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UTREDNINGSRAPPORT FALLSKÄRMSOLYCKA 2-2018

Dödsolycka i samband med fallskärmshopp 2018-07-26

Dnr SFF-2019-16

INVESTIGATION REPORT SKYDIVING ACCIDENT 2-2018

Fatal skydiving accident July 26, 2018

English version

The Swedish Parachute Association (SFF) is a non-profit organization that has the task of a delegated authority towards the Swedish Transport Agency to conduct supervision and quality assurance of sports parachuting in Sweden with the aim that all sports parachuting activities are conducted in an aviation safety way.

The Swedish Parachute Association conducts investigations of accidents with the purpose of improving the safety of skydiving. SFF investigations aim to clarify the course of events and cause of events as far as possible. An investigation shall provide a basis for decisions aimed at preventing a similar event happening again or limiting the effect of such an event.

SFF has supervisory tasks and has the task in its supervision to ensure that all skydiving is conducted in accordance with the rules and guidelines set by the Swedish Parachute Association Regulations for Parachute Operations (SBF) and Rigger's Handbook (MHB). In the case of debt or liability, cases are handed over to the Swedish Transport Agency for further processing.

Investigation
The Swedish Parachute Association was informed on July 26, 2018 that a fatal skydiving accident occurred at Gryttjom Airport outside Tierp.

The accident has been investigated by:

Sven Mörtberg
SFF Director of Safety and Training

Assistance during the investigation:

Stefan Burström	Chief instructor Stockholm Parachuting club, SFF Parachute Rigger
Jesper Bergstrand	SFF Safety and Training Committee, USK
Kjell Pålsson	SFF Parachute Rigger, Expert
René Bacchus	SFF Rigger's Committee, MK, Wingsuit expert
Mark Procos	General Manager UPT, United Parachute Technologies

Investigation ended January 30, 2020

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Skydiving equipment
A system consisting of two parachutes connected to a harness. One of the parachutes is the main parachute, which can be disconnected. The second parachute is a reserve parachute. The parachutes are packed in separate containers. The parachutes are deployed by activation of a pilot parachute.
The main parachute's pilot parachute is thrown into the relative wind by the skydiver. The reserve parachute's pilotchute is spring activated when a pin releases it.

AAD - Automatic Activation Device
Automatic Activation Device is an electronic or mechanical device that measures vertical speed through pressure measurements. Activation can be done through either mechanical spring power or with a pyrotechnic-driven knife sleeve. CYPRES 2 Expert is due in this investigation and is an electronic device with pyrotechnic knife sleeve. If the device passes a preset altitude exceeding a certain speed, the device is activated, the reserve closing loop is cut off, the reserve container is opened and the reserve pilot with its spiral spring is deployed.

Audible altimeter
A technical unit mounted on the helmet that gives a loud sound at a preset altitude, or at several different altitudes.

Risers
The risers attached between the harness of the parachute system and the parachute's suspension lines.

Suspension lines
The lines that carry the skydiver between parachute and the risers. The number of the suspension lines varies depending on the parachute type. The lines closest to the skydiver are in singles but divide by a cascade closer to the parachute to distribute the load on the wing parachute and give it specific flight characteristics.

Bag
The part of the parachute system which the actual parachute is packed in. The bag of the main parachute is pulled out from its casing using a small pilotchute.

Pilotchute

Container
A container has several closing tabs to close the covering around the bag the parachute is packed in. Through grommets, a closing loop is secured with a sprint.

Rigger
A person certified by the Swedish Parachute Association to carry out periodic maintenance, packing of a reserve parachute and repairs on sports parachutes and its systems.

Malfunction
A parachute interference or parachute system's normal function.

Freebag
The part of the reserve system in which the reserve parachute itself is packed.

GoPro video camera
A small *action camera* that skydivers use to video document their skydives with.

Jump Leader
A person with permission from the Swedish Parachute Association to be the daily operations manager for sports jumping. Jumping leaders are a requirement for all sports jumping.

Cutaway
Step 1 of the emergency procedures, which involves a release of the main parachute by pulling the cutaway handle.

SBF - Swedish Regulations Parachute operations
Swedish rules, guidelines and regulations for operations and instructions for sports parachute jumping, skydiving.

CI – Chief Instructor
The chief instructor is responsible for safety and training and the skydiving activities of a skydiving club.

Cutaway handle
A handle designed as a pillow attached with Velcro to the harness of the parachute system and on the front of the skydiver. When the handle is pulled out, the 3-ring mechanism that "hooks" the main parachute to the harness is released.

Pilot parachute
A small assisting parachute thrown into the wind by hand from a pocket on the underside of the main parachute container. The pilot parachute pulls out a pin and the main parachute container opens. Then the pilot parachute pulls the bag with the main parachute out of the open container.

RSL - Reserve Static Line
The Reserve Static Line is a piece of lanyard attached to the main parachute's risers and the shutdown parachute closing pin. When the main parachute is disconnected, the lanyard pulls the reserve closing pin so that it opens the reserve container and the reserve can start its deployment.

Reserve pull
Step 2 of the emergency procedures, which involves an activation of the reserve parachute by pulling the reserve handle.

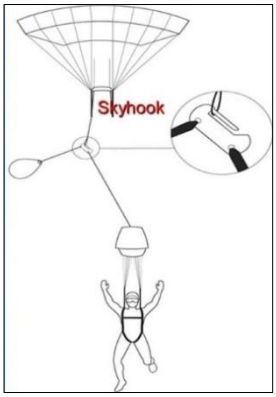
Emergency procedures
Procedures performed during a malfunction. The emergency procedures mean that the skydiver performs several operations to activate the reserve parachute. In this investigation, it aims to the pull of the cutaway handle to release the main parachute and then the pull of the reserve handle to activate the reserve parachute.

Reserve handle
Handle connected to the reserve parachute system. The reserve handle is used to activate the reserve parachute manually.

Reserve pilot
A small assisting pilotchute with built-in spiral spring in the casing. After activation, the reserve pilot chute hops out of the reserve container and pulls the freebag with the reserve parachute out of the open reserve container.

SFF - Swedish Parachute Association
Swedish Parachute Association. A non-profit organization founded in 1955 with delegated government rights from the Swedish Transport Agency to run supervision and quality assurance over sports parachute jumping, skydiving, in Sweden. SFF is also a voluntary defence organization and a member of the National Sports Federation through the Swedish Aviation Sports Federation.

Skyhook
The Skyhook is United Parachute Technologies version of a Main-Assisted Reserve Deployment system (MARD), a safety feature on skydiving parachute systems. It builds on the concept underlying an ordinary reserve static line (RSL), which uses the force of the departing main parachute to open the reserve parachute container after the malfunctioning main parachute is cut-away, by further using the force of the jettisoned main parachute to extract the reserve parachute out of the reserve container. This greatly reduces the time, and hence loss of altitude, required to fully open the reserve parachute.



The Skyhook system is engineered so that it should not interfere with reserve deployment activated by directly pulling the reserve rip cord in situations where no main parachute had been deployed. The key component in the system, from which the Skyhook derives its name, is a cantilevered hook that grasps the reserve bridle about midway between the reserve pilot chute and the bag containing the packed reserve chute. If the departing main parachute applies more pull force on the bridle than the reserve pilot chute, then the main parachute will remain hooked onto the reserve bridle, and so it will pull the reserve parachute out of the reserve compartment. If the reserve pilot chute exerts more pull force on the bridle than the main parachute, then the main parachute will unhook, and the reserve pilot chute will deploy the reserve parachute normally.

Reserve pin
A pin that runs through a closing loop that keeps the reserve parachute container closed. The reserve pin is sealed by a parachute rigger and attached to a wire that goes to the reserve handle.

Line twists
A type of malfunction where the parachute twists around the vertical axis on deployment. The suspension lines are twisted around itself, but not tangled. This causes the parachute to open only partially.

Wingsuit
A jumpsuit fitted with wings between arms and body and between legs. The wings are of "parachute type", i.e. they have a top skin and a bottom skin and creates a wing profile when they filled with air.

Skydiver
A skydiver is a person who engages in the sport of parachuting. A freefall parachute jump is also referred as a skydive.

Drop zone - DZ
A drop zone (DZ) is a place where skydivers take off in aircraft and land under their parachutes.

Slider
A slowing mechanism for the development of parachutes. A slider consists of a reinforced piece of square fabric that has a grommet in every corner. Through the grommets, the parachute's suspension lines go. The function is that when the parachute unfolds, the slider brakes like a small horizontal "sail" the development process until the vertical speed of the parachute has gone down slightly and the parachute begins to spread out its wing shape and the slider is pushed downwards. The size and shape of the slider tend to be crucial for the trigger speed.

Skydiving - Sports parachute jumping
All civilian parachute jumping in Sweden is described as skydiving. It includes recreation, practice, competition, student training, demos and tandem jumping.

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Wingsuit

1. FACTUAL REPORT

1.1 Presentation of the course of events

1.1.1 *Conditions*

Stockholm Parachute Club was operating skydiving on July 26, 2018. The club's activities consisted primarily of sports parachute jumping, skydiving, which includes student training and tandem jumping. At the same time as regular operations, a wingsuit event was held organized by international, well-qualified instructors. Some 20 wingsuit skydivers with different experience levels participated. The wingsuit skydivers were divided according to the level of experience and jumped in different constellations during the week. The fatal skydiver was one of the participants at the event.

1.1.2 *Summary of events*

The fatal skydiver RB) exits the plane from 4000 meter and performs his wingsuit skydive together with another wingsuit skydiver. They separate from each other according to plan of approx. 1500 meter and deployed their main parachutes. During the development of the main parachute, RB gets a malfunction, line twists. The malfunction results in RB getting a spinning rotation. RB tries for a very long time, 27 seconds, to solve the spinning rotation and the line twists, but fails. At low altitude, RB performs the emergency procedure. RB is in a hard-spinning horizontal rotation when the reserve parachute is deployed. One of the risers gets entangled around RB's right arm. The reserve parachute has an interference during the development process. It does not develop completely and is spinning. RB tries to sort out the malfunction without success. RB hits the ground hard with his back first about 2 km from the drop zone. The first to find RB are neighbors from an adjacent farm. They call the skydiving club and the jump leader immediately informs the emergency services sends out cars. When military medically trained personnel from the skydiving club arrive at the scene, they immediately begin rescue work through CPR to the injured skydiver. Later, emergency personnel arrived by ambulance and took over responsibility of the operation and took RB to Uppsala University Hospital.

The location of the event is: **60 16,355 N 017 26,962 E**

1.2 The deceased skydiver

1.2.1 *Personal data*

1.2.1.1 RB, Polish citizen born in 1977.

1.2.1.2. Exit weight, the skydiver including full equipment, 100 kg according to information recorded in the SkyWin manifest program.

1.2.2 *Health*

1.2.2.1 No indication that health has been a contributing factor.

1.2.3 *Training*

1.2.3.1 Unknown.

1.2.4 *License*

1.2.4.1 Valid C license issued by the British Parachute Association, BPA.

1.2.5 *Skydiving status*

1.2.5.1 Guest skydiver in Gryttjom, Stockholm Parachute Club. RB has completed 600 skydives total, including 200 wingsuit skydives. In 2018, 125 wingsuit skydives total have been carried out, including 34 in the last 6 days in Gryttjom. Other skydives have not been exactly determined by logbook.

1.2.6 *Previously reported incidents*

1.2.6.1 No previously reported incidents in Sweden. Otherwise, unknown.

1.3 Equipment

	Manufacturer	**Model**	**Valid until date**
System	UPT	Vector 3	2018-12-07
Reserve parachute	Aerodyne	Smart	2018-12-07
Main parachute	PD	Sabre 2 - 135	2018-12-07
AAD	Airtec	CYPRES 2 Expert	2018-12-07
Wingsuit	Squirrel	Freak 2	N/A

1.3.1 *Evaluated status on the equipment used in the skydive.*

1.3.1.1 The equipment is considered to have been airworthy in the performance of hope.

1.3.2 *Other equipment*

1.3.2.1 Open hard helmet, skydive goggles, no gloves, sneakers and wingsuit.

1.3.3 *Notes*

1.3.3.1 The parachute system was equipped with a Skyhook.
At the time of the accident, RB had a GoPro video camera with mounting on the helmet.

1.3.4 *Special equipment studies*

1.3.4.1 The equipment was examined by Stockholm's Parachute Club's Chief Instructor, CI at the accident site and photographed. No visible errors or damages on the equipment were observed.

1.3.4.2 CI was given the opportunity to make copies of RB's and the co-skydiver's GoPro video recordings.

1.3.4.3 Police seized the equipment. The equipment was later sent to RB's relatives before staff from SFF were given the opportunity to examine it further.

1.4 External conditions

1.4.1 *Weather and wind*

1.4.1.1 Weather on July 26, 2018, consisted throughout the skydiving day (10:00-20:00) of clear skies and calm winds.

1.4.2 *Club and organization*

1.4.2.1 Stockholm Parachute Club, member of the Swedish Parachute Association and the Swedish Aviation Sports Association.

1.4.3 *Organization Accident Day July 26th, 2018*

1.4.3.1 The responsible jump leader was currently competent according to SBF: 402:01, 1.4.3.5.

1.4.3.2 Planned activities consisted of normal skydiving activities with different types of skydives.

1.4.4 *Aircraft*

1.4.4.1 The skydive was conducted from a Twin-Otter SE-GEE.

1.4.5 *Drop zone*

1.4.5.1 Gryttjom Airport. The drop zone, skydiving landing field is approved according to SBF 402:04, 4.4.

Fig. 1 Gryttjom Airport with planned landing area at the DZ marked with red cross.

1.5 Course of events of the fatal wingsuit skydive

1.5.1 *Prior to boarding the plane*

1.5. 1.1 No deviations in preparation for the skydive have been observed.

1.5.2 *Exit out of the plane*

1.5.2.1 The exit takes place at an altitude of 4000 meters together with a fellow skydiver.

1.5.3 *Free fall*

1.5.3.1 Video footage from the skydiver's own GoPro and fellow skydiver's GoPro, show RB conducting the wingsuit flight in a controlled manor along with the other skydiver. They separate according to plan at normal break altitude, about 1300-1500 meters AGL (Above ground level). to then deploy their parachutes.

1.5.4 *Deployment of the main parachute*

1.5.4.1 RB deploys his parachute at approx. 1100 m AGL.

1.5.4.2 Nothing irregular in terms of body position, stability, etc. during the pull procedure has been observed.

1.5.5 *Course of events after deployment of main parachute*

1.5.5.1 RB experiences a malfunction on the main parachute; line twists, picture 1.

Picture 1. Main parachute with line twists immediately after the pull.

1.5.5.2 RB gets a strong rotation clockwise due to the malfunction, picture 2.

Picture 2. Main parachute with line twists approx. 10 seconds after pull.

1.5.5.3 The parachute dives aggressively and is spinning. RB loses altitude rapidly, picture 2-4.

1.5.5.4 RB opens the wingsuit's sleeve zippers.

1.5.5.5 RB tries to solve the line twists, picture 3-4.

Picture 3. Attempts to untwist the lines.

Picture 4. Attempts to "unwind" the twist.

1.5.5.6 Attempts to resolve the line twists on the main parachute do not work.

1.5.5.7 RB performs cutaway 27 seconds after deploying the main parachute.

1.5.6 *Cutaway of main parachute and deployment of the reserve parachute*

1.5. 6.1 After the cutaway, the main parachute releases due to the 3-ring system.

1.5.6.2 The parachute system is equipped with a Skyhook that activates the reserve, Picture 5-8.

1.5.6.3 RB also pulls the reserve handle manually.

Picture 5. After cutting away the main parachute. The reserve pin is visible to the right.

1.5.6.4 When the reserve parachute is activated, RB is in rotation.

Picture 6. The main parachute with the Skyhook pulls the reserve pilot bridle.
The Red Skyhook Lanyard is tense (upper right corner).

Picture 7. Bridle of the reserve parachute pilot is stretched. The Skyhook is still pulling.

Picture 8. The Skyhook has disconnected. (The reserve parachute pilot bridle is not stretched).

1.5.6.5 RB ends up in an oblique diving body position with his left shoulder down, which turns to a skewed front flip to back position. The flip is completed diagonally over the right shoulder, see picture 9-13.

Picture 9. RB in diving body position with left shoulder down.

Picture 10. RB in back position during front flip.

Picture 11. RB in front flip diagonally over the right shoulder.

Picture 12. The flip is completed.

Picture 13. The front flip is completed.

1.5.7 *Opening shock and line stretch of reserve parachute*

1.5.7.1 RB is quickly turned from horizontal position to a right position, picture 14.

Picture 14. RB is quickly turned from horizontal position to a right position.

1.5.7.2 RB is straightened up to vertical position when the reserve parachute suspension lines are stretched, picture 15.

Picture 15. RB straightened up to vertical position

1.5.7.3 The reserve parachute malfunctions during the development process, resulting in an incomplete developed canopy and line twists, see picture 16-18.

Picture 16. The reserve parachute immediately after opening. Above the reserve, the cut away main parachute and freebag. Note! Only the left risers are visible.

Picture 17. The reserve parachute incompletely developed and with line twists approx. 10 seconds after opening. Only the left risers are visible. The lines on the right side go down to the right risers below the image.

1.5.7.4 The malfunctioned reserve parachute with only 3 out of 7 cells fully inflated, picture 18.

Picture 18. The reserve parachute with 3 cells out of 7 fully inflated.

1.5.7.5 RB pulls the right suspension line group outwards and down, pictures 19-20.

Picture 19. RB pulls the right suspension line group outwards and down.

Picture 20. RB pulls the right suspension line group outwards and down.

1.5.8 *Impact to the ground*

1.5.8.1 RB hits the ground at high-speed spinning/rotating with the back first and the body stretched in the direction of rotation, picture 21.

Picture 21. RB in a back to earth position stretched out by the rotational force immediately before impact.

1.5.8.2 The scene of the accident is located 2 km straight line outside the Drop Zone, the parachute landing area, picture 22.

Picture 22. Gryttjom Airport and scene of the accident 2 km SE of the DZ.

1.6 Testimony

1.6.1 *Witness statements*

1.6.1.1 The other wingsuit skydiver, who witnessed the incident, has been interviewed by .

1.6.1.2 The witness statements describing the incident come mainly from video footage from fellow skydivers and RB's own video footage. From the later video, "screenshots" were taken for use in investigation material.

1.6.1.3 The observations of the equipment are made by persons with expertise from the parachute club's organization who operative during the rescue work.

1.6.1.4 The equipment was seized by the police and could not be further investigated.

2. ANALYSIS

2.1 The skydiver's skydiving status and experience

2.1.1 *Skydiving status*

RB has completed 600 parachute skydives in total, including 200 wingsuit skydives. In 2018, 125 wingsuits have been carried out, including 34 curried out in Gryttjom during the 6 days prior to the accident. RB may therefore at the time be considered to be current and in good skydiving status.

2.1.2 *Experience*

Definitions of experience levels wingsuit flying according to SBF 402:07 are:
- *Beginner*: 0-50 wingsuit skydives.
- *Intermediate*: 51-200 wingsuit skydives.
- *Advanced*: +200 wingsuit skydives, of which at least 100 of these using a wingsuit in the *Intermediate* category.

RB's experience level: between *Intermediate* and *Advanced*.

2.2 Sequence

SFF's investigation has created a hypothesis of what may have happened through the use of available data in the form of an engineering investigation of the equipment, testimony and video recording from RB's own GoPro and the fellow skydiver's GoPro.

The analysis of the course of events consists primarily of the video recording from the skydiver's own GoPro. The video footage from the fellow skydiver's GoPro is from a long distance. It can observe RB's rotating main parachute, the opening of the main parachute and parts of the reserve parachute opening, but not the impact. Unfortunately, the long distance does not allow any conclusions from that video recording.

SFF's investigation can undoubtedly state that the malfunction of the main parachute that resulted in a severely rotating and diving parachute with line twists, started a chain of events that resulted in RB's death.

RB experiences a malfunction on the main parachute. RB tries to both untwist the line twists and to "wind it down". None of these methods work. The parachute rotates aggressively and dives. 27 seconds from the main parachute being opened and the resulting malfunction, RB carried out the emergency procedure. RB is unstable and as the reserve parachute develops, he gets entangled with one side's line groups and risers around his right arm. The reserve parachute is developed with a malfunction. It rotates severely and is not slowing down the descent enough for RB to survive the landing.

RB strikes the ground rotating at high speed with his back first.

Examination on the ground shows that right risers are located around the right arm wing. The risers cross the right shoulder, around the front, under the armpit and back up the back.

The investigation also shows that skyhook "unhooked".

2.2.1 *Theories as to why the reserve parachute was prevented from developing normally*

When cutting away, RB rotates severely, which affects his stability in a negative way. During the development of the reserve parachute, RB makes a forward flip diagonally over his back.

RB has opened the zippers to the sleeves of the wingsuit before cutting away.

During the development of the reserve parachute, the right risers end up around RB's right arm wing. The suspension lines on the right side and risers go around the elbow, shown in pictures 13-14, where RB is quickly turned from horizontal position to right position. This occurs during the development of the reserve parachute in connection with the "opening shock" when the suspension lines are stretched.

As risers go around the right arm wing, the right side of the reserve parachute is prevented from developing completely. Only 3 out of 7 cells are air-filled. The reserve parachute has line twists and it rotates.

RB is trying to sort out the line twists by pulling them down and outwards.
No attempts are made by RB to fix the entangled risers around the right arm wing.

2.2.2 *Theories as to why the right risers go around one arm*

The reason that the right risers go around the right arm and thus prevent the reserve parachute from developing completely, as well as the circumstances that contributed to this, cannot be determined for sure.

However, the likely scenario is that it is RB's instability during the development process that has been the cause:

- RB was in a front flip when the reserve parachute developed.

- The front flip was "warped", forward diagonally over the back.
- When the risers came out of the container, it wasn't free to get stretched out for the risers.
- When the flip was completed, the right arm wing came in between the line groups and "caught" the right risers.
- The risers on the right side could not be stretched out as they went around the arm wing.
- It is also possible that a loose part of the wing suit's opened sleeve, contributed to the risers getting stuck in the development process.

2.2.3 *Theories as to why the Skyhook "unhooked"*

The likely scenario for the Skyhook to unhook, is that RB interferes with the development of the reserve parachute during the front flip:

- RB has somehow got his right arm between the line groups, thereby preventing the risers from going free and also hitting the freebag with some part of body or wingsuit.
- Entangled risers and the freebag being hit, have affected the force of the pull of the Skyhook with the disconnected main parachute becoming a lesser force than that of the reserve pilot.
- When skyhook unhooked, the reserve pilot takes over and completes the development of the reserve parachute. In picture 6-7, the pilot bridle is shown stretched, i.e. that the main parachute with Skyhook pulls. In picture 8, the pilot bridle is shown without drag, even though the reserve parachute has not been developed.

The fact that the Skyhook unhooks, delays the development of the reserve parachute by an estimated 1 second compared to the completion of the Skyhook deployment.

However, the fact that skyhook "unhooked" during the reserve parachute development process is not believed to have affected the outcome of the course of events, i.e. the outcome of the event that there was a malfunction on the reserve parachute.

2.3 Parachute system, airworthiness, survival aspects

2.3.1 *The design of the parachute system*

All parachute systems are currently generic. The parachute system is manufactured by UPT. The model is Vector 3. For its model year, it is up to the industry standard of a modern parachute system.

2.3.2 *Automatic Activation Device (AAD) CYPRES2 EXPERT*

The AAD has not been activated. The fall rate did not reach the CYPRES calibrated activation descent speed. Further examination of registered data from the device has not been able to be carried out.

2.3.3 *Survival aspects*

Line twists on the main parachute is the most common type of malfunction in wingsuit flying. Line twists are usually untwisted, and the parachute can then be flown and controlled as intended. A parachute with a line twists combined with an aggressively diving and rotating parachute, is difficult to untwist and is also dangerous. A diving rotating parachute causes the skydiver to lose altitude very quickly and sometimes even loses altitude awareness due to the dramatic loss of altitude. The rotation can create such G-forces that it can be difficult to get the arms up in position to perform the emergency procedure. Therefore, the emergency procedure should be initiated immediately after the skydiver has determined that the line twists cannot be quickly solved. A hard rotation also has a negative impact on the development of the reserve parachute compared to a skydiver in a stable freefall body position.

A malfunction on the reserve parachute is very unusual. If it happens, it is extremely serious, and the skydiver must then do everything possible to sort out the malfunction. Time to identify the cause of the problem can be crucial, and then to have time to do something that improves the situation.

2.3.4 *The Skyhook back up system*

RB's parachute system was equipped with a Skyhook that is the UPT, United Parachute Technologies' version of a MARD, Main Assisted Reserve Deployment system. A MARD is based on the concept behind a standard RSL that uses the force from the cutaway when the skydiver is separated from the main parachute to pull the pin of the reserve parachute and open the reserve parachute container. It also releases a riser if it hasn't released from the 3-ring system when cut away. The Skyhook then uses the cut away main parachute as a large pilot parachute to pull the reserve parachute out of the reserve container and out of the freebag. This significantly reduces the time to open the reserve parachute and thus loss of altitude.

In the current case, activation has taken place in the way the Skyhook is intended to do after the cut away. At some point during the deployment, the Skyhook has unhooked and hence stopped pulling. The pilot of the reserve parachute has then "taken over" the deployment process as the Skyhook hooked out.

2.3.5 *Airworthiness*

Foreign licensee may skydive with parachute equipment packed and inspected in accordance with the rules of the country of the skydiver from which the skydiver has his parachute license, adding that the use of an AAD under 402:01 point 1.1.19s shall apply. SBF 403:01 FALLSKÄRMSMATERIEL 2.4

RB's equipment was packed and inspected by a licensed parachute rigger.

3. ORGANISATIONAL FACTORS

3.1 Operation of the parachute club

3.1.1 *Jump Leader*

The current Jump Leader (JL) was instructor rated according to Swedish rules. The operation was carried out during prime season. The jump leader's task and

responsibilities are to run the skydiving operations according to SBF 404:02. On site was also the Chief Instructor, CI of the Stockholm's Parachute Club.

404: 02 1.3 Jump leader, JL leads, organizes and is responsible for the activities of drop zone, when skydiving occurs. JL shall ensure compliance with the provisions and instructions in force.
402:01 1.2.14 Chief Instructor (CI) is JM, JL and Coach, who in skydiving club is responsible for training and safety and for the skydiving operations.

3.1.2 *The Chief Instructor's written statement*

About 13:50, Jump Leader, JL alarms that he has received a report of a wingsuit skydiver having spiraled down with a malfunction on the reserve, outside the field. The JL car with medical equipment immediately leaves and I bring two skydivers with medical training and follow. JL alarms 112 while waiting for more precise localization of the wingsuit skydiver. JK was the skydiver who alerted, and it later turned out that he even skydived with the person who was in the accident. Pretty quickly, 3-4 cars are out looking for the wingsuit skydiver and after some confusion about where the wingsuit skydiver went down, he and the ambulances which were heading for the field are redirected to the site of the accident. On site, several skydivers have already begun life rescuing attempts and paramedics are taking over to try to get a pulse started.

Rescue helicopter is alerted, but due to the fact that it is busy on another case quite far away, the decision is made after about 10 minutes, to transport the wingsuit skydiver in an ambulance instead. We help cut off the harness and wingsuit so that the wingsuit skydiver can be put on a stretcher to be taken to hospital. The ambulance leaves to meet up with the ambulance helicopter on the road.

About 10-15 minutes later, police arrive at the scene to conduct an initial investigation. I explain the situation to the police, and we together document the crash site. I lead the examination of the equipment and we photograph as much as possible, but we do not make any observations that can give any clues to the accident. I inform the police that the wingsuit skydiver's helmet has a camera that probably contains parts of the course of events and I ask to access the footage before the police take care of the equipment. Initially, we get a negative message through their internal command. We regroup from the crash site where I have taken care of the equipment and loaded it into the police car and move to the skydiving club's drop zone. Another police patrol arrives to the drop zone.

3.1.3 *Organizational notes*

RB's fellow wingsuit skydiver landed by the JL and reported on their observations and approximate landing place. Rescue operation began with 112 ALARM and the JL car *Jullan* and another car with CI and medical trained personnel were sent out.

The distance from the drop zone and JL's position to RB's crash site was about 2 km straight line, see picture 23.

Due to the long distance and the road network, getting to the location was complicated and this extended the time from the start the relief operation to point that RB was found.

Figure 23. Gryttjom Airport and scene of the accident 2 km SE of the DZ.

3.1.4 *Rescue operation*

The jump leader's actions taken once the accident was identified are without fault. With the entry values that existed, a realistic number of individuals were sent to the site. Actions on crash site by people from the Skydiving Club are highly creditable.

3.1.5 *Police actions*

Police resources arriving at the crash site to investigate the incident chose to seize the parachute equipment. The seizure is part of the police procedures. It is the SFF investigation's assessment that police procedures in the event of a skydiving accident are an obstacle to the Swedish Parachute Association's ability to carry out a breakdown investigation in accordance with delegation agreements established between SFF and the Swedish Transport Agency.

Despite the above, the measures taken by the skydiving club's organization at an accident site in the form of visual inspection of equipment and copying of GoPro video have, despite the above, created good opportunities to clarify the course of events at RB's wingsuit skydive.

4. STATED OPINION

4.1 Findings

a) SFF investigation finds no indication that technical failures on the parachute system have occurred or been contributing cause of the accident.

b) RB wore a Camera of type GoPro mounted on the helmet. The camera's installation and design has not contributed to the accident.

c) RB's video recording from the accident skydive has been absolutely crucial in analyzing the course of events.

d) RB was authorized to perform skydives (sports parachute jumps) with wingsuit.

e) The skydiving club's operation at the time of the accident was authorized in accordance with SFF rules, regulations and guidelines.

f) The parachute equipment used at the time of the accident was technically airworthy and maintained according to the rules.

g) RB was wearing an altimeter at the time of the accident.

h) RB wore an acoustic altimeter at the time of the accident.

i) RB has cut away the main parachute after being it malfunctioned.

j) The Skyhook was connected and has activated the reserve parachute.

k) After activation and stretching of the reserve pilot's bridle, the Skyhook has "unhooked".

l) RB has also pulled the reserve handle manually.

m) The AAD has not been activated.

n) The reserve parachute has a malfunction and does not have enough bearing capacity before landing.

o) RB has not used the hook-knife.

p) The risers of the right side of the reserve parachute have gone around the right wing; over the right shoulder, around the front, under the armpit and back up the back.

q) Impact occurs rotating at very high vertical velocity.

4.2 Cause of fatal accident

4.2.1 *The development process of the reserve parachute is disrupted*

The development process of the reserve parachute was disrupted by heavy rotation and an unstable fall position with an unfavorable posture.

4.2.2 *Risers around the arm wing*

The right risers of the reserve parachute went around the right arm, preventing the reserve parachute from developing completely.

4.2.3 *No action taken to the actual cause of the malfunction of the reserve parachute*

The video shows RB trying to sort out the line twists by pulling the lines down and outwards. However, there are no attempts by RB to address the main problem why the reserve parachute is prevented to open fully, i.e. the entangled risers around the arm.

It is likely that the stress of having experienced double malfunctions became so high that RB's assessment of the situation suffered.

It is possible that RB has not understood that the risers of the right side were hooked under the right arm and thus did not run freely. It is also possible that the field of vision was interfered by the size of the opened arm wings and further made it difficult for RB to discover that the risers did not run correct.

4.2.4 *Insufficient carrying capacity*

The malfunction of the reserve parachute prevented it to open completely to achieve enough carrying capacity to save RB's life.

4.3 Contributing causes to the accident

SFF's investigation has not been able to determine exactly what contributing reasons may have caused the malfunction of the reserve parachute. The likely contributing reasons based on the theory the SFF investigation has concluded are described below.

4.3.1 *Wingsuit skydiving in general*

4.3.1.1 Skydiving with a wingsuit involves increased risks versus regular skydiving during the parachute opening; the wingsuit creates a large turbulent area around the skydiver.

4.3.1.2 A wingsuit has a very large surface area and thus sensitive to instability caused by incorrect body position, e.g. unsymmetrical.

4.3.2 *Choice of parachute*

4.3.2.1 The wingsuit skydiver shall be well familiarized with the parachute. During all wingsuit skydives, a non-elliptical parachute with a relatively low wing load is recommended. SBF 402:07, 7.4.4.

4.3.2.2 International established recommendations for making a wingsuit skydive is a non-elliptical 7-cell docile parachute.

4.3.2.3 RB's main parachute was a Sabre 2, 135 from Performance Designs – a 9-cell semi-elliptical parachute.

4.3.2.4 RB's reserve parachute was a Smart from Aerodyne - a 7-cell non-elliptical reserve parachute, size unknown.

4.3.3 *Wing loading*

4.3.2.1 Wing loading describes the total amount of mass distributed per square foot of the parachute. Wing load tells the relationship between the weight of the skydiver and the size of the parachute. A measure of wing loading is the skydiver's "exit weight" (total weight including all equipment) in US lbs. divided by a square foot of the parachute. The higher the wing loading, the more sensitive the parachute becomes during the development process.

4.3.2.2 A well-established recommendation for skydiving with wingsuits is a wing loading of approx. 1.3 or less.

4.3.2.3 RB had a wing loading of 1.63 on the main parachute, a Sabre2-135 (220 lbs./135 sqf.). Following the recommended size of the parachute due to wing loading, the parachute should have been ≥168 sqf.

4.3.4 *Emergency procedures*

4.3.3.1 In case of a spinning and diving malfunction, it is important to immediately carry out the emergency procedures to avoid losing time and altitude.

4.3.3.2 RB spends 27 seconds from the main parachute is activated, to the emergency procedures are initiated.

4.3.3.3 In the event of a spinning and diving malfunction, it is generally the high priority to implement the emergency procedures rapidly – not to open the zippers of the arm wings.

4.3.3.4 RB gets a spinning diving malfunction, line twists, but opens the arm wing's zippers before the emergency procedures start. If this has affected the outcome, it is not possible to determine.

4.3.3.5 An emergency procedure with a reserve parachute deployment when wearing a wing suit increases the risk of disturbance of the development process. A malfunction during a wing suit skydive usually involves rotation of the skydiver. Due to the fact that the wing suit has a very large surface exposed to the wind between body and arms as well as body and legs, likelihoods are great that the emergency procedures are performed when body position is not stable.

4.3.3.6 RB was spinning when cutting away the main parachute.

4.3.3.7 RB was unstable and did a front flip during the development of the reserve parachute.

4.3.5 *RB may have had a pack-related malfunction*

4.3.4.1 The reserve parachute had been repacked and inspected by a certified parachute rigger. The possibility that the reserve parachute was packed with the risers incorrectly stowed in the reserve container, finds the investigation too unlikely.

5. RECOMMENDATIONS

5.1 Equipment

SFF should continue to stress the importance of selecting specially adapted equipment for wingsuit flying.

- Parachute:
  7-cell parachute with appropriate wing loading and suspension lines in trim
- Parachute system:
  The system should be intended for wingsuit flying, e.g. the size of the pilot, the length of the pilot's bridle, the design of the container, etc.
- Choice of wingsuit:
  The wingsuit skydiver's experience level is in accordance with the manufacturer's recommendations

SBF 402:07 VINGOVERALL (WINGSUIT)

5.2 Emergency procedures

SFF should continue to stress the importance of well-practiced emergency procedures.

- Practice on the emergency procedures on regular basis
- Perform emergency procedures immediately in case of a heavily spinning and diving malfunction
- Be mentally prepared to the fact that the emergency procedures with wingsuits can negatively affect stability
- Be mentally prepared to the fact that the emergency procedures when wingsuit skydiving, may affect stability in a negative way

6. OTHER – INVESTIGATION OF PARACHUTING ACCIDENTS

SFF should be given stronger legitimacy from the Swedish Transport Agency to carry out accident investigations. The police should be provided with a documented decision-making basis to allow SFF to seize parachute equipment during an investigation of a skydiving accident.

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The investigation was conducted by Sven Mörtberg, Director of Safety and Training Swedish Parachute Association.

The investigation is presented to the Safety and Training Committee of the Swedish Parachute Association.

The investigation is presented and delivered to the Swedish Transport Agency.

The Swedish Transport Agency has overall responsibility for drawing up regulations and ensuring that authorities, companies, organizations and citizens abide by them. The department of Civil Aviation formulates regulations, examines and grants permits, as well as assessing civil aviation with particular regard to safety and security. The Swedish Transport Agency monitors developments in the aviation market.