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Swiss Transportation Safety Investigation Board STSB

Aviation Division

Final Report No. 2254 by the Swiss Transportation Safety Investigation Board (STSB)

concerning the serious incident involving the AgustaWestland AW109SP helicopter, registration HB-ZRS,

on 6 June 2013

Zurich Airport

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Ursachen

Der schwere Vorfall ist darauf zurückzuführen, dass sich das Seil der Rettungswinde hinter der Mutter des Haltebügels verfing und beim Anheben der Last riss.

Als ursächlicher Faktor wurde die Konstruktion der Befestigungseinheit der Rettungswinde ermittelt.

Als beitragender Faktor wurden die eingeschränkten Sichtverhältnisse aus der Arbeitsposition des Windenoperateurs ermittelt.

General information on this report

This report contains the Swiss Transportation Safety Investigation Board's (STSB) conclusions on the circumstances and causes of the accident which is the subject of the investigation.

In accordance with Article 3.1 of the 10th edition, applicable from 18 November 2010, of Annex 13 to the Convention on International Civil Aviation of 7 December 1944 and Article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident/incident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

All information, unless otherwise indicated, relates to the time of the accident.

All times in this report, unless otherwise indicated, follow the coordinated universal time (UTC) format. At the time of the accident, Central European Summer Time (CEST) applied as local time (LT) in Switzerland. The relation between LT, CEST and UTC is:
LT = CEST = UTC + 2 hours.

Final Report

Aircraft type	AgustaWestland AW109SP	**Registration**	HB-ZRS
Operator	Schweizerische Luft-Ambulanz AG, Postfach 1414, 8058 Zurich, Switzerland		
Owner	Schweizerische Luft-Ambulanz AG, Postfach 1414, 8058 Zurich, Switzerland		

Pilot	Swiss citizen, born 1960			
Licence	Airline transport pilot licence helicopter (ATPL(H)), issued by the Federal Office of Civil Aviation (FOCA)			
Flying hours	**total**	4348 hours	**during the last 90 days**	20:49 hours
	on the type involved in the serious incident	292 hours	**during the last 90 days**	7:15 hours

Location	Rega-Center, Zurich Airport (LSZH)		
Coordinates	685 451 / 256 992	**Altitude**	430 m AMSL
Date and time	6 June 2013, 15:05		

Type of operation	Visual flight rules (VFR), technical flight
Flight phase	Hovering
Type of serious incident	Hoist cable break

Injuries to persons

Injuries	Crew	Passengers	Total number of occupants	Others
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	0	0
None	3	0	2	Not applicable
Total	3	0	2	0

Damage to aircraft	Hoist cable and rescue hoist attachment elements
Other damage	None

1 Factual information

1.1 Pre-flight history and history of the flight

1.1.1 General

For the following description of the pre-flight history and history of the flight, the statements of the persons involved were used.

1.1.2 Pre-flight history

A six-month (200-hour) check was carried out on the HB-ZRS helicopter by the Swiss Air-Rescue (Rega) maintenance organisation at Zurich Airport. After concluding this work, it was required to perform a functional check of the rescue hoist which was mounted on the right side of the helicopter (cf. Fig. 1).

The required technical flight for this check was prepared on 6 June 2013. The plan was to lift a test load of 250 kg attached to the hoist cable, to extend the cable to its maximum length and then retract it.

A briefing between the pilot, the hoist operator and the mechanic who was to attach the load was conducted before the flight. This included the following points:

- The precise check flight procedure
- Handling of the test load
- Preparedness to cut the cable
- Procedure in the event of an emergency

1.1.3 History of the flight

At 15:03 on 6 June 2013 the pilot took off in the HB-ZRS helicopter on a technical flight. On board was a hoist operator and on the ground was a mechanic with the prepared load. The mechanic's task was to attach the load to the hoist hook.

After the helicopter took off and climbed to an estimated height of 7 m above ground level, the hoist operator received clearance from the pilot to extend the hoist cable while the helicopter was hovering. The hoist operator extended the cable to approximately 7.5 m. The mechanic on the ground had difficulty attaching the load to the hoist hook, whereupon the hoist operator extended the cable further. After the load had been attached to the hoist hook, the hoist cable was touching the ground. The hoist operator gave the pilot the command to position the helicopter approximately one metre further forward. At the same time, the hoist operator slowly began to retract the hoist cable. When the helicopter was directly above the load, the hoist operator continued to retract the hoist cable and told the pilot that the cable was under tension and that the load could be lifted. According to the statement of the hoist operator, his focus at this time was on what was happening below him and how the cable was being guided on the rescue hoist was outside his field of vision. When lifting the load, the pilot noticed a sudden change in the helicopter's attitude to the left and heard a bang. The hoist operator then informed the pilot that the hoist cable had broken. Up until the cable broke, neither the pilot nor the hoist operator had noticed anything unusual.

After the cable broke, the helicopter pilot hovered in place until he had gained an overview of the situation on the ground. He then landed on the apron at the Rega-Center.

The hoist operator wore gloves and a helmet with a radio while on duty. He was in constant radio contact with the pilot and the mechanic on the ground.

1.2 Personnel information

1.2.1 Hoist operator

The hoist operator's primary function was that of a helicopter mechanic at Rega. After a two-day additional training programme, he was authorised to act as hoist operator on technical flights. He had performed this function for three years. According to his statement, he was engaged for such flights approximately twice per year on type EC145 helicopters and approximately two to three times per year on type AW109SP.

1.3 Meteorological information

1.3.1 General meteorological situation

Switzerland was on the forefront of a trough over the Eastern Atlantic. Pressure differences were small across all altitudes.

1.3.2 Weather at the time and location of the serious incident

There was a weak to moderate Bise wind on the Swiss plateau. The weather was sunny with isolated fair-weather cumulus clouds.

Weather/cloud	Sunny, 1/8 cumulus at approximately 6000 ft AGL[1]
Visibility	35 km
Wind	030 degrees, 7 kt Variable between 340 and 120 degrees
Temperature/dewpoint	23 °C / 8 °C
Atmospheric pressure QNH	1018 hPa
Hazards	None

1.4 Aircraft information

1.4.1 General information

Manufacturer	AgustaWestland S.p.A., Cascina Costa di Samarate, Italy
Type	AW109SP
Characteristics	Twin-engine multi-purpose helicopter with medical equipment
Year of manufacture	2009
Serial number	22202
Operating hours	1129:16 hours
Equipment	Load mirror, rescue hoist
Max. permitted take-off mass	3175 kg
Mass and centre of gravity	Both the mass and centre of gravity of the helicopter were within the limits according to the rotorcraft flight manual (RFM).
Types of operation in commercial and non-commercial use	VFR day / VFR night

[1] AGL – above ground level

Certificate of airworthiness	Issued by the FOCA on 22 June 2010
Airworthiness review certificate	Issued by the FOCA on 3 April 2013, valid till 7 May 2014

1.4.2 Rescue hoist information

Manufacturer	Goodrich
Maximum cable length	88.4 m (85 m available)
Maximum hoist load	272 kg
Hoist load during the technical check flight	250 kg
Total number of hoist operations	702
Total number of times hoist cable used	240
Installation of rescue hoist on HB-ZRS	9 June 2011

The rescue hoist is mounted on the right side of the helicopter above the sliding door. It is attached to the helicopter airframe by means of an attachment assembly (cf. Section 1.4.3).

The rescue hoist is powered by an electric motor. The hoist operator controls the hoist cable via a handheld control unit (control pendant) (cf. Annex 1). The hoist can also be controlled by the pilot via a control unit on the collective. In emergency situations, the cable can be separated by the hoist operator using a manual cable cutter or using a hoist cable squib (explosive device). The pilot can separate the cable by using a hoist cable squib.

Figure 1: Overview of the rescue hoist installation. The picture is of an identical helicopter type.

1.4.3 Rescue hoist attachment elements

Fixed to the rescue hoist attachment assembly is a handle assembly, which consists of a cylindrical handle bar and two flat brackets. The handle assembly is fixed to both sides of the attachment assembly with two bolts and the corresponding nuts. The nuts on all four bolt connections protrude. The nuts (Item 18) are secured with a cotter pin (Item 19). This cotter pin projects approximately 2 mm beyond the nuts. The nuts (Item 29) are mounted without a cotter pin. For detailed information, see Annex 2.

The edges of the two flat brackets of the handle assembly feature a small radius of approximately 1 mm, i.e. the profiles are almost sharp edged.

In the context of the investigation, signs of abrasion were detected on the upper edge of the flat brackets of the handle assembly and on the door frame of identical helicopters of this operator (fig. 2 yellow circle).

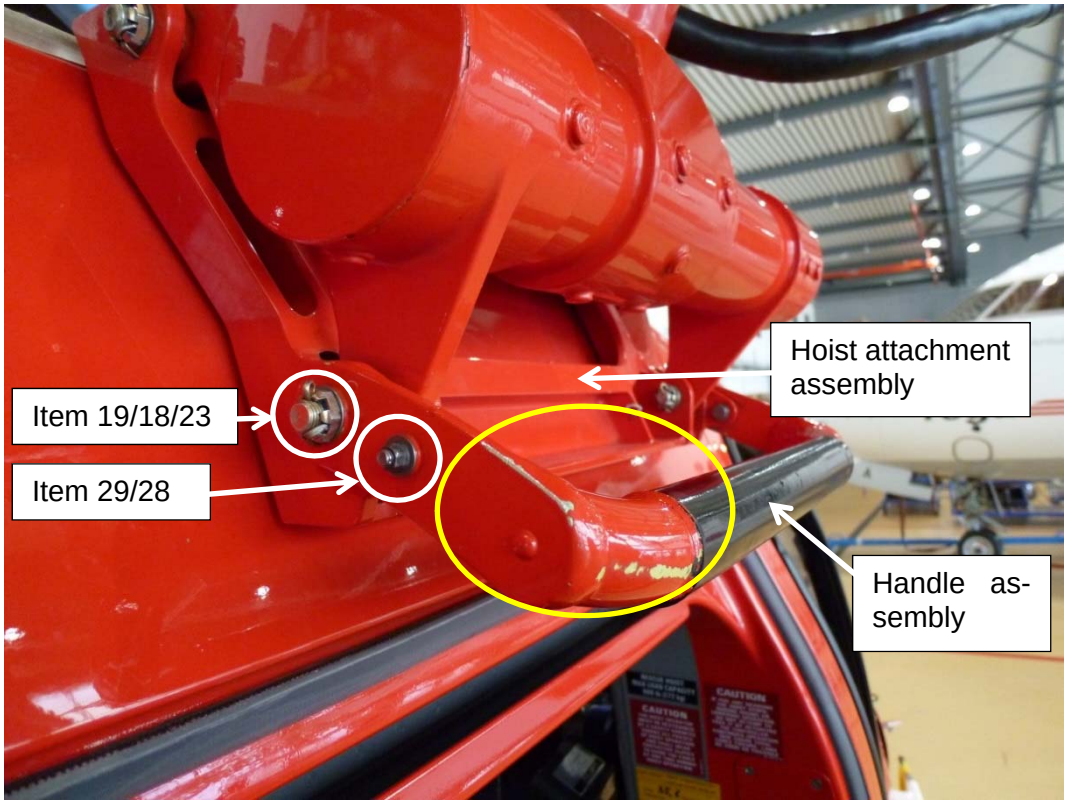


Figure 2: Rescue hoist installation. The picture is from an identical helicopter type.

1.5 Tests and research

1.5.1 Detailed investigation of the handle assembly

After the serious incident, damage was discovered along the upper edge of the aft flat bracket of the handle assembly, as well as on the nut (Item 29) and the corresponding washer (Item 28) (cf. Fig. 3 - 5). This damage was new, because all damaged paintwork on the handle assembly had been touched up the day before.

Visual and microscopic investigations revealed the following:

The imprint of the surface structure of the hoist cable was clearly visible on the damaged edge of the aluminium flat bracket of the handle assembly, on one side of the nut (Item 29) and on the corresponding washer (Item 28).

All this damage indicates that there was contact with the cable under load.

Figure 3: Handle assembly with the damaged flat bracket (for detail, see Figure 4).

Figure 4: Detail of the damaged edge of the flat bracket with the imprint of the surface structure of the cable.

Figure 5: Detail of the damaged nut (Item 29) and washer (Item 28).

1.5.2 Investigation of the hoist cable

1.5.2.1 General

According to the manufacturer's data, the hoist cable is a non-rotating stainless-steel cable with a diameter between 4.78 and 4.87 mm. It consists of 19 strands with 7 wires in each strand, making a total of 133 wires. The breaking load is specified as 14,000 N.

Steel cables that are loaded when kinked or bent have a reduced load-bearing capacity at the point where they are kinked. For example, the load-bearing capacity of a 5-mm cable that is bent over a 5-mm radius (the ratio of the bend radius to the cable diameter is 1) is only approximately 60 % of the effective breaking load. In the case of more extreme bend radii, the load-bearing capacity of the cable is correspondingly lower.

1.5.2.2 Detailed investigation

The breaking point of the hoist cable was approximately at the height of the handle assembly.

Particles of red paint were found at the breaking point of the cable. Stereo-microscopic analysis could not distinguish these from the material of the flat brackets of the handle assembly.

1.5.2.3 Tension test

An intact piece of cable was removed from the broken cable and a breaking load test was performed in the laboratory. The tested section of cable was 4.80 mm in diameter and corresponded to the manufacturer's specifications with regard to materials and construction. The measured breaking load of the cable was 14,715 N.

The specified load-bearing capacity of the cable relates to shock-free loading without a kink.

The load-bearing capacity of the cable is lower in the case of non-shock-free loading or loading with a kink in the cable.

1.6 Additional information

1.6.1 Rotorcraft Flight Manual Supplement

The procedures for the operation of the rescue hoist are described in Supplement 9.2.5, *External Hoist*.

In particular, the following is mentioned:

> "*CAUTION*
> *The hoist operator must always maintain a*
> *gloved hand on the cable to confirm correct*
> *functioning when reeling in and reeling out."*

1.6.2 Standard operating procedures

At the time of the serious incident, standard operating procedures (SOP) Version 3.0 were valid for use of the AW109SP rescue hoist at Rega.

At various points it indicates that the hoist operator must guide the hoist cable with his hand. The hoist operator must wear gloves to prevent injury caused by the hoist cable.

The process for conducting the technical hoist check flight was not described in the SOP.

1.6.3 Visibility from the hoist operator's working position

In order to document the visibility from the hoist operator's working position during operation of the rescue hoist, the relevant working positions were reconstructed on the ground (cf. Fig 6 - 13). The person visible on the photos agreed for the publication and was not involved in the serious incident. The reconstructions included both a normal cable position and a position in which the cable became snagged behind the nut (Item 29). It should be noted that the helicopter was on the ground and that during flight operations the attitude of the longitudinal and lateral axis varies. This has a direct impact on the cable position.

Figure 6: Hoist operator's working position in the case of a normal cable position. The red markings on the step show the limits for the longitudinal position of the hoist cable. They were added after an incident not related with this case based on an airworthiness directive (AD).

Figure 7: Hoist operator's working position in the case of a snagged cable. The lateral cable offset is approximately 15 cm compared to the normal cable position.

Figure 8: Hoist operator's working position in the case of a normal cable position. The hoist operator mainly looks down to carry out operation of the rescue hoist.

Figure 9: Hoist operator's working position in the case of a snagged cable. The cable hangs closer to the step bar compared to the normal cable position.

Figure 10: Required working position of the hoist operator to identify a possibly snagged hoist cable.

Figure 11: The hoist operator must lean forward until he is below the upper door frame in order to be able to see the rescue hoist.

Figure 12: The visible range for the hoist operator if he leans out of the cabin and looks upwards, as illustrated in Figures 10 and 11.

Figure 13: The visible range for the hoist operator if he looks upwards, but does not lean out of the cabin.

1.6.4 Number of systems in use

According to the statement of the helicopter manufacturer, the same handle assembly as in the present case is used on various rescue hoist configurations installed on types A109 and A119. At the end of August 2013, a total of 245 such systems had been installed worldwide.

1.6.5 Risk assessment by AgustaWestland

In the context of the investigation, the manufacturer AgustaWestland was informed of the findings of the investigation and asked to comment. These are as follows:

"A comprehensive review on the subject was hold in AW following the event notification.

(…)

As noted the cable out of position is undoubtedly evident to the Winch Operator that is required to always maintain a gloved hand on the cable to confirm correct functioning during reeling in and out (Ref. AW109SP REGA RFM Supplement 9.2-5).

As reported the cable was retained between the handle connection bolt being looped during the reeling out operation following the hook lying on the ground resulted in cable wide loops.

No other similar cases have been reported.

Cable retaining on the hoist structure should be the consequence of the WOP to not properly maintain the hand on the cable during the operation, nevertheless the wrong cable position is immediately evident and no winch operation are allowed with the cable well outside to the cable position limitation.

A review of the certification activities, including the flight test, confirmed the impossibility for the cable to reach the position you experienced in any condition of the loaded hoist flight envelope, also because physically precluded by the installation of the step bar limiting the cable position versus the helicopter side.

The reported case was therefore considered very peculiar and just possible as result of an operational issue.

The approach adopted by REGA issuing the Engineering Order RE.10147, requiring the replacement of one of the two bolts of the handle installation with a pan head bolt outside installed, was noted and considered not mandatory.

In accordance with general criteria of safety risk evaluation (i.e. ICAO Doc 9859), the event can be conservatively assessed as remote, in terms of risk probability, and major/minor in term of risk severity. Risk matrix classification 3C/3D can be accepted based on risk mitigation.

Considering the above consideration, training instruction on cable handling will reduce the risk probability down to extremely improbable leading therefore to an acceptable risk as it is.

I hope to have provided the consideration for which it is considered not mandatory the requested hand hold modification as for your recommendation."

2 Analysis

2.1 Technical aspects

The investigation of the handle assembly and the hoist cable revealed the following:

- The hoist cable corresponded to the manufacturer's specifications with regard to construction, dimensions and load-bearing capacity.
- The load-bearing capacity is reduced when the cable is kinked while loaded. In the case of a kink over a sharp edge or over a small radius, this reduction is considerable. In addition, the load-bearing capacity is only achieved in the case of shock-free loading without a kink in the cable.
- Paint particles originating from the handle assembly were found at the breaking point of cable. The surface structure of the damaged edge of the flat bracket of the handle assembly, one side of the nut (Item 29) and the corresponding washer (item 28) featured an imprint which corresponded to the surface texture of the cable.

The findings of the investigation allow the conclusion that the hoist cable became snagged behind the nut before the load was lifted and subsequently broke under load.

In unfavourable conditions, the cable may become positioned behind the protruding nut (Item 29) of the handle assembly. There is therefore a danger that the cable becomes snagged behind this nut and is then not free to slide away from the side of the handle assembly when the cable is retracted or the load is lifted. As a result, the cable can be bent over the sharp edge of the flat bracket of the handle assembly. In addition, when the load is lifted, the cable loading is not shock-free and the cable could break. This must be prevented using appropriate design measures.

2.2 Human and operational aspects

During operation of the rescue hoist in accordance with the rotorcraft flight manual supplement and Rega standard operating procedures, the hoist operator must run the hoist cable through his glove protected hand, resulting in a slight braking effect. It is possible that a sudden reduction of tension causes a cable loop to form in the hoist cable and this can become snagged on the handle assembly. Tension is reduced if, for example, the hook is grabbed to attach the load or the end of the hoist cable makes contact with the ground. This situation was described in the present case.

In principle, it is only possible for the hoist operator to determine that the hoist cable has snagged on the handle assembly if he is in a corresponding position and looking upwards. However, it should be noted that during operation of the rescue hoist, the hoist operator must focus mainly on events on the ground and on any obstacles in the helicopter's environment. According to the statement of the hoist operator, the visibility from his working position was not perfect and a direct view of the hoist was restricted by his helmet and the cabin structure of the helicopter.

Guiding the hoist cable by hand alone does not allow detection of the described problem.

The newly added markers on the step bar do not improve the chances of being able to recognise a snagged cable.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The helicopter was licensed for VFR operations.
- The design of the rescue hoist attachment assembly allows the hoist cable to become snagged.
- Signs of abrasion were detected on the upper edge of the flat brackets of the handle assembly and door frame on similar helicopter types of the operator.

3.1.2 Crew

- The crew held the necessary licences and ratings for the flight.
- There are no indications of the crew suffering health problems during the flight.

3.1.3 History of the flight

- At 15:03 on 6 June 2013, HB-ZRS took off on a technical flight to perform a functional check of the rescue hoist.
- The hoist cable was not constantly under tension while the load was being attached.
- The hoist cable broke while the test load of 250 kg was being lifted.
- The findings of the investigation suggest that before the load was lifted the hoist cable became snagged behind the nut (Item 29) of the rescue hoist and subsequently broke under load.
- The hoist operator was wearing gloves and a helmet with a radio.

3.1.4 General conditions

- The weather conditions had no influence on the serious incident.
- When operating the rescue hoist, the hoist operator focuses mainly on events on the ground and on any obstacles in the helicopter's environment.
- The hoist operator's visibility from his working position is restricted by his helmet and the cabin structure of the helicopter.
- In principle, it is only possible for the hoist operator to determine that the hoist cable has become snagged on the handle assembly if he is in a corresponding position and is looking upwards.

3.2 Causes

The serious incident is attributable to the fact that the rescue hoist cable became snagged behind the handle assembly nut and broke when the test load was lifted.

The design of the rescue hoist attachment assembly was identified as a causal factor.

The restricted visibility from the hoist operator's working position was identified as a contributing factor.

4 Safety recommendations, safety advices and measures taken since the serious incident

Safety recommendations

According to the provisions of Annex 13 of the International Civil Aviation Organization (ICAO) and Article 17 of Regulation (EU) No. 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC, all safety recommendations listed in this report are intended for the supervisory authority of the competent state, which must decide on the extent to which these recommendations are to be implemented. Nonetheless, any agency, any establishment and any individual is invited to strive to improve aviation safety in the spirit of the safety recommendations pronounced.

Swiss legislation provides for the following regulation regarding implementation in the Ordinance on the Safety Investigation of Transport Incidents (OSITI):

„Art. 48 Safety recommendations

[1] The STSB shall submit the safety recommendations to the competent federal office and notify the competent department of the recommendations. In the case of urgent safety issues, it shall notify the competent department immediately. It may send comments to the competent department on the implementation reports issued by the federal office.

[2] The federal offices shall report to the STSB and the competent department periodically on the implementation of the recommendations or on the reasons why they have decided not to take measures.

[3] The competent department may apply to the competent federal office to implement recommendations."

The STSB shall publish the answers of the relevant Federal Office or foreign supervisory authorities at www.stsb.admin.ch in order to provide an overview of the current implementation status of the relevant safety recommendation.

Safety advices

The STSB may publish safety advices in response to any safety deficit identified during the investigation. Safety advices shall be formulated if a safety recommendation in accordance with Regulation (EU) No. 996/2010 does not appear to be appropriate, is not formally possible, or if the less prescriptive form of a safety advices is likely to have a greater effect. The legal basis for STSB safety advices can be found in Article 56 of the OSITI:

"Art. 56 Information on accident prevention

The STSB may prepare and publish general information on accident prevention."

4.1 Safety recommendations

4.1.1 Rescue hoist attachment assembly

4.1.1.1 Safety deficit

At 15:03 on 6 June 2013 the pilot took off in the HB-ZRS helicopter on a technical flight to conduct a functional check of the rescue hoist. On board was a hoist operator and on the ground was a mechanic with the prepared load of 250 kg. The mechanic's task was to attach the load to the hoist hook at the given time. The hoist cable broke when the test load was being lifted.

The findings of the investigation lead to the conclusion that before the load was lifted, the hoist cable became snagged behind the nut (Item 29) which attaches the rescue hoist handle assembly, and subsequently broke under load.

The design of the rescue hoist attachment assembly was identified as a causal factor.

4.1.2 Safety recommendation No. 528

The European Aviation Safety Agency (EASA) in cooperation with the helicopter manufacturer, should introduce technical measures to ensure that the hoist cable is prevented from snagging on the rescue hoist attachment assembly.

4.2 Safety advices

None

4.3 Measures taken since the serious incident

4.3.1 Aviation operator

In the "*Flight Safety Notiz"*, Edition 3/2013 of 6 June 2013, Rega makes reference to the serious incident and mentions the following points to reduce risks:

"(…)

- Prevent cable loops between the hoist operator's hand and the rescue hoist

- Visual check to ensure the hoist cable is running vertically between the rescue hoist and any person or load on the hoist hook. (…)"

Furthermore, an engineering order of 18 June 2013 required that the attachment bolts on the handle assembly are replaced. There follows an excerpt from this document:

"1.2 Description of work

Under certain circumstances it can occur that the hoist cable is able to move aside of the hand-hold and become hindered of moving back into its normal position. This because of the protruding threats of the attachment bolts. This could lead to damages to the hoist cable or the hand-hold assembly.

For this reason, the two Hex-head attachment bolts of the Rescue Hoist Handle assembly shall be replaced with two Pan-Head screws from same strength. In addition, the screws are installed the other way round (head on outside instead of the inside) in order to improve the situation for the hoist cable."

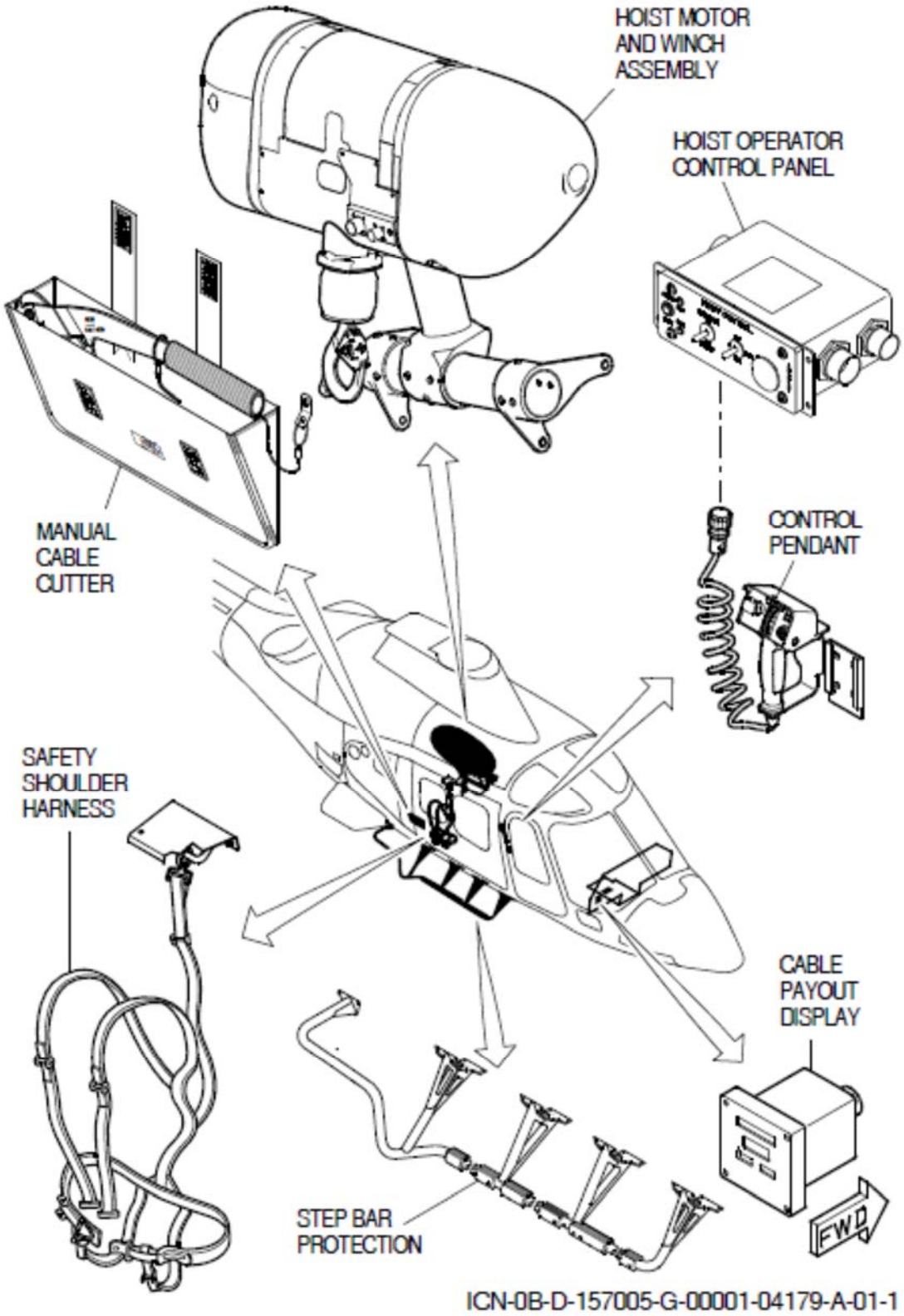
Following this serious incident, Version 4.0 effective 1 August 2013 of the standard operating procedures (SOP) incorporated the chapter "*Technischer Windencheckflug*" ("Technical Check Flight for Hoist").

Payerne, 23 December 2016 Investigation Services STSB

This final report was approved by the Board of the Swiss Transportation Safety Investigation Board STSB (Art. 10 lit. h of the Ordinance on the Safety Investigation of Transportation Incidents of 17 December 2014

Berne, 13 December 2016

Annex 1: Overview of the main components of the rescue hoist from the illustrated parts catalogue



Annex 2: Detailed representation of the main components of the rescue hoist attachment assembly from the illustrated parts catalogue

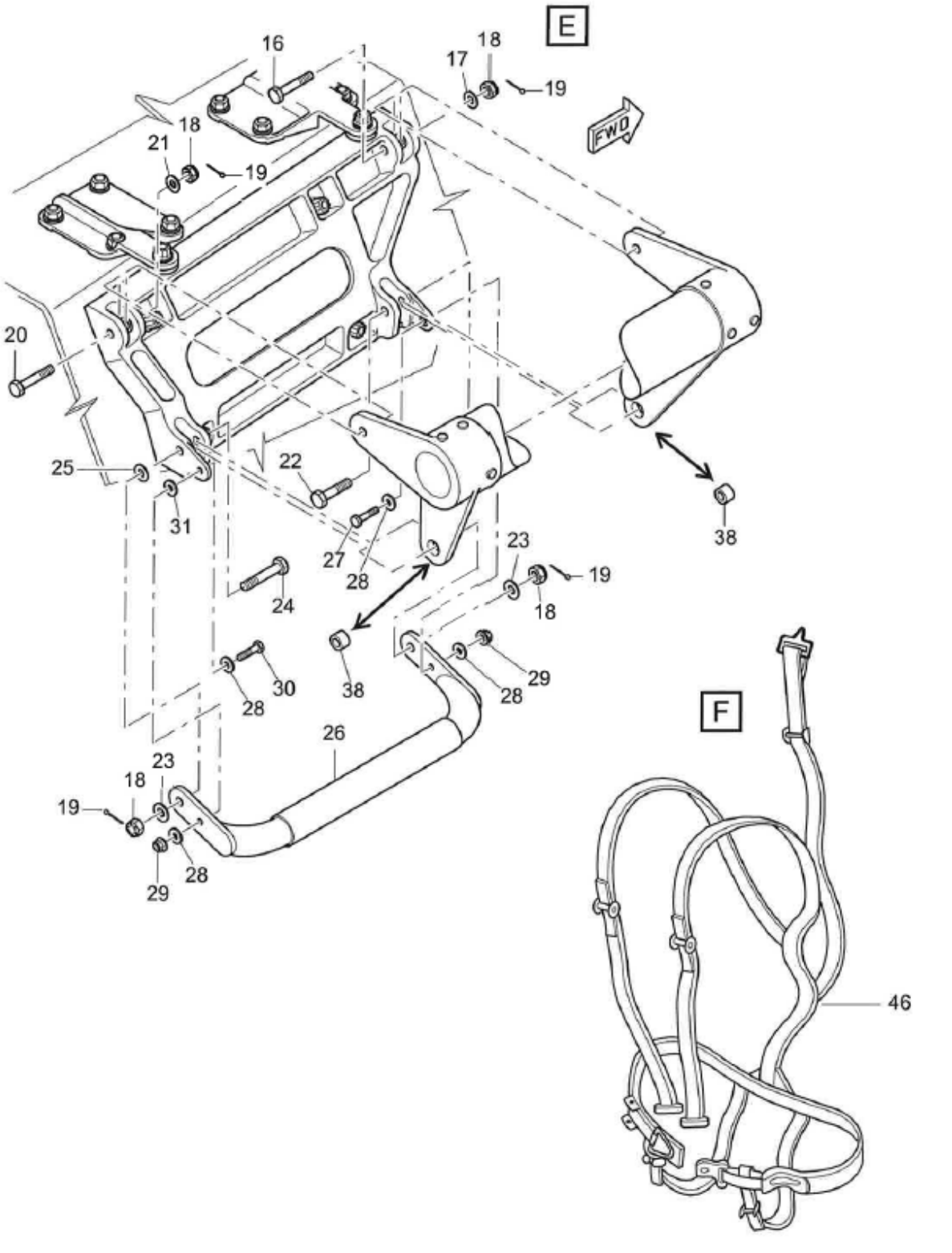


FIG. 01T - RESCUE HOIST KIT INSTL (SHEET 3 OF 7)