Air Accident Investigation Unit Ireland

SYNOPTIC REPORT

ACCIDENT
Tandem Parachute Jump
Near Clonbullogue Airfield (EICL),
Co Offaly, Ireland
18 August 2012

An Roinn Iompair
Turasóireachta agus Spóirt
Department of Transport,
Tourism and Sport

FINAL REPORT

AAIU Report No: 2013-007
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In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No. 996/2010 and the provisions of S.I. 460 of 2009, the Chief Inspector of Air Accidents, on 18 August 2012, appointed himself as the Investigator-in-Charge to carry out an Investigation into this Accident and prepare a Report. The sole purpose of this Investigation is the prevention of aviation Accidents and Incidents. It is not the purpose of the Investigation to apportion blame or liability.

Aircraft Type and Registration:	Pilatus, PC-6/B2-H4 Turbo-Porter, EI-IAN
No. and Type of Engines:	1 x Pratt & Whitney PT6A-27
Aircraft Serial Number:	810
Year of Manufacture:	1981
Date and Time (UTC):	18 August 2012 @ approx. 16.06 hrs (17.06 hrs local)
Location:	Forest area approximately 150 meters north of Clonbullogue Airfield (EICL), Co Offaly, Ireland
Type of Operation:	Aerial Work – Parachuting
Persons on Board:	Crew - 1 Parachutists - 9
Injuries:	Crew - Nil Parachutists – 2 (serious injury)
Nature of Damage:	None to aircraft
Tandem Master Licence:	Parachute Association of Ireland (PAI)
Tandem Master Details:	Male, aged 52 years
Tandem Master Experience:	2,625 jumps of which approx 1,600 were tandem
Notification Source:	Club Chief Instructor (CCI)
Information Source:	AAIU Field Investigation

SYNOPSIS

Following an uneventful tandem drogue-fall (see Section 1.2) from 10,000 ft, the main chute was deployed at approximately 5,500 ft, but following inflation, it immediately developed a violent spiral rotation to the right. Unable to cut-away the main canopy, the tandem master deployed his reserve chute. There then followed a complex sequence of events that resulted in both canopies being in a condition of partial inflation. This condition persisted throughout the remaining descent until the tandem pair impacted heavily within a forest clearing. Both the tandem master and the tandem passenger suffered serious impact injuries.

1. FACTUAL INFORMATION

1.1 History of the Jump

On the day of the accident, parachuting operations were being conducted from early morning (approx. 09.00 hrs) at Clonbullogue Airfield. The Tandem Passenger (henceforth referred to as the TP) arrived at Clonbullogue with his father, brother and sister at approximately 10.30 hrs. The TP, his brother and sister signed relevant documents and then observed the parachuting operations until they were scheduled to jump. At approximately 16.15 hrs the TP was kitted up in a jumpsuit and harness and received a standard safety briefing from his Tandem Master (henceforth referred to as the TM) covering among other things, aircraft entry and exit, hooking up, tightening, free-fall, deployment, landing and emergencies.

Specific to the accident jump, two aircraft, a Pilatus PC-6/B2-H4 Turbo-Porter (EI-IAN) and a Cessna 182 (EI-CDP) were being utilised and two Jump Masters[1] were assigned to each aircraft. EI-IAN was on its 18th drop of the day. It had one pilot and nine jumpers on board, made up of three tandem pairs and three singletons. The TP was located in EI-IAN. The second aircraft EI-CDP was on its 4th drop of the day and had one pilot and four jumpers on board made up of two tandem pairs, including the brother and sister of the TP. EI-CDP dispatched first followed by EI-IAN and they climbed to the assigned altitude of 10,000 ft.

Jumping commenced at approximately 17.04 hrs from 10,000 ft with the TM and TP first to leave EI-IAN, followed by the other jumpers from EI-IAN and EI-CDP. All jumpers exited the two aircraft safely. A number of witnesses then observed one of the tandems in a spiral rotation, followed by a release of the left side riser (see Section 1.2) of the main canopy. Both the main canopy and the reserve canopy went to a condition of partial inflation. The canopies remained in that condition until impact within a forest clearing **(Photo No. 1)** where both individuals suffered serious impact injuries.

[1] **Jump Master:** An experienced certified Skydiver, or Instructor, responsible to the Club Chief Instructor (CCI) and pilot for the parachutists on each lift/drop.

Photo No. 1: Impact site

1.2 General Description of Tandem Parachute System

Tandem parachuting is a type of skydiving where a person is connected to a harness attached to a TM. The TM guides the student through the whole jump from exit of the aircraft, through free-fall/drogue-fall (see below), piloting the canopy, and landing. The TM remains primarily responsible for the safe and timely deployment of the main chute and also responds to any emergencies encountered.

In general terms, the tandem parachute system (as used on the day of the occurrence) is made up of a main harness and container. The main parachute is held in the bottom half of the container, while the reserve parachute is held in the top half. A separate harness is provided for the TP who is connected to the front of the main harness at four separate points. A diagram of the different elements of the parachute system is presented at **Appendix A**.

On leaving the aircraft, a drogue-chute is deployed by the TM into the slipstream in order to reduce the tandem free-fall velocity. When fully inflated, the drogue provides enough drag to give a tandem pair a descent velocity of approximately 120 mph. Without a drogue, a tandem pair would accelerate to 170 mph in 18 seconds, risking hard opening shocks and possible canopy damage. Descent with a drogue deployed is referred to as 'drogue-fall'. The drogue may be released at any time during the drogue-fall but normally for a tandem jump it would be no lower than 5,500 ft. The drogue is released (thus deploying the main canopy) by pulling the orange drogue release handle normally located at the bottom left-hand corner of the container. The drogue can also be released through a second blue handle located on the right hand side of the container.

The drogue is connected to a piece of nylon webbing (2 to 3 meters long) called a 'bridle', which in turn is connected (via a closing 'curved' pin) to a bag called the deployment bag, or 'D-bag'. The parachute is packed into the D-bag and the D-bag is loaded into the bottom of the container. This is done through a closing loop which, during packing, is fed through the grommets of the four flaps that are used to close the container. The closing pin, which is attached to the bridle, is inserted through the closing loop and holds the main canopy inside the container.

On drogue release, the closing pin is pulled, the four flaps on the container open and the bridle pulls the D-bag (containing the canopy and lines) from the container. All of the parachute's lines are stowed in a zig-zag pattern by looping them underneath rubber bands attached to the D-bag. The drogue partially collapses into a drogue pilot-chute and through the bridle, acts as a pilot-chute to pull the D-bag from the container. As the lines completely unfold and start to pull (line stretch) with the tension from the drogue (pilot) chute, they pull 'risers' out of the container. The risers are heavy nylon straps that connect the lines from the canopy to the container at each shoulder. There are two risers per shoulder. The lines are also referred to as the 'suspension lines' and are broken down into line groups when they connect to the canopy as the A-Lines, B-Lines, C-Lines and D-Lines. The tension on the lines also pulls the canopy itself out of the D-bag. As the canopy releases from the D-bag the airflow begins to enter the front of the canopy into the blind cells, pressurises/fills the cells and gives the canopy an aerofoil shape. The cells are closed at the back of the canopy.

A rectangular piece of fabric called the 'slider', which separates the parachute lines into four main groups fed through grommets in the four respective corners of the slider, slows the opening of the canopy and works its way down the lines until the canopy is fully open and the slider is just above the head of the TM. The slider slows and controls the deployment of the parachute. Without a slider, the canopy would inflate fast (hard opening), potentially damaging the canopy fabric and/or suspension lines. Once the canopy is fully open, it must be checked by the TM to confirm that it has deployed correctly.

In order to control the parachute, two sets of lines, referred to as 'control/steering lines' are connected to the rear edge of the canopy on the left and right sides. These lines are controlled by two handles known as 'toggles' which are located at the end of each line. When you pull on the left toggle, you lower the back part of the left side of the canopy. This causes the left side of the canopy to slow down, and you turn to the left. If you pull down the right toggle, you turn to the right. If both toggles are pulled down together it slows the whole canopy down and acts like a brake. This allows you to flare for landing.

If a malfunction of the main parachute is experienced and cannot be corrected, there is a facility to release the main canopy from the harness/container through a 'cutaway' handle (green soft pillow pad attached by Velcro) which is normally located on the front right-hand side of the harness. At the bottom of the risers there is a mechanism for attaching and releasing the risers of the main chute from the harness/container, usually in the form of a three-ring release assembly. Two yellow cables run from the 'cutaway' handle to each shoulder harness where they are fed through the three-ring release assembly. When the 'cutaway' handle is activated, the yellow cables are physically pulled from the three-ring assembly, the risers are released from both shoulders simultaneously and the main chute departs.

The reserve chute is packed in a 'free-bag' located in the upper half of the container and utilises a spring-loaded pilot chute to assist in its deployment. The suspension lines of the reserve are stowed within a 'stuff pouch' on the underside of the reserve free-bag. Once free of the malfunctioning main chute, the reserve can either be activated manually, by pulling a second handle 'reserve ripcord' on the front left harness or this can be achieved through versions of a main-chute-assisted reserve deployment system.

One such system is the reserve static line (RSL), which is a lanyard connecting one of the main parachute risers (in this case the right shoulder) to the reserve ripcord and will automatically pull the reserve pin and open the reserve parachute container when the main parachute is cut-away. The primary advantage of using an RSL is a faster reserve parachute deployment compared with using the emergency handles alone; after a cut-away, the RSL will usually activate before the reserve deployment ripcord is pulled.

The 'Skyhook' is a version of a main-chute-assisted reserve deployment system, which builds on the concept underlying an ordinary RSL in that it further uses the force of the departing main parachute to extract the reserve parachute out of its compartment. This greatly decreases the time, and hence loss of altitude, required to fully open the reserve parachute after a cut-away.

The Skyhook system is designed so that it should not interfere with reserve deployment when activated by directly pulling the reserve rip cord and in situations where no main chute 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 chute applies more pull force on the bridle than the reserve pilot-chute, then the main chute will remain hooked onto the reserve bridle, and so it will pull the reserve chute out of the reserve compartment. If the reserve pilot-chute exerts more pull force on the bridle than the main chute, then the main chute will unhook and the reserve pilot chute will deploy the reserve chute normally.

A component of the Skyhook system is the 'Collins Lanyard', which is designed to prevent a main chute – reserve chute entanglement by releasing the left (non-RSL) main riser, in the event that the right main riser breaks or prematurely releases by itself for any reason.

Finally, most parachute systems contain an Automatic Activation Device (AAD), which monitors the rate of descent and altitude and starts a sequence for the reserve deployment if the skydiver passes below a set altitude at a high rate of descent without the main chute having been deployed.

1.3 Witness Information

1.3.1 Tandem Master (TM)

The TM informed the Investigation that he had completed 6 tandem jumps earlier in the day and prior to the accident jump. He was matched for height and general size with the TP, he assisted the TP in kitting up and provided the standard safety briefing. He walked to the waiting aircraft with the TP, entered last and hooked up together. The aircraft climbed to 10,000 ft and they prepared for the jump as they were scheduled to leave the aircraft first.

The TP *"balled-up"*[2] in the doorway and they flopped out of the aircraft. He pitched (released) the drogue and descended in drogue-fall for approximately 30 sec to 5,500 ft. During the descent the TM checked his equipment.

He then initiated deployment of the main chute by pulling the drogue release handle and was under canopy by approximately 5,000 ft. He stated that the TP was in a *"solid"* position and he considered that the canopy "*came out nicely"*. However, he stated that almost immediately after deployment/inflation the canopy commenced a rapid and violent spiral to the right, like a *"mad thing"*, there were *"huge forces"* and the TP was being thrashed about like a *"rag doll"*.

He pulled on the brake lines, but to no effect and then opted for a main canopy cut-away. While attempting to pull the 'cutaway' handle to release the main chute, he stated that, '*his hand kept coming off it'*. He recalled that, '*once I reached the 'cutaway' handle, the tension on the cut-away cable, due to the centrifugal force of rotation, was such that I was unable to activate the release'*. He even struggled to use his left hand in order to assist his right hand but to no avail.

He advised the Investigation that in his 30 years' experience, he had cut-away on a number of occasions (approximately 15 times) without any problems. However, now concerned with his closure rate to the ground and in the belief that he was at 2,000 ft and that this was his last chance, he pulled the reserve, but *"nothing happened"*. He could see that the main canopy was nearly full and the reserve pilot-chute was out and twisting. He pulled on the free-bag and started to shake the reserve canopy out of the bag. He then went back to working on the riser. He noted that he had got a bit of inflation on the reserve canopy but recognised that it was going to be a very hard landing. He started shouting to the TP, telling him that this was going to be a very hard landing and to keep both feet together.

During the final stages of the descent, he recalled passing over sheds and a concreted area and drifting towards a forest close to the airfield. Just prior to entering a forest clearing, he ensured that they both had their legs together and the head of the TP was in his chest. The impact was very heavy and he immediately went to the assistance of the TP whom he could see had suffered serious injuries. Very shortly thereafter a fellow parachutist arrived on scene, followed by a number of others, who administered first aid.

The TM told the Investigation that he was unaware of the release of the left hand side riser during the descent and that throughout the occurrence he had no directional control of the canopies.

1.3.2 Tandem Passenger (TP)

The TP, who was accompanied by his father, stated that his brother, sister and himself, were availing of a vouchered tandem jump, which they had received as a present. They arrived at Clonbullogue at approximately 10.30 hrs, went to reception, where their names were taken and they signed a number of documents related to the jump itself.

[2] **Balled-up:** A common condition for a first time jumper where the individual instinctively reacts to the imminent jump by recoiling into the tucked position.

The TP stated that there were a number of people looking to jump and they had to wait for most of the day before they got their turn. He was introduced to his TM, who assisted him in kitting up and he received a safety briefing.

They then boarded the aircraft and hooked up inside. He recalled that the aircraft climbed to 10,000 ft as planned and they then prepared to leave the aircraft first. He was nervous, as it was his first jump. During the fall, he got an "OK" signal from the TM. Another "OK" signal was made just before the TM pulled the main cord. They rose a bit and he saw the parachute above his head but almost immediately it started *"rocking and spinning".* It was hard to see, but he could hear the TM shouting and the TM trying to pull something. At this stage he got worried and knew something was wrong. He saw the reserve chute being pulled and then the spinning stopped. He noticed that one side of chute departed. They were falling very fast and he could see the fields below.

The TM then started shouting continuously that it was going to be a very hard landing and to keep his legs together. He remembered approaching a house and thinking that they were going to hit it, but they missed it, clipped some trees and entered a clearing in the forest. They had a very hard impact and he was in a lot of pain.

The TM started helping him and a number of other people arrived very quickly, including, another parachutist, a doctor and a nurse. He was cut out of his harness, administered first aid and thereafter he was brought to hospital by helicopter.

1.3.3 Club Chief Instructor (CCI)

The CCI was monitoring parachute openings and landings from the airfield. Following what appeared to be standard openings, he noticed one particular tandem canopy immediately enter a spiral rotation after deployment. This was a sign to him of a malfunction of the main canopy, particularly when it happened so quickly after opening, and he expected to see a clean cut-away of the main canopy followed by deployment of the reserve chute. After a number of rotations he observed the reserve pilot-chute deploy and trail behind the TM. He then saw the left hand side harness (riser) of the main chute release. At this point the CCI was aware that he was witnessing a serious situation and he instructed another jumper, who was beside him at the field, to immediately telephone for an ambulance. The CCI further witnessed that the reserve started to deploy but slowly spun up, twisting the lines up towards the canopy and preventing the reserve canopy from fully deploying.

The spiral had stopped at this stage and he continued to watch the descent all the way to the ground. He contacted the pilot of EI-IAN by radio, advised him of the situation and stopped all jumping for the remainder of the day. The CCI then coordinated the emergency response.

1.3.4 Pilot of EI-IAN (Pilot)

The Pilot, who held a commercial pilot's licence, was the duty pilot for parachute operations on the day of the accident. The flight was number 18 of the day and was a tandem load for a drop from 10,000 ft.

The weather conditions of partial cloud and wind aloft of 220/08 kts dictated a jump run and 'spot' on a bearing of 220 degrees from the airfield at a distance of between 1.2 and 1.5 nm. Having safely dispatched the skydivers and descended for landing, he was informed on the ground by the CCI that operations were being suspended due to a double-malfunction of a tandem parachute.

He was told that the tandem pair had suffered multiple traumatic injuries during impact close to the airfield and as he was familiar with the Irish Air Corps (IAC) Emergency Aeromedical Service (EAS) at Athlone, he elected to contact them directly and forewarn them of the casualty site location. Approximately 8 minutes later, the helicopter 'Ambulance 274' made contact on Clonbullogue frequency, stating that they were inbound. The Pilot then elected to get airborne again in order to identify the casualty site location for 'Ambulance 274'. Subsequently, he returned to Clonbullogue and went by road to the scene where he remained until both casualties were removed by ambulance and helicopter.

1.3.5 Camera Parachutist

This parachutist jumped from EI-IAN and started filming the tandems as they descended. Following deployment of his own main chute he noticed that one of the tandems was in difficulty. He noticed the reserve coming out but not inflating.

He knew that they were in trouble and that they were not going to land with a fully functioning canopy so he flew over towards them in the hope that he could be close to where they would land and offer assistance. He landed close by, ran into the forest and found the casualties. They were both conscious and able to respond to questions. However, due to their injuries he decided not to move them, but rather to await medical assistance which arrived shortly thereafter.

1.3.6 Parachutist/Advanced First Aider

This experienced parachutist and advanced first aider was watching from the airfield and witnessed the double-malfunction. He immediately got into his car and chased after the canopies as they descended towards the ground. He saw the tandem pair descending into the forest followed by two other parachutists landing close by. On entering the forest he met up with the camera parachutist who informed him that the tandem pair was seriously injured. He reported this back to the CCI and then went to assist the casualties. On arrival he noticed the following specific to the condition of the parachute equipment:

The left riser and lines from the TM's container were draped across the face of the TP. One of the yellow cut-away cords (long cord – left shoulder) was looped and hanging free. The other cord (short cord – right shoulder) was still engaged. The 'cutaway' handle was not fixed in its stowed position but rather resting on the 'cutaway' handle Velcro housing.

In order to allow him better access to both the TP and the TM, he decided to disconnect the lines by pulling the 'cutaway' handle, which released the three ring assembly/riser from the right shoulder of the TM. The cutaway/release was normal. On assessing the condition of the casualties, he determined that the injuries were such as to necessitate calling an air ambulance and this was conveyed to the CCI. On arrival of the doctor and nurse he gave a brief description of the situation and the apparent injuries.

1.4 Personnel Information

1.4.1 Tandem Master (TM):

Personal Details:	Male, aged 52 years
Licence:	Issued by the Parachute Association of Ireland (PAI)
Ratings:	Display - 24/07/2003 Jump Master - 24/07/2003 Tandem Master - 24/07/2003 CCI Declaration Licence Renewal Valid 2012
Medical Certificate:	Class 2 and valid until 23/09/2012 (**Note 1**)
Jump Experience:	2,625 of which approximately 1,600 were tandem 6 tandem jumps on the day and just prior to the accident 107 tandem jumps in 2011 92 tandem jumps in 2012 (up to 18/08/2012)

Note 1: The TM was required under the conditions of his air medical to wear spectacles, which he did during the accident jump.

1.4.2 Tandem Passenger (TP)

Male, aged 21 years. This was the TP's first parachute jump.

1.4.3 Senior Rigger

The Senior Rigger oversees the general packing operation; he is responsible for the inspection/maintenance of the equipment and in particular has sole responsibility for the inspection and packing of the reserve chute. The Senior Rigger had over 10 years parachuting experience and had accumulated over 4,780 jumps of which approximately 2,500 were tandem jumps. He was awarded his Federal Aviation Administration (FAA) USA Senior Rigger ticket (qualification/rating) on 3rd April 2007 and this was converted on the same day to a Parachute Association of Ireland (PAI) Basic Rigger rating. Following two years' experience as a Basic Rigger, he achieved his PAI Senior Rigger rating on the 3rd April 2009. He had a current Senior Rigger rating for 2012.

1.4.4 Packer

In general, each individual parachutist normally packs his/her own main chute. However, for non-individual packs such as a tandem main chute, a qualified packer is utilised.

The packer who packed the accident main tandem chute told the Investigation that she had been packing main chutes for 6 years and would have accumulated a couple of thousand pack jobs. The packer confirmed that she had packed the accident main tandem chute (Rig No. 3) on the day of the accident in the same manner as all other pack jobs and did not see anything unusual during the packing. Records determined that the packer had packed a total of 11 main chutes on the day of the accident and that the accident rig was packed only once on that day.

1.5 Injuries

Both individuals suffered serious impact injuries. The TM broke his left femur just above the knee. The TP suffered a broken back, broken left arm, a broken jaw and also lost a number of teeth. He was hospitalised in two different Dublin hospitals for a total period of 9 days.

1.6 Equipment

1.6.1 Equipment Details

The tandem pair descended into a forest clearing and impacted heavily on their left sides. In order to gain direct access to the injured pair, the first-aid responders disconnected the equipment and cut off the TP's harness. Photographs were taken of the impact site and following clearance from the AAIU, the equipment was recovered and secured for further examination.

The Sigma Harness Container System Serial Number (SN) 38148 was manufactured by the Relative Workshop (RWS) in May 2002 and its last inspection prior to the accident was 16 June 2012. The harness contained a 'Cypres' Automatic Activation Device (AAD).

The main tandem parachute, a Sigma Tandem 370, SN 59370-00281 was manufactured by RWS in August 2003 and it had accumulated 258 jumps since 16 Sept 2005.

The reserve tandem parachute, a Vector Tandem II 360, SN 5947 was manufactured by RWS in January 2008 and its last inspection by a Senior Rigger prior to the accident was 16 June 2012. It was compliant with the compulsory 6 month reserve check.

1.6.2 Equipment Examination

The AAIU acquired the services of a senior parachute instructor and advanced rigger from the UK who has over 40 years parachuting experience and has accumulated over 7,500 jumps. The role of this individual was to carry out an independent examination of the recovered equipment and provide specialist technical assistance to the Investigation. In addition, he visited Clonbullogue and observed packing procedures.

In general, he considered that the main canopy, the reserve canopy, the harness system and the lines were in good condition. Both the main brake toggles had been fired[3] and the reserve brakes were still stowed and intact.

The Collins lanyard of the RSL was found in situ on the Skyhook itself and the red locking thread was still intact. The AAD had not activated.

There was nothing found in the recovered equipment that would have directly contributed to a technical malfunction of the main chute nor was anything found that would have impeded or restricted a normal cut-away or full deployment of the reserve, had a successful cut-away been achieved.

[3] **Fired:** Term used to describe that brakes had been released. Brakes are set at half-brake during packing in order to assist in the canopy aerodynamics during deployment.

From a packing management point of view the examination noted that:

- The Velcro channel for the Collins lanyard was tightly meshed, indicating that the lanyard had been placed over the Velcro flap for some time rather than being stowed correctly in the channel itself.
- The reserve L-link locking screws were not adequately tightened. One was loose and standing proud of the link and the remainder were only hand tight.
- The elastic bands on the main deployment D-bag were worn indicating that they may have been in use for some time.

During his visit to Clonbullogue, the advanced rigger observed the main chute packing procedure, demonstrated his technique to clear twists in the control/steering lines during packing and explained the reasons and importance of doing so on a more regular basis.

1.6.3 Other Equipment

It was noted that the TM had a large wrist mounted double camera bracket and altimeter container on his left arm **(Photo No: 2).** However**,** no cameras were attached for the accident jump.

Photo No. 2: Camera and Altimeter Container Bracket

1.7 Video and Photographic Footage

Two videos of the occurrence where provided to the Investigation by the CCI and photographs were provided by the father of the TP.

Specific to the video footage, the first video (duration 1 min 50 sec) was shot from the ground and tracked the descent from just after canopy inflation, until moments before impact when it went out of view behind buildings. The second video (duration 1 min 12 sec) was from a helmet mounted camera on a singleton parachutist (see Section 1.2.5) who on seeing that the tandem pair was in difficulties tracked them down to impact. The first video footage was used to assist in determining the sequence of events during the descent following drogue-fall.

On first sighting the main chute had deployed, was inflated and was spiralling to the right. Freeze framing and magnification identified that there was a large distortion of a few cells on the right hand side edge of the main canopy.

Approximately 23 sec later (approximately 8 spiral rotations[4]) material was seen to emerge from the back of the TM and this was subsequently identified as the reserve pilot-chute. After a further two rotations, more material (the reserve chute free bag) was seen to emerge from the back of the container. A half rotation later, the left side riser released, rotation stopped almost immediately and the tandem pair resumed vertical descent. Approximately 11 spiral rotations were observed within a period of 28 sec.

The main chute slider was seen to be held half way up the remaining right hand line group and the left hand riser becoming entangled with the slider. The main canopy remained partially inflated. A further 16 sec later the reserve chute was seen to emerge from the free-bag, followed by the free-bag and bridle becoming entangled with the reserve slider at the top of the lines of the reserve canopy. The remaining reserve chute lines appeared twisted and the reserve canopy was only partially inflated. The reserve pilot-chute was seen at the riser end of that line group. Both partially inflated canopies remained in this configuration until impact **(Photo No. 3)**.

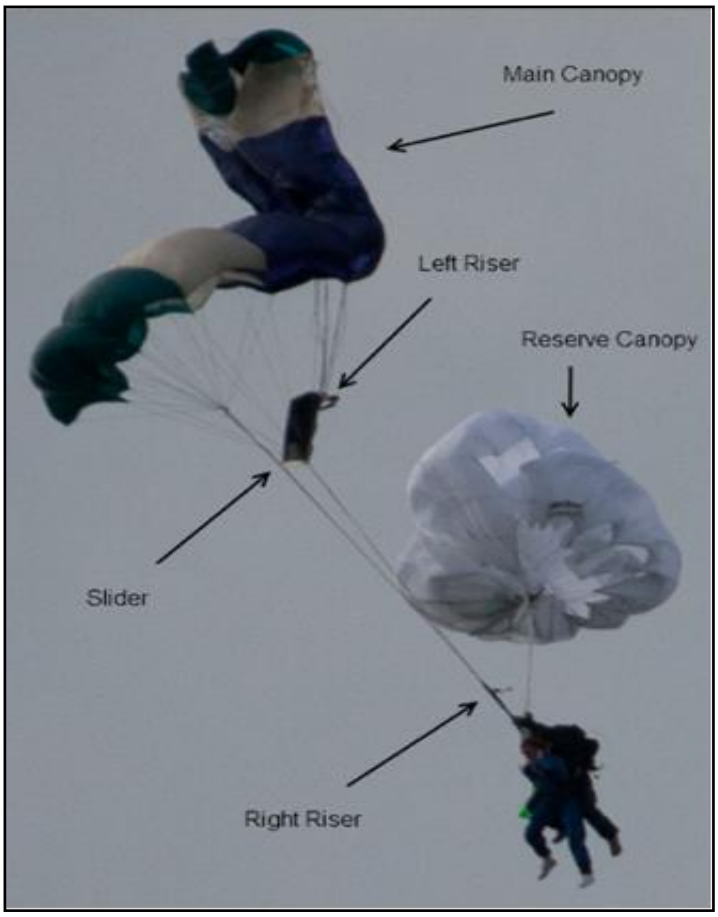

Photo No. 3: Configuration of Main and Reserve canopies prior to impact.

[4] **Rotations:** Parachuting documentation indicates that depending on the condition and circumstances height loss can be in the region of 200-300 feet per rotation.

1.8 Emergency Response

A doctor, nurse and a number of first aiders, who were present at Clonbullogue, ran from the airfield to the casualty site in order to provide medical assistance to the injured. The 999 call was received at 17.05 hrs. An ambulance was allocated at 17.06 hrs and arrived on-scene at 17.35 hrs. The ambulance left the scene at 18.54 hrs with the injured TM on-board and routed to Tullamore Hospital where it arrived at 19.36 hrs.

The Emergency Aeromedical Service (EAS) helicopter became airborne from Athlone Barracks at 17.15 hrs and arrived on-scene at 17.40 hrs. It departed the scene at 18.30 hrs with the injured TP on board and routed direct to Tallaght Hospital where it arrived at 18.42 hrs. The Fire Service also attended the scene having been called at 18.07 hrs.

1.9 Additional Information

1.9.1 Regulatory Information

Pursuant to Rule 7(2) of the Irish Aviation Authority (IAA) Rules of the Air Order, 2004, (S.I. No 72 of 2004) the IAA can, subject to specific conditions, grant a Parachuting Centre (PC) Permission for a Parachute Dropping and Training Centre run by an appropriate parachuting organisation. All parachute centres in Ireland must hold a valid PC Permission.

The Safety Regulation Division (SRD) of the IAA issued a General Advisory Memorandum (GAM) No: 01/10 dated 8th Jan 2010 and Appendix issued 9th Jan 2013 on Parachute Guidance Material. The purpose of this guidance material is to set out the minimum standards required prior to the grant or renewal of PC Permissions and to indicate the requirements for the conduct of parachuting operations in Ireland. The Investigation noted that the guidance material does not address the carriage of ancillary equipment such as camera mounts/brackets.

On the 24 June 2012, the IAA conducted a Parachute Centre Audit of the PC at Clonbullogue Airfield. The Audit found that the Centre was *'sufficient'* in all aspects and was signed off by an independent International Auditor on the 1 July 2012. This Audit is conducted on an annual basis for all Parachute Dropping and Training Centres in Ireland.

In addition, the IAA issued a PC Permission No. 2 of 2012 for Parachute Dropping and Training Centre for the PC at Clonbullogue on the 25 June 2012, to take effect from the 1 July 2012 and valid until 30 June 2013.

1.9.2 Parachute Association of Ireland (PAI)

The PAI is an association for sport parachuting in the Republic of Ireland. It seeks to set and maintain standards for safety, training and operations for its members who are affiliated to two parachute centres, one at Clonbullogue and one at Abbeyshrule. In addition, it seeks to promote Sport Parachuting at National and International level and is affiliated to the Federation Aeronautique Internationale (FAI) through the National Aviation Council of Ireland and to the European Parachute Union (EPU).

All PAI members are required to operate in compliance with the IAA General Advisory Memorandum on Parachute Guidance Material. To this effect, the PAI has developed documentation such as Operation Manuals and Instructor Manuals to take account of the guidance requirements. The Investigation noted however, that the Manuals do not provide guidance with regard to the carriage of ancillary equipment such as camera mounts/brackets.

1.9.3 Parachuting Centre (PC)

The Irish Parachute Club (IPC) has been in operation since 1956. It operates from its own airfield at Clonbullogue, near Edenderry, Co Offaly and offers a variety of parachuting courses and activities, including: Tandem Skydiving, Accelerated Free Fall student courses and Static Line student courses for new jumpers.

A review of the PC documentation determined that the TM's name was not listed on the PC Permission, under the Section 'Staff Parachute Instructors'. In addition, the Operations Manual does not provide guidance with regard to the carriage of ancillary equipment such as camera mounts/brackets.

A review of the PC activity and malfunction record for the period June 2010 – Sept 2012 determined the following:

Activity	From/To	Jumps	Single Malfunction	Double Malfunction
Sports Jumps[5]	June '10-Sept '12	25,148	39	
Tandem Jumps	June '10-Sept '12	4,156	9	1
Static Line	June '10-Sept '12	448	3	

Note 2: Historic records indicate that this particular accident event was the first such double-malfunction of a parachuting system recorded in Ireland.
Note 3: A single malfunction of a main tandem chute of another tandem master occurred on the morning of the accident event with a successful 'cut-away' to reserve. The particular tandem chute was not the accident chute and was packed by a different packer.

2. ANALYSIS

2.1 General

It is recognised that sporting/leisure activities such as parachuting do carry an element of risk, be that through malfunction of equipment or personal injury during the landing phase. While main chute malfunctions do occur from time to time, such malfunctions are usually resolved through a cut-away of the main chute, followed by deployment of the reserve chute. A double malfunction of both the main and reserve chute are rare and historic records indicate that this was the first double malfunction to occur in Ireland.

[5] **Sport Jumps:** Single jumpers

2.2 The Accident

Following an uneventful drogue-fall, the main chute was deployed and inflated but immediately suffered an abnormality/malfunction which led to a spiral rotation to the right. The TM was unable to perform the normal cut-away and as a last resort, he deployed the reserve with the main chute still attached.

The circumstances deteriorated into an escalating emergency situation whereby, following a complex sequence of events, both canopies went to a condition of partial inflation and this configuration persisted throughout the remaining descent until impact within a forest clearing. While both individuals suffered serious injuries, there was potential for the outcome to have been far more serious.

The certified TM was experienced, current and had responded successfully to a number of main chute abnormalities/malfunctions in the past. An examination of the PC Permission documentation determined that the TM was not specifically listed under the Section 'Staff Parachute Instructors'. The Investigation considers that while this was an administrative oversight on behalf of the PC, it had no bearing on the actual certification of the TM or on the accident itself. However, the Investigation does make a Safety Recommendation regarding administrative oversight.

There are some inconsistencies between the TM's recollection of events and that which was determined by the Investigation in the analysis of the video footage and the equipment. It is however acknowledged that following such a traumatic event, recall of the sequence of events can vary significantly. The fact that the TM had no knowledge of the release of the left side riser, whilst the TP clearly described its release, is a case in point.

2.3 Main Canopy Abnormality

In basic terms, following deployment, the main canopy normally forms to a uniform aerodynamic shape. When this aerodynamic shape is altered for example by manipulating of the control/steering lines the canopy will turn and/or flare. The initiating event for this accident was the abnormality/malformation of the main canopy after deployment.

It is clear that the main canopy entered a spiral rotation to the right immediately after it had deployed and it is considered likely that this was initiated by the development of a tension knot[6]. A specific reason for the likely development of the tension knot could not be definitively determined from the technical examination of the recovered parachute system. It may have been associated with twists in the control lines, or an out of sequence deployment or something else. However, the Investigation considered the most likely scenario to be that a tension knot formed in the control/steering lines of the right hand riser group and engulfed/shortened the C and D lines during the opening sequence, causing the main canopy malformation. This in turn caused the canopy to back stall and rotate to the right.

[6] **Tension knot:** Where one or more lines twist and interlock causing shortening and distortion of the line(s). This can be caused by a number of reasons, including, the incorrect stowage of lines, badly deployed lines, worn or bobbled lines; twists in the control/steering line configuration or out of sequence deployment.

On his visit to Clonbullogue, the advanced rigger did mention a need to clear twists in control/steering lines on a more regular basis as they are susceptible to the formation of tension knots.

Other issues identified in the equipment examination, such as the Collins lanyard not being stowed correctly in the channel; the reserve L-link locking screws not being adequately tightened and the worn elastic bands on the main D-bag are not directly associated with the development of tension knots but rather issues relating to the overall standard of packing. However, the Investigation does consider that there is a need to review the packing technique with regard to clearing twists in control/steering lines during packing. In addition, there is a need to review the maintenance schedule for tandem equipment to ensure that timely checks and replacement of components parts are undertaken. Two Safety Recommendations are made to that effect.

2.4 Reserve Canopy Malformation

Video evidence confirmed that after approximately 8 spiral rotations material was seen to emerge from the back of the TM and this was subsequently identified as the reserve pilot-chute. The emergence of the reserve pilot-chute was likely caused by an intentional pull on the reserve handle by the TM. The pilot-chute did not go to full bridle length, probably due to the fact that, as the main canopy was still attached/inflated, the rate of descent/drag speed was insufficient to fully inflate the pilot-chute and assist in the extraction of the reserve chute. Hence the belief by the TM, that '*nothing happened*' following his pull on the reserve chute handle.

The free-bag dislodged from the reserve tray and trailed behind the TM with the lines emerging from the stuff pouch. The pilot-chute end of the bridle was still attached to the reserve staging flap via the Skyhook.

The extra drag from the free-bag and the reserve canopy in trying to emerge from its free-bag was sufficient to activate the Skyhook attachment to the left hand 'cutaway' cable and released the left hand side riser. The Collins lanyard of the RSL was still in situ on the Skyhook itself and the red locking thread was still intact due to the reserve pilot-chute being at the container end. The force of the riser releasing caused it to engage with the slider and lock itself off halfway up the remaining line group which was sufficient to enable the main canopy to stay partially inflated rather than streaming as would normally be expected.

When the reserve canopy emerged from the free-bag, the reserve lines deployed and twisted as they deployed, entangling the free-bag and bridle. The reserve then tried to develop but remained in a 'squid like' configuration with the mouth of the cells inflated. Both canopies remained in this partially inflated configuration until impact.

2.5 Inability to Cut-Away

The TM stated that once he reached the 'cutaway' handle, the tension on the 'cutaway' cord ('*due to the centrifugal force of the rotation'*), meant that he was unable to activate the handle. In addition, he indicated that he attempted to use his left hand to assist his right hand but this too failed.

An examination of the equipment determined that there was nothing technically or mechanically found in the parachuting system that would have restricted the 'cutaway' from functioning correctly.

The Investigation is satisfied that the Skyhook, in conjunction with the RSL, activated the cut-away mechanism on the left side riser as a result of drag being exerted by the reserve pilot-chute, and the reserve canopy trying to emerge from its free-bag. The right hand side riser remained in place, as outside of a catastrophic failure, the only possibility of release is through manual application of the 'cutaway' handle. The Skyhook and RSL system functioned as expected as part of the manual back-up system and as such it is considered that the centrifugal forces experienced during the spiral rotation should not have put additional pressure on the cut-away system to impede its functionality.

Furthermore, the direction of rotation (right) should have enabled a one handed activation to take place without the need to use the left hand. As such it is unclear to the Investigation as to why the TM found it so difficult to operate and achieve the expected cut-away.

It is possible that the rate of rotation and the associated centrifugal forces created a state of disorientation that affected the TM's ability to accurately locate the 'cutaway' handle within the appropriate time frame. In addition, the *'rag doll'* effect of the TP during the prolonged spiral rotation may have interfered and impeded the cut-away. The TM may also not have fully appreciated or recognised the severity of the initial malfunction or failed to cut-away in a timely manner before the situation escalated further. In any case, it is not possible to be definitive in determining why the expected cut-away was not achieved.

Continuous awareness of the possibility of a main chute malfunction and the immediate actions associated with such malfunctions, including the location of the specific release systems is achieved through emergency practice drills both on the ground and in the air.

Because in this particular case a tandem master was unable to perform a standard cut-away, the Investigation considers that it would be appropriate to review the frequency and effectiveness of emergency practice drills for tandem masters and instructors, both on the ground and in the air and a Safety Recommendation is made to this effect.

2.6 Ancillary Equipment

The TM was observed to have a large wrist mounted double camera bracket and altimeter container on his left arm yet no cameras were attached for the jump. Apart from the altimeter itself (which can be singularly strapped to the arm) the empty camera container served no purpose. The Investigation is of the opinion that specific to tandem jumps, such a bracket could impede arm movements of a tandem master, it could snag in critical elements of the harness equipment or it could cause injury to a tandem passenger.

The Investigation found that the General Advisory Memorandum (GAM) and the documents developed from such guidance by the PAI and IPC do not address the issue of the carriage of redundant ancillary equipment during tandem operations and a Safety Recommendation has been made to that effect.

3. CONCLUSIONS

(a) Findings

1. The TM was properly rated, current and had a valid Class II medical.

2. The parachute centre had a valid Parachute Centre permission, issued by the IAA and had successfully passed a Parachute Centre Audit in June 2012.

3. Following an uneventful drogue-fall from 10,000 ft, the TM deployed the main chute at a height of approximately 5,500 ft; it inflated but then immediately entered a spiral rotation to the right.

4. The main canopy suffered a right side edge canopy abnormality/malformation most likely as a result of a tension knot forming on the right side lines.

5. Normal procedure following a main chute malfunction is to cut-away the main chute and deploy the reserve chute. In this particular circumstance the TM was unable to accomplish this standard procedure.

6. The Investigation was unable to definitively determine why the TM was unable to perform a standard cut-away of the main chute. It is possible that the TM may have suffered a disorientating and/or a destabilising effect from the violent rotations, which impeded his ability to locate and/or effectively use the 'cutaway' system.

7. The reserve pilot-chute was deployed by the TM approximately 8 spiral rotations after the main chute malfunction.

8. The rate of descent at the time of reserve chute release was insufficient to fully inflate the reserve pilot-chute and assist in the extraction of the reserve chute to full deployment.

9. The drag from the reserve pilot-chute and the reserve canopy in trying to emerge from its free-bag was sufficient to activate the Skyhook/RSL attachment to the left hand 'cutaway' cord and cut-away the left hand side riser. The right side riser remained attached.

10. The release of the left hand side riser stopped the spiral rotation, however its release caused it to engage with the main chute slider and lock itself off halfway up the remaining line group.

11. Both the main and reserve canopies went to a condition of partial inflation and this configuration remained in the descent until the tandem pair impacted heavily into a forest clearing.

12. Both the TM and the TP suffered serious impact injuries.

13. An examination of the recovered parachute system determined that it was in generally good condition and no direct technical evidence was found that would definitively identify why the tension knot may have developed. In addition, no technical evidence was found that would have caused a restriction and/or impeded the 'cutaway' system from functioning correctly or attaining a full deployment of the reserve had a successful cut-away been achieved.

14. Specific items found during the equipment examination and the visit to the parachute centre indicated that the general quality of packing management and procedures could be improved. In addition, a need was identified to clear twists in the control/steering lines on a more regular basis to reduce the susceptibility to tension knots forming.

15. An examination of the PC Permission documentation determined that the TM was not specifically listed under the Section 'Staff Parachute Instructors'.

16. Redundant ancillary equipment in the form of a double camera bracket was in use by the tandem master during tandem operations. Such equipment could cause injury to the TP, impede access to critical items or accidentally activate emergency equipment.

17. The parachute centre had an effective emergency response procedure in place and the overall emergency response by a number of different persons/agencies contributed greatly in providing immediate lifesaving medical assistance to both injured parties and subsequent recovery to hospital.

(b) Probable Cause

Following a malfunction of the main chute, the reserve chute was deployed by the TM, whilst the main canopy was still attached; both canopies went to a condition of partial inflation, resulting in a heavy impact and serious injuries.

(c) Contributory Cause(s)

1. The development of a tension knot in the right hand side lines, which resulted in the right side deformation of the main canopy and the subsequent entry into a right hand spiral rotation.

2. The inability of the TM to perform a standard cut-away following a malfunction of the main chute, possibly due to disorientation experienced during the spiral rotation.

4. SAFETY RECOMMENDATIONS

No.	It is Recommended that:	Recommendation Ref.
1.	The Irish parachute club, Clonbullogue review their administration procedures to ensure that all record keeping is accurate and current.	IRLD2013010
2.	The Irish parachute club, Clonbullogue review packing technique with the packers, in particular, with regard to clearing twists from control/steering lines on a more regular basis during packing.	IRLD2013011
3	The Irish parachute club, Clonbullogue review the maintenance schedule for tandem equipment and put a procedure in place to ensure timely checks and upgrades on component parts.	IRLD2013012
4	The Irish parachute club, Clonbullogue review the frequency and effectiveness of emergency practice drills for tandem masters and instructors, both on the ground and in the air.	IRLD2013013
5	The IAA considers the provision of guidance in the General Advisory Memorandum (GAM) No: 01/10 with regard to the carriage of ancillary equipment by tandem masters during tandem operations.	IRLD2013014

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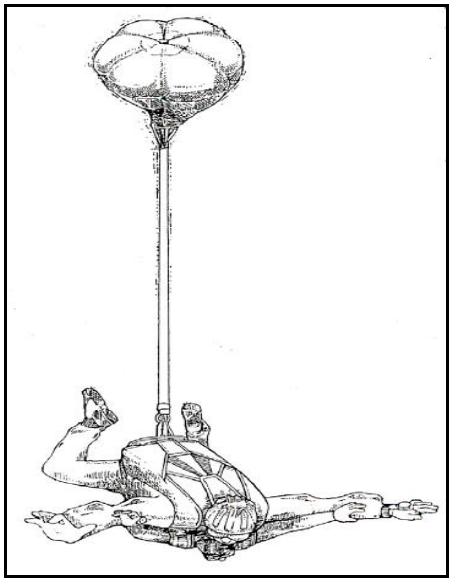
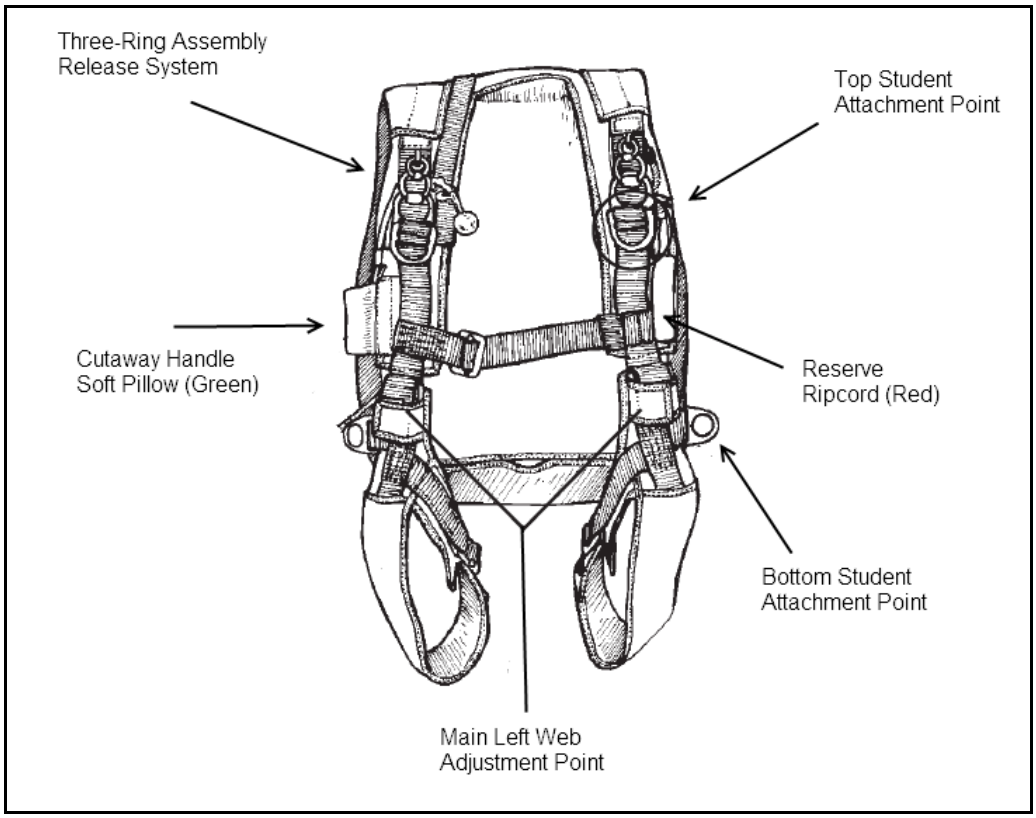
APPENDIX A

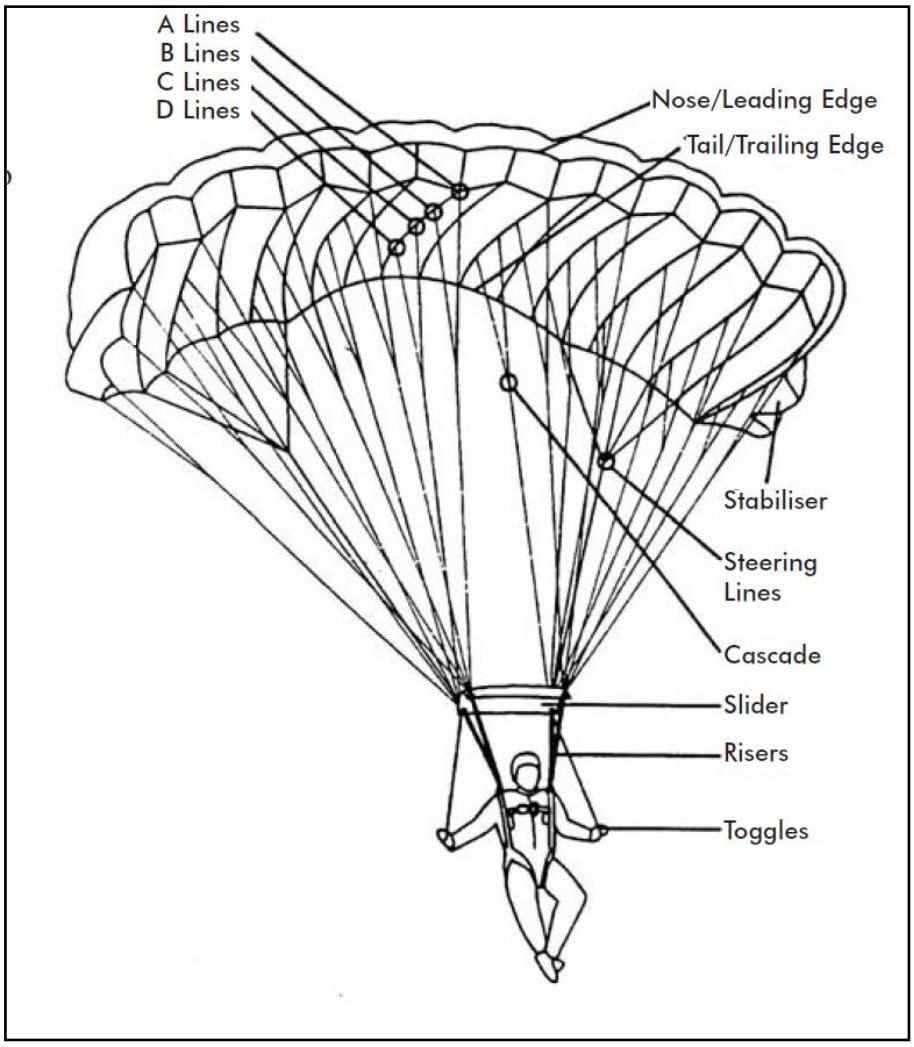
Graphics on elements of a Tandem Parachute System



Graphic No. 1: Drogue-fall



Graphic No 2: Main Harness System



Graphic No 3: Canopy and Lines

- END -

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No. 996/2010, and Statutory Instrument No. 460 of 2009, Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulation, 2009, the sole purpose of this investigation is to prevent aviation accidents and serious incidents. It is not the purpose of any such investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

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