence.

On 25 July 2009, at the airfield Chrcynno near Nasielsk the student skydiver participated in parachute jumps organized by Aeroklub Warszawski. Upon arrival at the airfield, she met with an instructor who trained her in the previous jumps, and agreed that the instructor would be supervising her jumps also on 25 July 2009. Then the student skydiver was entered on the list of participants of the 10th flight of an airplane. During preparation for the jump, the instructor discussed with the student her task (AFF-8), which covered exit from the aircraft, simulating opening of the main canopy, and then perfecting a belly down fall and performing left and right rotations by 90 degrees in the horizontal plane. Parachute opening was planned at the height of 1500 m, but not lower than 1300 m.

The student took parachute from packing room and put it on. The instructor verified the correctness of parachute and AAD setting. The AAD was set in the "Novice" mode. The student set an analogue altimeter to "zero" in the presence of the instructor. Then the student, along with the other persons scheduled for the flight No 10, went to the airplane. According to the opinion of many persons the behavior of the student, both on land and in the airplane did not deviate from normality. During climb, the student and the instructor compared indications of their altimeters. The instructor did not notice significant differences between them.

The student left Cessna 208B airplane with registration marks N-854BF on FL 133. According to the records in her personal logbook, it was 21st parachute jump in her life.

According to the findings of the Commission, until estimated height about 300 – 200 m AGL the student was not observed either from land or from the air. When the student reached height about 300 - 200m AGL, witnesses present in the area of manifest noticed that she was falling in a belly down position with a closed parachute. Some of those witnesses noticed that she completed a partial rotation or rotations in the horizontal plane. Nobody noticed opening a parachute during the observed portion of the fall. Below the altitude of about 100 m the observation was obstructed by trees. The student collided with the ground about 850 m from the manifest, suffering death on the spot.

Upon arrival at the accident scene the SCAAI Investigating Team found the student skydiver lying face down, with her right hand in the area of stomach and the fingers clenched around the main canopy pilot chute. The main canopy container was closed by a pin inserted properly, part of the bridle was under the right side flap of the main canopy container, the reserve canopy container was open, and the AAD cutter was

ejected from the flexible holder situated on the flap of the reserve canopy container. (Photo 1).

Photo 1. Outer part of cover.

- *Green arrow points the opened container of the reserve canopy;*
- *Blue arrow points AAD cutter ejected from the flexible holder;*
- *White arrow points the pin closing main canopy container;*
- *Yellow arrow points a part of the bridle situated under side flap of the main canopy container.*

The reserve canopy was outside of the container, partially pulled out of the free bag. The reserve canopy lines were situated in the axis of the student's body. The lines were completely stretched. The reserve canopy slider was in its highest position. The bridle was wrapped around lines near to canopy base. The further part of the bridle turned about 45 degrees left from the direction of lines and canopy. The reserve canopy pilot chute was not damaged, and its spring was not trapped. The reserve canopy did not seem to be inflated even partially during the jump. (Photo 2).

Photo 2. Reserve canopy partially pulled out of a bag and lines wrapped by bridle.

AAD cutter was in its closed position what indicated, that AAD had been activated. The cutter was ejected from the flexible holder which was situated next to the grommet of the flap of the reserve canopy container (Photo 3).

Photo 3. AAD cutter. White arrow points a hole in the cutter body closed by knife.

Reserve canopy container closing loop was separated (Photo 4 and 5). The upper part of the loop was still on a pin. Photo 4 shows a thread and the rigger seal label. The investigators attention was drawn to the frayed endings of the loop.

Photo 4. Pin of the reserve canopy opening handle and upper part of the closing loop. Green arrow points frayed ending of the separated closing loop.

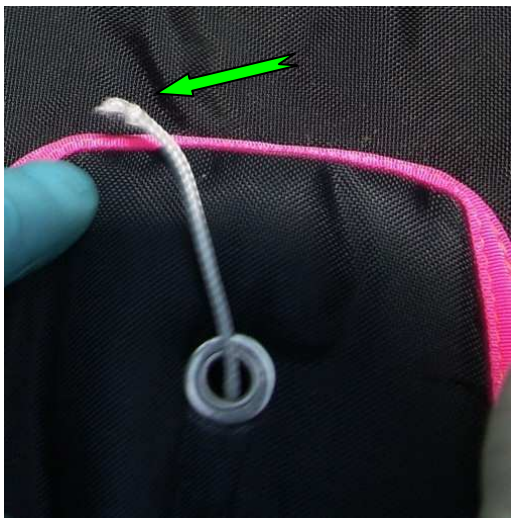


Photo 5. Lower part of the closing loop. Green arrow points irregular, frayed ending of the separated closing loop.

Pin of the reserve canopy opening handle was not bent (Photo 6). The picture was taken after removal of the upper part of the separated closing loop.

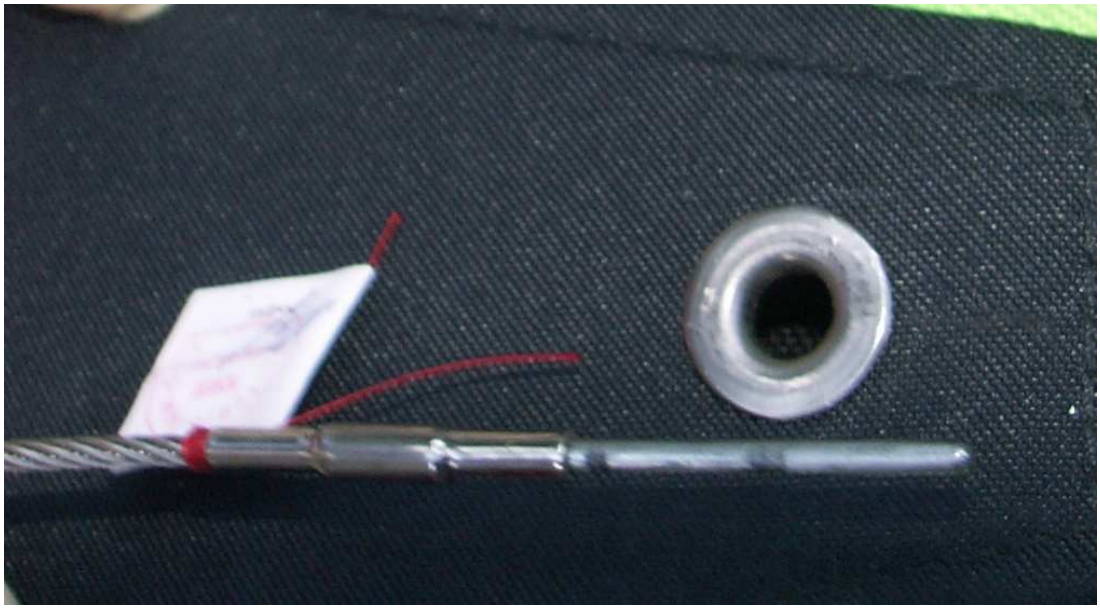


Photo 6. Pin of the reserve canopy opening handle.

Both - main canopy cut away handle and reserve canopy opening handle were not pulled out (Photo 7).

Photo 7. Back part of the harness/container. Visible main canopy cut away handle (white arrow) and reserve canopy opening handle (yellow arrow) - both not pulled out.

The LCD on the control panel of "Argus" AAD was damaged, but on the side part of the display there was a flashing sign (Photo 8).

Photo 8. LCD damage. Blue arrow points a flashing sign.

The student's helmet, in which she performed the jump, was found approximately 1,5 m from her body.

1.2. Injuries to persons.

Injuries	**Crew**	**Passengers**	**Other persons**
Fatal	**1**	-	-
Serious	-	-	-
Minor	-	-	-

1.3. Damage to aircraft.

Only AAD LCD was damaged during the jump.

1.4. Other damage.

None.

1.5. Personnel information (crew data).

On the day of the accident the student skydiver - female, aged 27, performed 21st parachute jump in her life. The first 5 jumps she performed in the Armed Forces. Then, in 2008 she started parachute training with AFF method. In 2008 she performed 9 jumps according to Aeroklub Warszawski Parachute Training Program – tasks AFF-1 - AFF-7. In 2009 she performed jumps according to tasks AFF-7 and AFF-8. Theoretical knowledge check passed on 29 April 2009, valid on the day of the accident.

The student skydiver had a medical certificate Class 3, valid on the day of the accident.

The instructor - male, aged 41, was a licensed commercial parachute jumper with PJIR (static line), AFF, and Tandem ratings. The license and ratings were valid on the day of the accident.

The instructor had a medical certificate Class 2, valid on the day of the accident.

The rigger - male, aged 36, who performed maintenance of the parachute system, had a certificate of aircraft maintenance with parachute rating (as a system). The certificate of qualification and rating were valid on the day of the accident.

The rigger had a medical certificate Class 3, valid on the day of the accident.

A male, who packed the main canopy for the jump was trained to pack main canopy for jump.

1.6. Aircraft information.

Back-back parachute system. Main canopy opening system – bottom of container (BOC). Parachute suitable for parachute training.

Type	Quest DQ	Smart 250	Argus	Black Hawk 265
Manufacturer	Atmosphere Gear	Aerodyne Research Inc.	Aviacom SA	Parachute Laboratories Inc.
Serial number	1428	251626	0 707021 103245	16202
Date of manufacture	March, 2007	3 November, 2005	July, 2007[1]	26 April, 2002
Certification for jumps:	1 October, 2009			1 October, 2009

According to SCAAI estimation, load of the main and reserve canopies recommended by manufacturers was not exceeded.

Parachute system was properly maintained by persons with appropriate qualifications.

The student was equipped with an analogue Barigo altimeter.

1.7. Meteorological information.

a. The accident site was in a high pressure area. Temperature 20,2^{0}C, surface wind 3 m/s from 240 direction. QNH calculated for Legionowo town (located about 18 km South of Chrcynno): 1012,5 hPa. QNH from SYNOP as of 12:00 UTC (14:00 LMT) for EPWA was 1012,6 hPa. QFE calculated for Chrcynno: 999,65 hPa.

b. Meteorological conditions were appropriate for performing training parachute jumps and had no influence on occurence and course of the accident.

1.8. Aids to navigation.

Not applicable.

1.9. Communications.

Not applicable.

1.10. Accident site information.

The student collided with the ground about 850 meters from the "manifest". The fall place was situated 112 m above the sea level. Coordinates of the place: N 52^0 34' 29,5" ; E 029^0 51' 12,9".

1.11. Flight recorders.

Some parameters of the jump were recorded in the „Argus" AAD memory.

[1] The date of manufacture relates to AAD processing unit. The cutter was labeled „*Jan 07*" that is January 2007.

1.12. Wreckage and impact information.

a. On the basis of the nature and location of injuries it can be assumed that the collision with the ground ocurred in the flat position, by the front part of the body, i.e. chest and abdomen, with a slight tilting of the trunk on the right side and a small tilt of the head towards the ground.

b. The collision with the ground occurred at a very high speed.

c. It can not be excluded that after hitting the ground there was a slight forward move of the body, for example, after rebound from the ground.

1.13. Medical and pathological information.

a. The cause of the student death was extensive damage to the vital organs of the body resulting from hitting the ground.
b. During autopsy no lesions were found.
c. Medical examination showed that the student was not under the influence of alcohol or psychoactive drugs.

1.14. Fire.

Not applicable.

1.15. Survival aspects.

The student died at the scene.

1.16. Tests and research.

Visual inspections of the accident site and the parachute system were conducted. An analysis of the student's training process documentation, medical documentation, organization and course of the jump was conducted. The AAD was red out and its operation tests were conducted at the manufacturer location. Tests of the cutter and closing loop of the reserve canopy were conducted in the Central Forensic Laboratory of the Polish Police. Ground operation tests of AAD and its components and assemblies were conducted. Ground trials of the parachute system, its parts and subsystems were carried out. The materials from the District Prosecutor of Pułtusk were used.

1.17. Organizational and management information.

Student was trained according to Aeroklub Warszawski Parachute Training Program approved by the Civil Aviation Office. No deficiencies were found in the training process.

On 9 March 2010, State Commission on Aircraft Accident Investigation published Interim Report on this occurence.

On 19 March 2010, the President of the Civil Aviation Office, on the request of the State Commission on Aircraft Accident Investigation suspended the use of "Argus" AAD.

On 5 September 2010 „Argus" AAD manufacturer issued Service Bulletin SB AMMO050910/2, requiring mandatory replacement of the cutters manufactured before September 2007. The replacement deadline was defined as the day of the next repack of the reserve canopy but not later than 31 December 2010.

Taking into account Bulletin SB AMMO050910/2 and assurance of the manufacturer to SCAAI concerning cutters quality improvement, on 8 October 2010 State Commission on Aircraft Accident Investigation, recommended to the President of the Civil Aviation Office to consider withdrawal of suspension of the use of „Argus" AAD. At the same time the Commission recommended mandatory replacement of the cutters manufactured prior to September 2007 in all „Argus" AAD to be used in the future.

On 7 December 2010 „Argus" AAD manufacturer issued mandatory Service Bulletin SB AMMO050910/3, which extended the period for mandatory replacement of the cutters to the first repack of the reserve canopy after 31 March, 2011.

On 13 March 2011 the Civil Aviation Office issued Airworthiness Directive No SP-0001-2011-D, which renewed „Argus" AAD use suspended previously by Airworthiness Directive No SP-0002-2010-D.

On 5 April 2011 „Argus" AAD manufacturer issued mandatory Service Bulletin SB AMMO050910/4, which withdrew mandatory replacement of the cutters placed below the pilot chute of the reserve canopy. Mandatory replacement of the cutters placed above the pilot chute remains in effect according to Bulletin No SB AMMO050910/3.

1.18. Additional information.

The following organizations were informed about their right to acquaint with the Draft Final Report:

- Training Organizer – Aeroklub Warszawski;
- Instructor, who supervised the jump of student skydiver;
- Rigger, who assembled the parachute system;
- Rigger, who serviced the parachute system last time;
- Aviacom company, manufacturer of "Argus" AAD.

None of the entitled (persons or institutions) exercised the right to become acquainted with the Draft Final Report, therefore it was assumed that no comments to the Report were made.

1.19. Useful or effective investigation techniques.

Examination of the mechanism separating fibers of the closing loop of the reserve canopy container was conducted to determine the cause of failure to open of the reserve

canopy. Comparative metallographic tests of cutters were also performed - cutter secured at the scene and comparative cutters. The tests were conducted with the methods previously recognized and applied, but for the first time in Poland in the parachute accident investigation. The tests were conducted by the Central Forensic Laboratory of the Polish Police.

2. ANALYSIS.

Student skydiver training level

The investigated jump was a perfecting one according to Aeroklub Warszawski Parachute Training Program – task AFF-8. According to the instructor, in the first jumps performed in 2009, the student was falling flat, but she performed uncontrolled slow rotations in the horizontal plane. In subsequent jumps, conducted under supervision of the same instructor, uncontrolled rotations were eliminated. The student mastered such figures as loop and barrel-roll, followed by switching to flat fall. In the opinion of the instructor, the student always controlled the height and opened parachute within the prescribed limit of 1500 - 1300 m. In the opinion of the Commission, the training level of the student was adequate to perform the jump according to task AFF-8.

Medical factors

Due to the fact that during autopsy no pathological changes were found, and the tests showed that the student was not under the influence of alcohol or psychoactive drugs, it must be assumed that the student skydiver was a healthy person and her medical condition had no influence on the occurence and course of the accident.

Course of the jump

According to the instructor, student correctly exited the aircraft at 4000 m AGL. It has not been determined, at which altitude the student skydiver pulled out the pilot chute of the main canopy. However, taking into account the fact that at the scene the part of the bridle connecting the main canopy with the pilot chute was still (though, it should be noted it was not blocked there) under the right flap of the main canopy container (Photo 1), it can not be excluded that the student pulled out the pilot chute at relatively low height, about 300 - 200 m AGL. Some witnesses noticed at that moment a partial rotation or rotations of the student body in the horizontal plane. Partial rotation during the pilot chute pulling out happens to less experienced skydivers. The Commission also considered the hypothesis that the student skydiver pulled out the pilot chute at the right height about 1500 – 1300 m AGL. In this case the Commission came to the conclusion that if this was the case, the air pressure most probably would pull out the whole bridle connecting the pilot chute with the main canopy. It can not be excluded that the air pressure could also pull out the pin, which blocked opening of the main canopy container.

During investigation into the accident, no medical or technical factors, or deficiencies in the training process were found, which could influence the fact that until the impact with the ground the student had not released the pilot chute from his hand and not pulled out the handle to open the reserve canopy.

Parachute system

Note: The studies and experiments described in this report were conducted only for the purpose of accident investigation, and may not be used by anyone for any other purpose, e.g. equipment certification.

a) Main canopy.

Visual inspection proved that the canopy was fit for jump. Position of the bridle was correct. The pilot chute and bridle were not found to be wrapped around the student hand or any part of the parachute or equipment. The pin closing the main canopy container was placed correctly. It was determined that if the student would had released the pilot chute, the main canopy container would had opened without any problem. Technical condition of the canopy and its folding did not indicate any possibility of improper opening or the possibility of any subsequent control problems.

b) Reserve canopy

Visual inspection proved that the canopy was not damaged. Technical condition of the canopy and its folding did not indicate any possibility of improper opening or the possibility of any subsequent control problems. Having analyzed on the scene the canopy condition, the Commission concluded that after collision with the ground and breaking the closing loop, the reserve canopy was moved out of the container by inertia. In the initial phase the pilot chute and bridle were pushed by the canopy inside the free bag. Probably then a part of the bridle was displaced under the free bag, what caused its wrapping around lines. Next, the moving canopy caused the lines to release and stretch. After the lines were stretched, the free bag partially slipped off the canopy. The pilot chute during its movement tightened the bridle around upper parts of the lines with the moderate force.

Having investigated many parachute accidents, the Commission found one similar ocurrence. This case (No 5/96) ocurred on 27 July 1996 at Krywlany airfield (EPBK). During this event, with the main canopy closed, the jumper in the flat, belly down free fall collided with the ground at high vertical speed. Commission investigating this accident concluded, inter alia, that during collision with the ground the reserve canopy closing loop broke and the reserve canopy moved out of the container and lines were fully released and stretched in the jumper body axis.

c) Harness/container

Visual inspection on the scene proved that the harness/container (including main canopy pilot chute pocket), were in the appropriate technical condition. Reserve canopy opening handle could be pulled out of the pocket without any difficulty. Cord had no splinters and moved freely in the protective hose. The reserve canopy opening handle pin was not bent (Photo 6), suggesting that at the time of the closing loop separation no major lateral forces acted on the pin. The endings of the separated closing loop were frayed, suggesting the need for an expertise to explain the way of the loop separation.

During investigation, the maufacturer of „Argus" AAD indicated, that the minimum force of the reserve canopy pilot chute spring (necessary for proper cutting of the closing loop by "Argus" AAD) should be 5 kG. During the conducted tests it was determined that in the case of the pilot chute found on the scene this force was over 5 kG. It should be noted, that neither *Argus AAD user manual* nor *Riggers Argus installation guide* valid on the day of the accident did determine the minimum force of the reserve canopy pilot chute spring. Such a requirement was introduced by the "Argus" AAD manufacturer into *Riggers Argus installation guide* version 1.4 dated 6 December 2010.

The "Quest" harness/container Manual also did not require testing the minimum force of the reserve canopy pilot chute spring.

Due to reservations of "Argus" AAD manufacturer concerning the scope of the conducted tests some additional trials were conducted. Their aim was to check operation of the parachute system involved in the accident. The trials were conducted several months after the accident, when organic remains on the parachute were naturally neutralized.

Due to lack of the manufacturer data concerning recommended canopy volume for which "Quest" harnes/container system was designed, it was decided to conduct test of interaction between "Quest" rig and Smart 250 reserve canopy with the Black Hawk 265 canopy inserted into the container of the main canopy.

In the course of the trials it was found that to pull the reserve canopy (weighing 3 kg) out of the container, the required force was 71 N (7,2 kG). The canopy could be pulled out of the container without any problem.

Given the trials results and the fact that on 28 March 2009, the same parachute was involved in the incident 162/09, in which, after the main canopy cut away, the reserve canopy was opened correctly, the Commission did not find any reason to conclude that during the accident might have existed any circumstances (such as insufficient capacity of the upper container for holding the canopy), which could had caused blockage of the reserve canopy in the container or delay its pulling out of the container.

The subsequent trials related to verification of assembly and compatibility of "Quest" rig and "Argus" AAD, including verification of opening of the reserve canopy equipped with "Argus" AAD. Instead of "Argus" AAD involved in the accident, another identical "Argus" AAD was used for testing and visual inspections. It was equipped with cutter labeled *"Jan 07"*.

Manufacturer of the "Quest" rig provides in its manual[2] several examples of the length of the reserve canopy container closing loop, ranging from 13 to 15 cm. It was recommended that the loop length should be measured starting from the knot on line. When choosing length of the loop the rig manufacturer recommended taking into account the volume of the reserve canopy, the rig size and the way of inserting the reserve canopy into the container. When testing compatibility of the rig and AAD, the "Argus" AAD manufacturer recommended to apply average loop length recommended by the rig manufacturer.

In the absence of data ("Quest" rig manufacturer did not provide the full range of loop length, but only the sample length), the AAD manufacturer recommended to determine the loop length based on a user experience. For this reason, a rigger involved in the trials, based on his own experience, adopted a loop length of 140 mm. Loop length, as recommended by the manufacturer was measured from the knot on the loop.

During the trials, when packing canopy the rigger purposefully did not take special care in order to enable to monitor the operation of a parachute in case of errors, which might have been made when packing reserve canopy for the jump. The trials were carried out with the following closing loop lengths: 119 mm (85%), 126 mm (90%), 140 mm (100%), 154 mm (110%), 168 mm (120%), 182 mm (130%) 196 mm (140%), and 210 mm (150%). Loops were made of the original cords coated with silicone supplied by Airtec GmbH - manufacturer of "Cypres" AAD.

The course and results of the trials were as follows:

- AAD installation
    - There was no instruction of AAD installation in the Quest harness/container manual in Russian. For this reason, the installation was carried out by analogy to similar rigs of other manufacturers. AAD wires length was sufficient to complete the installation.
    - It was found that the "Argus" AAD processing unit fits into reserve canopy container pocket.

[2] Quest harness/rig unit manual in Russian was delivered by Atmosphere Gear company on the Commission request.

- It was found that the holder flexibly holds "Argus" AAD cutter in place. It was noted that the end of the holder closer to grommet was located about 1,5 cm from the edge of the grommet.
- Control unit pocket fit to "Argus" AAD control unit and ensured appropriate visibility of LCD display.

- Practical trials of the reserve canopy container opening with AAD installed. Manual opening.
  - Loop length of 119 mm; two trials were made. Due to small length of the closing loop, the container closure was very difficult and required participation of two persons.
    - During the first trial a part of the pilot chute was trapped in the upper left area of the container. It was found that the cause of improper opening was improper (too wide) folding of the pilot chute fabric by a rigger. No circumstances or evidence were found, which would suggest that a similar mistake had been made during folding of the reserve canopy prior to the investigated jump.
    - During the second trial, for which the reserve canopy was packed strictly with the manufacturer recommendations, the container opening was correct.
  - Loop length of 126 mm; the container opening was correct.
  - Loop length of 140 mm; the container opening was correct.
  - Loop length of 154 mm; the container opening was correct.
  - Loop length of 168 mm; the container opening was correct.
  - Loop length of 182 mm; the container opening was correct.
  - Loop length of 196 mm; the container opening was correct.
  - Loop length of 210 mm; although the loop was much too long for the normal operation of the parachute, the container opening was correct.
- Inspection of the closing loops in terms of damage was done after each folding cycle.
  - None of the closing loops showed signs of damage.
- Inspection of AAD cutter.
  - Cutter did not show any damage after 9 openings of the container.

As a result of the conducted trials no disruption was found in the process of opening of the reserve canopy container, provided that packing technique recommended by the container manufacturer was applied. No influence of the placement of the cutter holder on container opening process was found.

- Test of the reserve canopy container opening by AAD cutter.
    - After closing of the reserve canopy container by 210 mm (150%) closing loop the „Argus" AAD cutter labeled „*Jan 07*" was activated.

<u>During the trial a video recording was made; this is Annex 1 to the Final Report.</u>

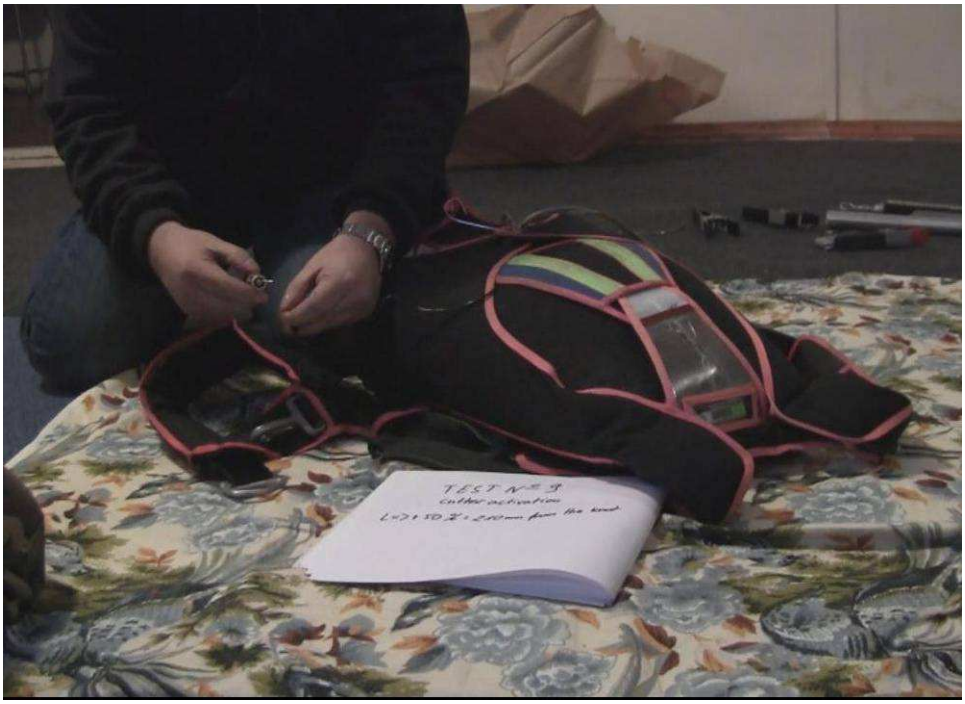


Photo 9. Parachute view prior to cutter activation.

Photo 10. Parachute just after cutter activation. The reserve canopy container was still closed.

Photo 11. The parachute condition just after pulling out the pin closing the reserve canopy container.

Photo 13. After the last flap was partialy pulled aside, it was found that the closing loop was trapped by the cutter, which blocked opening of the container. When flap was being pulled aside the cutter was gradually going out of the holder.

Photo 14. Visible location of the cutter over pilot chute. When the last flap was being pulled aside the cutter was further going out of the holder.

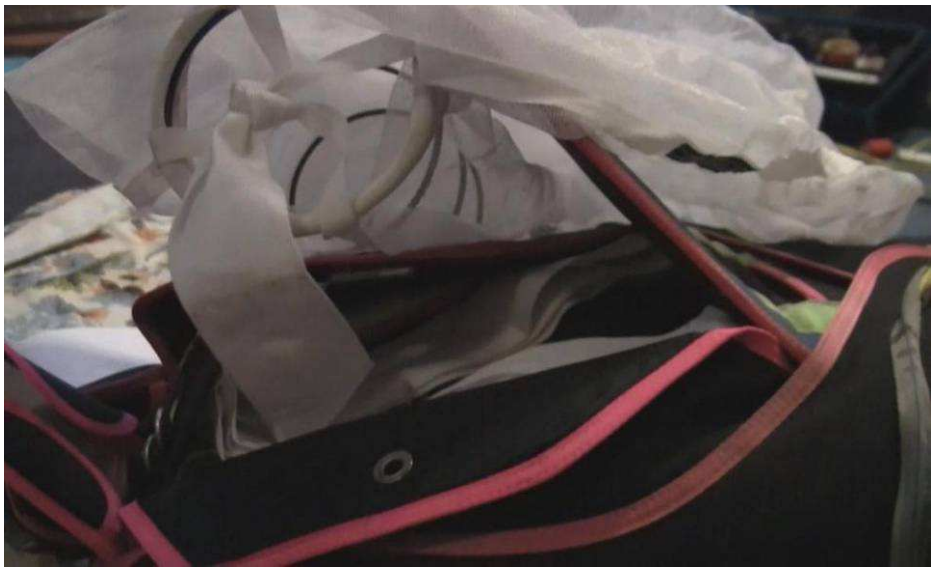


Photo 15. After manual breaking of the closing loop the pilot chute was ejected by its spring.

Photo 16. Upper part of of the closing loop, manually broken. The photo shows, that the cutter cut only a part of the fibers.

Photo 17. Visible fibers of the upper part of the closing loop, protruding from the cutter.

Photo 18. The visible part of the closing loop was trapped inside the cutter.

Photo 19. View of the reserve canopy container after the pilot chute was moved aside.

Photo 20. Close-up of the lower part of the closing loop. Frayed fibers endings are clearly visible.

Photo 21. Visible the cutter label fastened to the wire.

During the trial it was found, that AAD cutter was located directly over the metal grommet at the top of the pilot chute. It follows that location of the cutter holder did not affect the movement of the cutter. Closing loop was blocked by the activated cutter so that removal of the releasing handle pin did not cause opening of the reserve canopy container. When the last flap was being pulled aside the cutter was gradually going out of the holder. The cutter was fastened to this last flap.

According to the Commission, the conducted trial of opening of the reserve canopy container by activating the cutter, allowed to retrace the sequence of operations of the parachute and "Argus" AAD cutter as occurred during the investigated accident. Particular attention was drawn to the appearance of the broken closing loop and the fact that cutter went out of the holder.

d) AAD

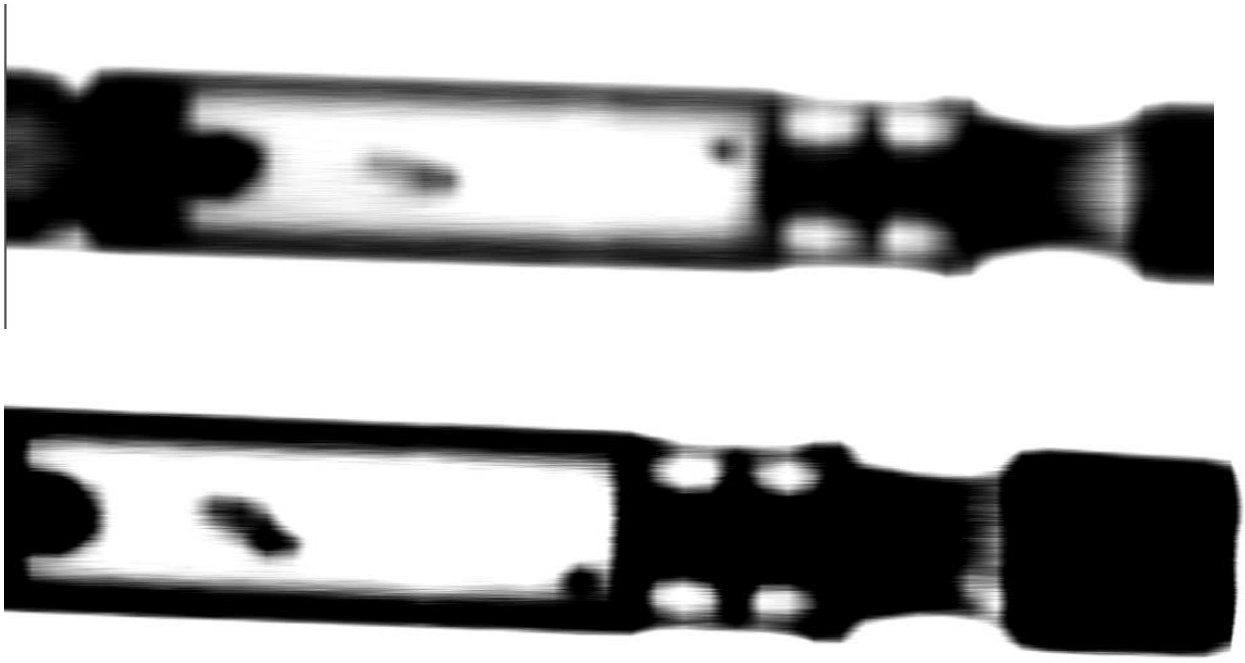
During the accident investigation a number of activities were carried out. They were connected with verification of the correctness of operation of "Argus" AAD involved in the accident.

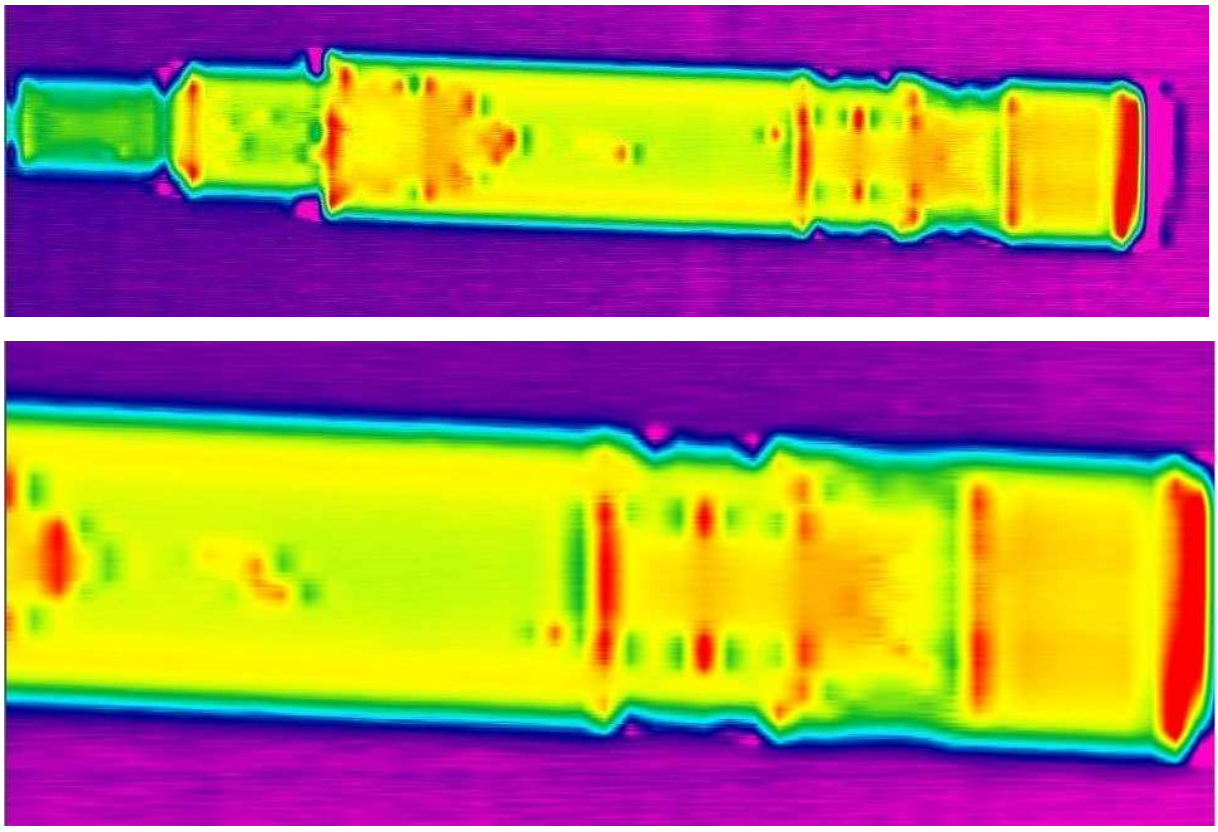
At the accident site it was found that the holes in the body of the cutter, labeled *"Jan 07"* were closed by knife (Photo 3), which indicated that the propelling charge was activated and worked. LCD screen on the control unit was damaged (Photo 8). In the Commission opinion this damage occurred during collision of the student with the ground. Despite the damage, the screen displayed a sign, which indicated that the AAD had been switched on. The processing unit had no external damage.

On 30 July 2009, in the presence of SCAAI member some tests of AAD were carried out by its manufacturer - the Aviacom SA company. Visual inspection of the device was carried out, the data from the memory was red out and AAD operation in the low pressure chamber was checked. A copy of data retrieved from the AAD memory was handed over to the SCAAI representative.

In the presence of the Commission member, the manufacturer demonstrated operation of two cutters labeled *"Jun 09"*. One cutter cut a non-tensed loop while the other cut a loop tensed with the force of 2 kG. Both loops were cut completely and evenly.

X-rays of the cutter were made prior to its further tests.





Photos 22-25. X-rays of the cutter secured at the accident site.

No foreign metallic objects were found between the knife and the bottom of the cutter body.

In the process of further investigation more tests of closing loops and cutters were carried out. These tests were commissioned by SCAAI to the Central Forensic Laboratory of the Polish Police. They included examination of the loop and cutter secured at the scene and the loop and cutter which were used during the demonstration by the manufacturer.

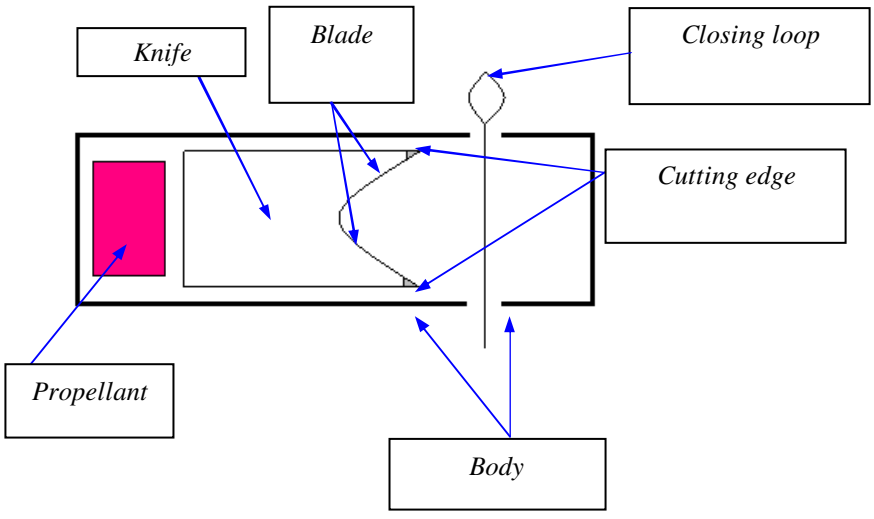


Fig.1. Diagram of the "Argus" AAD cutter.

As the result of the tests it was determined:

- The closing loop of the reserve canopy container, secured at the scene, was made of the same material as supplied by the manufacturer of the "Cypres" AAD and was coated with the same substance (acid-free silicone), as supplied by the "Cypres" AAD manufacturer. This fact proves that the rigger, who packed the reserve canopy met the requirements stipulated in paragraph 1.1 of AAD *User Manual* and paragraph 4.1 of *Riggers Argus instalation guide*, both issued by "Argus" AAD manufacturer.
- Examination of the loop used by the manufacturer for demonstration showed that the endings of the cut loop were even, with slightly molten tips. The result of this trial showed that the loop properly cut should have even endings.
- Careful visual inspection of the cutter secured at the scene revealed white fibers on both sides ot the cutter. (Photo 22).

Examination of the loop secured at the scene revealed that the endings of the fibers had been separated into different lengths. Shorter fibers endings had been cut, and the longer torn and molten. It indicated that during operation of the cutter (when its knife was moving) the loop passing through its holes was cut only partially. The rest of the loop was separated by stretching and squeezing them between the knife blade and the bottom surface of the cutter body (Photo 27).

The Commission opinion is that the collision of the student with the ground caused similar course of event as described above (the closing loop only partially cut, was torn as a result of impact).

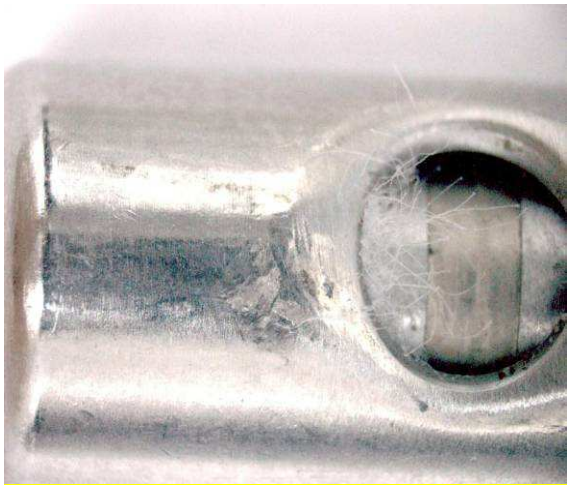


Photo 26. Visible fibers of the closing loop protruding from the hole of the cutter secured on the scene.

Photo 27. Closing loop secured on the scene (partially cut and partially torn).

- Examination of the cutter knife secured at the scene revealed that the knife blade is damaged (deformed plastically) in line with the cutter body holes (Photo 28).
- Examination of the knife of the cutter used by manufacturer for demonstration revealed no damage (Photo 29).
- Examination of the cutter used by manufacturer for demonstration revealed on the knife (close to its blade) a material from the inner part of the cutter body (Photo29). Such material was not found on the knife blade secured on the scene, which indicates that in that case the knife blade did not hit the inner part of the cutter body (Photo 28).

Photo 28. Cutter secured on the scene. Knife view from the blade side. Red arrows indicate damage to the cutting edge of the knife blade.

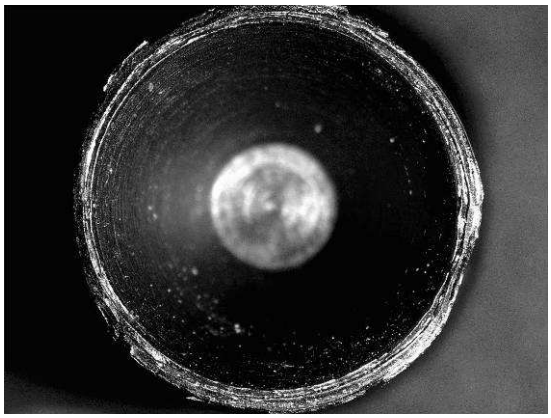


Photo 29. Cutter used by the manufacturer for demonstration. Knife view from the blade side. Material from the body bottom visible on the cutting edge of the knife blade.

- Examination of the cutter used by manufacturer for demonstration revealed circular indentation on the body bottom corresponding to the knife diameter (Photo 31).
- Examination of the cutter secured at the scene did not reveal circular indentation on the body bottom corresponding to the knife diameter (Photo 30).

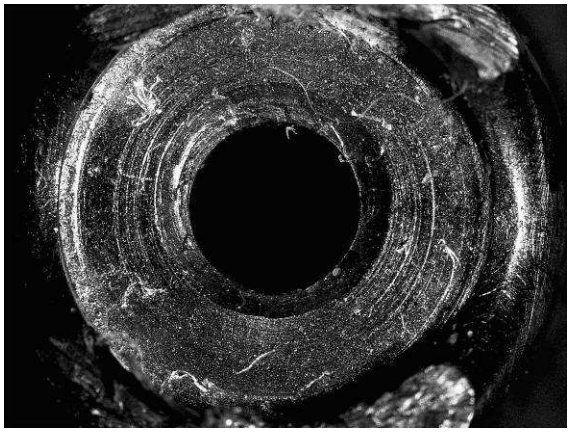


Photo 30. Body bottom. Lack of indentation corresponding to the knife diameter.

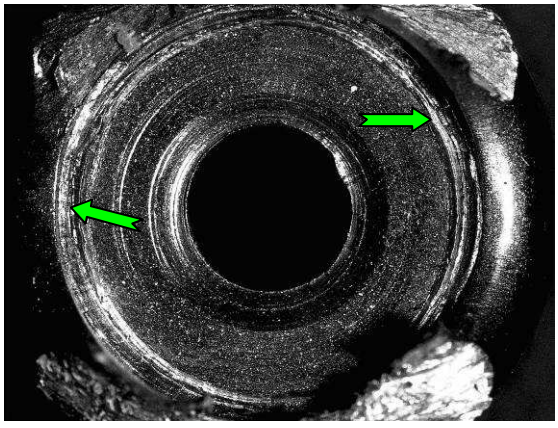


Photo 31. Body bottom. Green arrows indicate circular indentation corresponding to the knife diameter.

The conducted trials showed that the cutting edge of the knife secured at the scene was damaged during cutting of the loop fibers. However, not all fibers were cut, and the blade did not hit the bottom of the cutter body, as evidenced by the lack of a circular indentation in the bottom. Loop fibers which remained not cut held the reserve canopy container in the closed position. Complete separation of the closing loop occurred due to G-force, that is, at the time when the student crashed into the ground.There was an experimental activation of the "Argus" AAD cutter conducted in the Central Forensic Laboratory of the Polish Police. For the experiment purpose the cutter was marked MP-5. It was from the same production lot as *"Jan 07 ",* which was secured at the scene.

Photo 32. MP-5 cutter used for trial tensed with the force of 5 kG.

The experiment was recorded and the video recording is attached as Annex 2 to the Final Report. The cutter was immobilized, and a typical closing loop was inserted into the cutter hole. It was made of the same material as supplied by the "Cypres" AAD manufacturer and coated with the same substance (acid-free silicone), as supplied by "Cypres" AAD manufacturer.
The loop was tensed with the force of 5 kG to meet the manufacturer requirements concerning the proper tension of the loop.

After connecting the power source - battery typical for "Argus" AAD - the propellant was initiated and the knife moved in the direction of the loop.

Photo 33. View of MP-5 cutter and the loop prior to propellant activation.

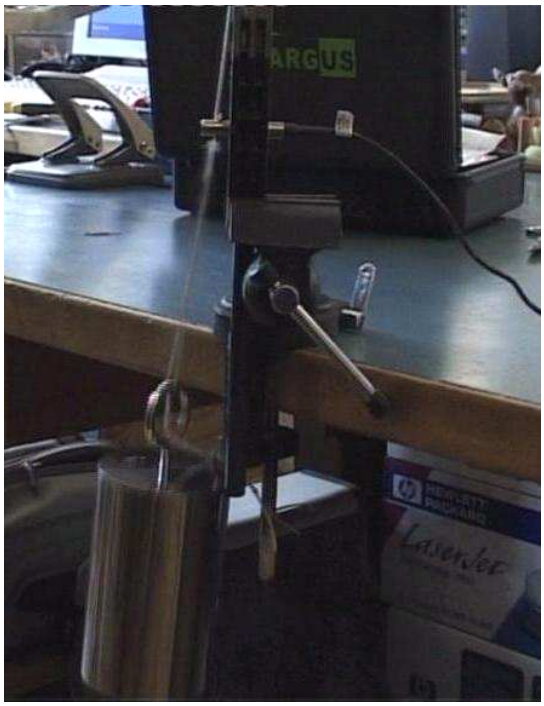


Photo 34. View of MP-5 cutter and the loop at the moment of propellant activation.

Photo 35. View of MP-5 cutter and the loop just after propellant activation.

Photo 36. Subsequent view of MP-5 cutter and the loop just after propellant activation.

As a result of the cutter operation the weight slided down the loop, but part of the loop fibers were not completely cut.

Photo 37. View of the MP-5 cutter and the loop just after propellant activation.

Photo 38. The result of the MP-5 cutter operation.

Photo 39. View of the MP-5 cutter and two parts of the loop after experimental activation of the cutter.

During subsequent examinations of the MP-5 cutter it was found that the cutting edge of the knife blade was damaged in line with the cutter body holes (Photo 40) similarly as the cutting edge of the knife blade secured at the accident site (Photo 28). There was no circular indentation caused by the blade on the body bottom of the MP-5 cutter (Photo 41), similarly as on the body bottom of the cutter secured at the accident site (Photo 30).

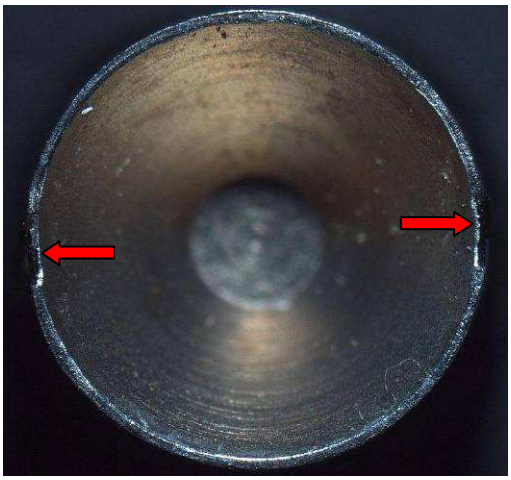


Photo 40. Experimental cutter MP-5. Knife view from the blade side. Red arrows indicate damage to the cutting edge of the knife blade.

Photo 41. Body bottom. Lack of circular indentation corresponding to the knife diameter.

Based on these experiments it was found that the "Argus" cutter labeled in the same way as the cutter secured at the accident site may not completely cut the closing loop made of the material supplied by the “Cypres” cutter manufacturer, despite the loop tensing force of 5 kG.

The next trial was aimed at determination whether the knife was not subject to excessive friction in the body during propellant activation. Examination of the inner surfaces of the body of the cutter secured at the accident site and the comparative cutter showed that the traces found on these surfaces were similar, and were caused by the burning propellant and displacement of the products of its combustion along with the moving knife (Photo 42). It follows that during activation of the cutter secured at the accident site the knife was not seized up in the body.

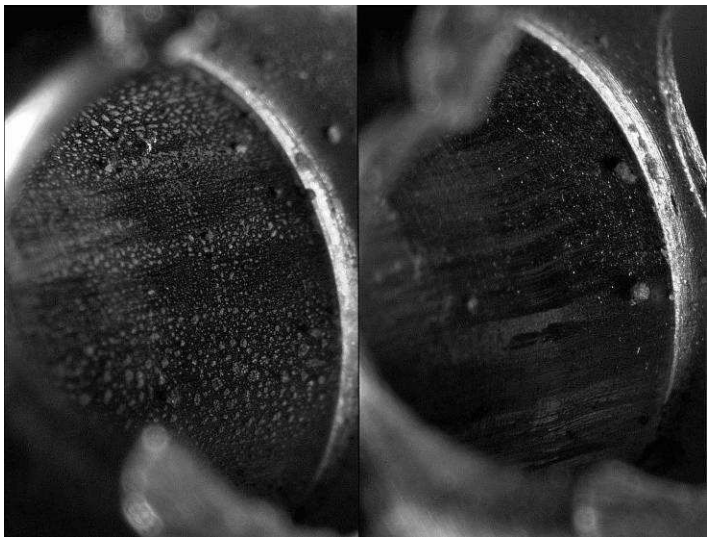


Photo 42. Inner surfaces of the body of the cutter secured at the accident site and the comparative cutter.

Next the metallographic examinations were performed. The following cutters were examined:

- One cutter secured at the accident site - manufacturer label „*Jan 07*" - which was marked MD-1 for examination purpose;
- Two comparative cutters - manufacturer label „*Jun 09*" - which were marked MP-1 and MP-2 for examination purpose;
- Three comparative cutters - manufacturer label „*Jan 07*" - which were marked MP-3-I, MP-3-II and MP-3III for examination purpose;
- One comparative cutter - manufacturer label „*Jan 07*" - which was marked MP-5 for examination purpose (this cutter which was activated with the tensing force of 5 kG - Photos 32-39).

During examinations, the cutters bodies were cut open in order to determine the structure and hardness of the knife steel of the cutter secured at the accident site and six knives of the same type, provided as reference material. While the bodies were cut open, their knives were pushed out of the cutters bodies. This was caused by rapid decompression of gases produced as a result of combustion of propellants and contained in the bodies. This meant that the cutter secured at the scene, and the reference cutters were hermetic.

The results of metallographic examinations were as follow:

In the knife of the MD-1 cutter (secured on the accident site) the acicular structure was found, characteristic for the martensite (Photo 43).

Photo 43. Structure of the MD-1 cutter knife steel. Magnification 200 x.

In the knives of MP-1 (Photo 44) and MP-2 (Photo 45) cutters (comparative), the structure of fine grain was found, characteristic for the martensite.

Photo 44. Structure of the MP-1 comparative cutter knife steel. Magnification 200 x.

Photo 45. Structure of the MP-2 cutter knife steel. Magnification 200 x.

In the knives of MP-3-I, MP-3-II, MP-3-III and MP-5 cutters (comparative) the acicular structure was found, characteristic for the martensite (Photos 46-49).

Photo 46. Structure of the MP-3-I comparative cutter knife steel. Magnification 200 x.

Photo 47. Structure of the MP-3-II comparative cutter knife steel. Magnification 200 x.

Photo 48. Structure of the MP-3-III comparative cutter knife steel. Magnification 200 x.

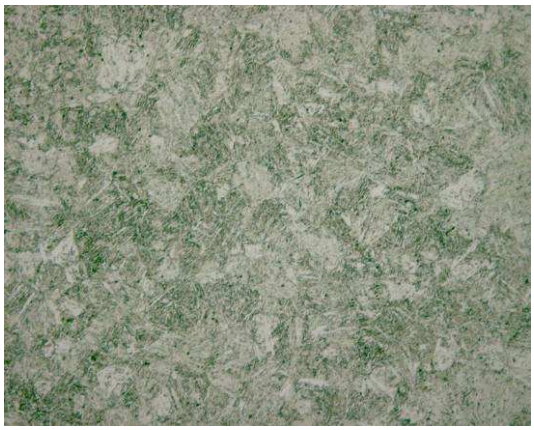


Photo 49. Structure of the MP-5 comparative cutter knife steel. Magnification 200 x.

Based on these examinations it was found that:

- Structure of the MD-1 cutter knife steel (secured at the accident site - manufacturer label „*Jan 07*") with the martensite characteristics and the acicular structure is similar to the of the MP-3-I, MP-3-II, MP-3-III and MP-5 cutters knives steel structures (comparative cutters - manufacturer label „*Jan 07*");
- Structures of the MP-1 and MP-2 cutters knife steel (manufacturer label „*Jun 09*") with the martensite characteristics and fine grains structure had the grain size different from MD-1, MP-3-I, MP-3-II, MP-3-III and MP-5 (manufacturer label „*Jan 07*").

The hardness of the metallografic samples was tested using Vickers method with test load of 0,5 kG. The test was carried out using Vickers scale 54 HV 0,5 with the accuracy of ±15 units. The results from the Vickers scale were converted into Brinell scale and Rockwell scale using Polish standard PN-93/H-04357 "Comparative Tables of hardness and tensile strength".

The hardness test was performed to determine and compare the hardness of the cutter secured on the accident site and six comparative cutters of the same type.

The test results showed that:

- Hardness of the **MD-1** cutter knife (secured on the accident site - manufacturer label *"Jan 07 "*) in the Vickers scale was about **487 $HV_{0,5}$** which corresponds to **451 HB** or **48 HRC**;

- Hardness of the **MP-1** cutter knife (comparative - manufacturer label *"Jun 09"*) in the Vickers scale was about **604 $HV_{0,5}$** which corresponds to **564 HB** or **55 HRC**;
- Hardness of the **MP-2** cutter knife (comparative - manufacturer label *"Jun 09"*) in the Vickers scale was about **594 $HV_{0,5}$** which corresponds to **560 HB** or **55 HRC**;
- Hardness of the **MP-3-I** cutter knife (comparative - manufacturer label *"Jan 07"*) in the Vickers scale was about **531 $HV_{0,5}$** which corresponds to **497 HB** or **51 HRC**;
- Hardness of the **MP-3-II** cutter knife (comparative - manufacturer label *"Jan 07"*) in the Vickers scale was about **513 $HV_{0,5}$** which corresponds to **475 HB** or **50 HRC**;
- Hardness of the **MP-3-III** cutter knife (comparative - manufacturer label *"Jan 07"*) in the Vickers scale was about **516 $HV_{0,5}$** which corresponds to **475 HB** or **50 HRC**;
- Hardness of the **MP-5** cutter knife (comparative - manufacturer label *"Jan 07"*) - which was experimentally initiated - in the Vickers scale was about **473 $HV_{0,5}$** which corresponds to **442 HB** or **47HRC**.

In the BS 970-1:1996 standard, provided to the Commission by AAD manufacturer, the hardness of the knife material was defined to be within the range of 248 - 302 HB (24 - 32 HRC). However, in the Commission assessment it was the hardness of the non-hardened material.

It should be noted that the hardened elements are rated for example in the Rockwell scale within the range of 50-65 HRC. Therefore, the hardness of the MD-1 and MP-5 cutters knives did not fit into the scale of products made of the hardened steel[3].

The test results showed that:

- Hardness of MD-1 cutter knife secured on the accident site (manufacturer label *"Jan 07 "*) was very close to the hardness of the MP-3-I, MP-3-II, MP-3-III and MP-5 cutters knives (manufacturer label „*Jan 07*");
- Hardness of the MP-1 and MP-2 cutters knives (manufacturer label *"Jun 09"*) was significantly higher than the MD-1 cutter knife secured on the accident site.

[3] Test results showed that the hardness of the cutter knife of the shape similar to that used in "Argus" AAD but produced by another manufacturer was 674 $HV_{0,5}$, which corresponds to 634 HB or 59 HRC and the hardness of a wedge-shaped cutter knife of another manufacturer was 796 $HV_{0,5}$, which corresponds to 722 HB or 64 HRC.

The above tests confirmed that the reserve canopy container failure to open was caused by incorrect operation of AAD cutter. Incorrect operation of AAD cutter was caused by low hardness of the cutter knife.

Having analyzed the tests results, the Commission concluded, that after improper operation of the cutter even if the release handle would had been pulled out (which had not been done by the student) it would not had resulted in initiation of the process of the reserve canopy container opening. Such a situation was caused by the cutter (located above the pilot chute) which "trapped" a part of non-cut fibers of the closing loop of the reserve canopy container. These fibers held the pilot chute in the compressed position, blocking opening of the parachute.

The above conclusions, concerning improper operation of the cutter, were on the current basis communicated to the AAD manufacturer – Aviacom SA company.

Moreover, it was found that in the case of placement of the cutter above the pilot chute or below the pilot chute and above the reserve canopy, the described improper operation of "Argus" AAD practically blocks manual opening of the reserve canopy by a skydiver in the following conditions:

- in the STANDARD and SWOOP modes - below 250 m;
- in the NOVICE mode - below 300 m;
- in the TANDEM mode - below 660 m.

It is also possible that if the number of non-cut fibers is small, they would be broken by the pilot chute spring. In such case, however, the reserve canopy opening would be delayed, which could cause a fatal result, taking into account low height of AAD operation.

In the Commission opinion, improper operation of the "Argus" AAD cutter was not foreseeable by the training organizer, that was the AAD owner, or by the rigger who maintained the parachute for the jump, or by the instructor who supervised the student on 25 July 2009.

The AAD manufacturer has made three preliminary reports on results of "Argus" AAD operation tests. The tests were conducted by the manufacturer or on its order. The reports were sent to the State Commission on Aircraft Accident Investigation. Their conclusion was that during the investigated jump AAD was set on NOVICE mode and operated properly. The AAD was activated at the height about 300 m, and the collision of the student with the ground occurred 7 seconds later.

The Commission analyzed the data stored in the AAD memory. The Commission requested the manufacturer many times to explain the meaning of all records, but despite initial promises to the date of this Final Report the manufacturer has not sent the complete information. Only some records was explained by the manufacturer.

In this situation, the meaning of unexplained parts of the records was interpreted by the Commission based on general principles of AAD operation, and the records related to AAD tests in the manufacturer low pressure chamber. Based on the above mentioned information and assumptions, the Commission analyzed the data recorded in AAD memory. In the Commission opinion the records meaning is as follows:

a) *11:18:07*[4] *> [MON_STATE-CHANGED] : [NOV-GROUND] [J=37] : A=-10000m; vspd=-10000km/h; ACorr=0.* According to the Commission, this line relates to AAD switching on on the ground (real time - 07:50); „NOVICE" mode; 37th AAD switching on; altitude (A) and vertical speed (vspd) – real value unknown; height correction - 0m.

b) *17:32:57 > [MON_STATE_CHANGED] ; [NOV-RISE] [J-37] ; A=201m vspd=20km/h ACorr=0.* According to the Commission, this line says that AAD was set on the "NOVICE" mode; identified climb (of airplane); 37th AAD switching on; height 201m; vertical speed 20 km/h; altitude height correction - 0m.

c) *17:49:42 > [MON CUTTER INHIBITED]: Delay 2s.* According to the Commission, this line says that AAD identified pressure surge (suspension of eventual cutter activation for 2 seconds). It was most likely related to the exit of the student from the airplane.

d) *17:49:42 > [MON_STATE_CHANGED]: [NOV-FFALL] [J=37] ; A=3815M vspd=-70km/h ACorr=0.* According to the Commission, this line says that AAD set on the "NOVICE" mode identified: free fall; 37th AAD switching on; height of the student exit from the airplane – 3815 m; vertical speed -70 km/h; height correction 0 m.

e) *17:49:44 > [MON CUTTER REACTIVATED].* The meaning of this line has not been clarified by the manufacturer. The Commission did not interpret the meaning of this line.

f) *17:50:48 > [MON RESET AVG]: sCnt=0 Ref=947,00 Spl=961,40.* The meaning of this line has not been clarified by the manufacturer. According to the Commission, *„Ref=947,00"* means the reference value of 947 hPa which was red by AAD earlier. The value of *„Spl=961,40"*as the value red at *17:50:48* was related to this reference value of 947 hPa.

g) *17:50:50 > [MON_CUTTER_BLOWED]: [NOV-FFALL] [J=37]: A=213m vspd=-209km/h ACorr=0m*. According to the Commission, this line relates to the cutter activation;

[4] After the last battery change, the date and time of the AAD internal clock was not set. For this reason, the retrieved data indicate other date and time than the real date and time of the accident. The time shift was calculated to be 3 h 28 min. Failure to set the date and time did not influence the occurrence and course of the accident.

AAD set on the "NOVICE" mode; free fall; 37th AAD switching on; height 213m; vertical speed - 209 km/h; height correction 0 m.

h) *17:50:52 > [MON_STATE_CHANGED]: [NOV-PARACH] [J=37] A=236m vspd=-62km/h ACorr=0.* According to the Commission, this line says that AAD set on the "NOVICE" mode identified: 37th AAD switching on; parachute opened; height 236m; vertical speed - 62 km/h; height correction 0 m.

i) *17:50:52 > [MON_STAE_CHANGED]: [NOV-FFALL] [J=37]: A=217m, vspd=-72 km/h, ACorr=0m*. According to the Commission, this line says that AAD set on the "NOVICE" mode identified: 37th AAD switching on; free fall; height 217 m; vertical speed - 72 km/h; height correction 0 m.

j) *17:50:53 > [MON_CUTTER_BLOWED]: [NOV-FFALL] [J=37]: A=-194 vsdp=-84km/h ACorr=0m.* According to the Commission, this line relates to the cutter activation; AAD set on the "NOVICE" mode; free fall; 37th AAD switching on; height 194 m; vertical speed - 84 km/h; height correction 0 m.

k) *17:50:56 > [MON RESET AVG]; sCnt=0 Ref=989,60 Spl=1008,7.* The meaning of this line has not been clarified by the manufacturer despite many requests. According to the Commission, *„Ref=989,60"* means the reference value of 989 hPa which was red by AAD earlier. The value of *„Spl=1008,7"*as the value of was red at *17:50:56* and was related to this reference value of 989,60 hPa.

l) *17:50:57 > [MON_STATE_CHANGED]: [NOV-PARACH] [J=37]: A=-1 vspd=-14km/h ACorr=0m.* According to the Commission, this line says that AAD set on the "NOVICE" mode identified: 37th AAD switching on; parachute opened; height -1m; vertical speed - 14 km/h; height correction 0 m.

m) *17:51:09 > [MON_STATE_CHANGED]: [NOV-GROUND] [J=38]: A=-2m vspd=0km/h.* According to the Commission, this line says that AAD set on the "NOVICE" mode identified: on the ground; 38th AAD switching on; height -2m; vertical speed 0 km/h; height correction 0 m.

In relation to the record in line d) concerning the jump height 3815 m (AGL); the Commission compared the data retrieved from AAD memory and the data recorded by altimeters of the two skydivers, who jumped in the same lift. One of the altimeters recorded height 3950 m AGL and the other 3940 m AGL. In addition, a radar record indicated that Cessna 208B airplane with registration marks N-854BF was at FL 133 during the jump. The Commission recognized the radar record as credible because during the whole day of 25 July 2009, Air Traffic Services had no objections concerning altitudes emitted by N-854BF airplane transponder working in "C" mode.

After necessary corrections and calculations, the height of the airplane above ground level (AGL) was obtained. For FL 133 it was 3993 m AGL. After taking

account of tolerance value of ± 90m (300ft) used to determine that Mode C-derived level information displayed to the controller is accurate[5], it was determined that at the time of skydivers exit from the airplane its height must have been within the range of **3903 – 4083 m AGL.**

The heights recorded by the two altimeters: **3940 and 3950 m AGL** were within this range. However, the height of 3815 m AGL recorded by "Argus" AAD was of 88 m or more lower than 3903 m.

For this reason, the Commission could not consider the jump height recorded in the "Argus" AAD memory as the correct one.

Based on the results of the above analysis of the jump height, it could not be excluded that the height indication error generated by the AAD was of the same value during student exit from the airplane and during her fall near the ground. It follows that the height of the cutter activation (213m) recorded in AAD memory should be increased by 88 m or more which would give 301 m AGL or more as the true height of the cutter activation.

In relation to the record in line f); the *"spl"* value of 961,4 hPa gives the height of 335m AGL, taking into account QFE = 999,65 hPa at Chrcynno. After 2s AAD recorded (in line g) the height of 213 m. It means that the vertical speed at that distance was 61 m/s which is close to the value calculated and recorded by AAD at 17:50:50hrs (209 km/h or 58 m/s). The fall speed in the range of 61- 58 m/s at a height between 300 m and 200m seems to be unlikely for the jumper 170 cm tall weighing together with the parachute about 80 kg, falling in the flat position. However, in the absence of precise data on the jumper configuration, the Commission finally could not verify the speed calculated and recorded by AAD.

In line "k)", at 17:50:56 hrs there was recorded inter alia *"Spl = 1008,7",* which the Commission interpreted as QFE 1008,7 hPa recorded by AAD at 17:50:56hrs. Taking into account QFE = 999,65 hPa at the accident site, QFE 1008,7 hPa would correspond to the height of **79,4 m below the ground level.** In the Commission opinion, it can not be excluded, that the record of pressure higher than QFE could have been caused by disruption of AAD operation during collision with the ground. Thus, the jumper collision with the ground probably occurred at 17:50:56hrs.

Therefore, it is probable, that the cutter was activated at the height of about 300m. The collision of the student skydiver with the ground occurred 6s after cutter

[5] ICAO DOC 4444, Item 8.5.5.1.1 „*Verification of level information"*

activation. In this case, the student skydiver speed near the ground could be about 50 m/s, which seems very likely.

Using the data stored in AAD memory, the Commission checked information concerning the jump in Chrcynno on 28 March 2009. During that jump the incident No 162/09 occurred. The same parachute system was used during 162/09 incident and the accident on 25 July 2009. During 162/09 incident, the student (a person other than the one involved in the accident on 25 July 2009), had a problem with control of the main canopy, resulting from tangling steering lines with suspension lines. In that case the student skydiver cut away the main canopy and opened the reserve canopy.

In relation to 162/09 incident the following data was recorded in the AAD memory:

13:24:41[6]>[MON_STATE_CHANGED]: [NOV-GROUND] [J=10]: a=-10000m vspd=-10000 km/h ACorr=0m
16:50:33>[MON_STATE_CHANGED]: [NOV-RISE] [J=10]: A=204 vspd=7km/h ACorr=0m
17:07:30>[MON_CUTTER_INHIBITED]: Delay 2 sec
17:07:31>[MON_STATE_CHANGED]: [NOV-FFALL] [J=10]: A=3981m vspd=-71km/h ACorr=0m
17:07:32>[MON_STATE_REACTIVATED]:
17:08:17>[MON_STATE_CHANGED]: [NOV-PARACH] [J=10]: A=1351m vspd=-71km/h ACorr=0
17:08:36>[MON_STATE_CHANGED]: [NOV-FFALL] [J=10]: A=1137m vspd=-73km/h ACorr=0m
17:08:39>[MON_STATE_CHANGED]: [NOV-PARACH] [J=10]: A=1097m vspd=-44km/h ACorr=0m
*17:08:56>[MON_STATE_CHANGED]: [NOV-**GROUND**] [J=10]: **A=1081m** vspd=-5km/h ACorr=0m*

The above data was interpreted by the Commission as a jump from the height of 3981 m, opening the main canopy at 1351 m, cutting away the main canopy at 1137 m, opening the reserve canopy at 1097 m. The Commission requested AAD manufacturer to clarify the last line, indicating landing at 1081 m, although in fact the landing was at the same height as AAD switching on.

The manufacturer did not explain why AAD recorded such a height, however assured that AAD was ready for further operation and, if necessary it would cut the closing loop of the reserve canopy container. It should be noted that the weather conditions in Poland in March practically could not cause a long horizontal parachute flight (falling speed = 0 m/s), which could have been red by AAD as a landing.

Due to lack of adequate technical documentation and software, the Commission could not verify correctness of operation of AAD processing unit.

[6] After the last battery change, the date and time of the AAD internal clock was not set. For this reason, the retrieved data indicate other date and time than the real date and time of the incident.

3. CONCLUSIONS.

3.1. Commission findings.

a) The student was trained according to the training program approved by the Civil Aviation Office.

b) No deficiencies in the training process were found.

c) The student had the proper and valid medical certification.

d) The student was not under the influence of psychoactive agents.

e) It was not determined why the student did not open the main canopy.

f) It was not determined why the student did not open the reserve canopy.

g) The student died as a result of injuries sustained during a high speed collision with the ground.

h) Meteorological conditions had no influence on the accident occurrence.

i) The parachute system used by the student was appropriate for her.

j) The parachute system was properly maintained. The maintenance was carried out by certified personnel.

k) Parachute system documentation was properly issued and filled in by the riggers.

l) Main canopy opening system worked properly.

m) Reserve canopy opening system worked properly.

n) Reserve canopy container closing loop was cut by AAD only partially, which caused failure to open the reserve canopy.

o) Full separation of the reserve canopy container closing loop occurred only during student collision with the ground as a result of G-force.

p) No foreign metallic objects were found between the knife and the bottom of the cutter body.

q) During activation of the cutter secured at the accident site the knife was not seized up in the cutter body.

r) The reserve canopy container failure to open was caused by incorrect operation of AAD cutter. Incorrect operation of AAD cutter was caused by low hardness of the cutter knife.

s) The Commission found that in the case of placement of the cutter above the pilot chute or below the pilot chute and above the reserve canopy, the described improper operation of "Argus" AAD practically blocks manual opening of the reserve canopy by a skydiver. It is also possible that if the number of non-cut fibers is small, they would be broken by the pilot chute spring. In such case, however, the reserve canopy opening would be delayed, which could cause a fatal result, taking into account low height of AAD operation.

t) Improper operation of "Argus" AAD cutter found during the conducted tests was not foreseeable by the training organizer, that was the AAD owner, or by the rigger, who certified the parachute for the jump, or by the instructor who supervised the student skydiver.

3.2. Causes of the accident.

1. Failure to open main canopy by the student because of unknown reasons;
2. Failure to open reserve canopy by the student because of unknown reasons.
3. Malfunction of AAD which resulted in failure to cut the closing loop of the reserve canopy container.

4. SAFETY RECOMMENDATIONS.

The State Commission on Aircraft Accident Investigation, taking into account the evidence gathered during the investigation, the fact of issuing Service Bulletin SB AMMO050910/4 by the „Argus" AAD manufacturer, recommend that the President of the Civil Aviation Office should suspend the use of „Argus" AAD with the cutters manufactured prior to September 2007 if one of the following circumstances exists:

- the cutter is placed above the pilot chute of the reserve canopy;

- the cutter is placed below the pilot chute and above the reserve canopy;

- AAD is used with a parachute system for a student skydiver;

- AAD is used with a tandem parachute system.

In the course of investigation into the accident the Commission received assurance of the „Argus" AAD manufacturer concerning quality improvement of the cutters manufactured after August 2007. This fact limited the scope of suspension recommended by SCAAI and related to use of "Argus" AAD with cutters manufactured prior to August 2007.

Commission Comment:

Taking into account the findings contained in this report, it should be noted that persons practicing parachute jumps should, in accordance with applicable procedures, open main canopy, or if necessary reserve canopy at appropriate altitude, and AAD should be treated only as a back up device.

5. ANNEXES.

1. Video recording of the test checking correctess of cutting of the reserve canopy container closing loop by "Argus" AAD cutter.
2. Video recording of experimental activation of „Argus" AAD cutter conducted in the Central Forensic Laboratory of the Polish Police.

THE END

Investigator-in-Charge

Signature illegible

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