



Investigation report

L2014-01

Experimental Aircraft Accident and Risk of Explosion at Nummela Aerodrome on 27 March, 2014

Translation of the original Finnish language report

OH-XAC

Jodel D18

According to Annex 13 to the Convention on International Civil Aviation, paragraph 3.1, the sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability. This basic rule is also contained in the Safety Investigation Act (525/2011) and European Union Regulation No 996/2010. Use of the report for reasons other than improvement of safety should be avoided.

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Investigation report 1/2015
Translation: R&J Language Service
ISBN (PDF) 978-951-836-451-4
ISSN 2341-5991

Helsinki 2015

SUMMARY

A two-seat wood-structured Jodel D18 aircraft, registration OH-XAC, which the pilot had built himself for his private use took off for a test flight from Nummela aerodrome on Thursday 27 March, 2014 at 13.49. During the climb the aircraft made a sharp turn which resulted in a stall and a collision with the ground. One pilot perished and the other was seriously injured. The aircraft was destroyed. The cause of the accident was a turn at low altitude and at a low airspeed. It is possible that the flight crew made the turn in an attempt to avoid hitting an imagined towing line of a paraglider. The practice that the pilots had adopted, i.e. climbing at a low airspeed in a clean configuration and making a turn at low altitude, is a factor which subjected them to the accident. Insufficient coordination between operators at an uncontrolled aerodrome was a contributing factor. The fact that flight activity was taking place on a runway which was reported closed can also be regarded as a contributing factor.

The aircraft was fitted with a pyrotechnical, ballistic parachute system, the rocket motor of which caused a risk of ignition during the rescue operation. The investigation specifically focused on how a rescue operation can be conducted in a safe manner if the accident aircraft is fitted with a recovery parachute. In the case at Nummela the markings warning of the presence of a recovery parachute were not clearly identifiable, nor did the rescue personnel realise that they were subjected to the risk of explosion. The investigation determined that the rescue sector is not aware of pyrotechnical systems in general aviation or sport aviation, and that virtually no related training or regulations exist.

Moreover, there are foreign aircraft flying in Finland whose pyrotechnical system markings either differ from those used in Finland or are completely absent. In addition, incorrectly installed systems have been discovered abroad. The present aircraft register does not indicate whether an aircraft is fitted with a rocket-propelled ballistic recovery system. The presence of any such system can only be established by inspecting the aircraft on site.

On the basis of the investigation eight safety recommendations were issued.

Finnish Transport Safety Agency:

- Add information about the aircraft's pyrotechnical systems into the aircraft register, define the minimum requirements for the safe installation and use of such systems and make thermal exposure indicators compulsory for them.
- Also give attention to pyrotechnical systems installed in aircraft, including any potential hazards to rescue operations, in aerodrome maintenance regulations, and
- Recommend that operators of uncontrolled aerodromes update any of their own rescue plans, together with the local rescue authority.

European Aviation Safety Agency (EASA):

- Harmonise the markings of pyrotechnical systems and add a system-related segment into LAPL(A) and PPL(A) curricula.



International Civil Aviation Organization (ICAO):

- Standardise the colours of pyrotechnical system parts so that they are clearly distinguishable and easily identifiable.



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ABBREVIATIONS

ATS	Air Traffic Service
BPS	Ballistic Parachute System
BRS	Ballistic Recovery System
CPL	Commercial Pilot Licence
CRI(A)	Class Rating Instructor, Aircraft
EASA	European Aviation Safety Agency
GPL	Glider Pilot Licence
HEMS	Helicopter Emergency Medical Service
ICAO	International Civil Aviation Organization
IRI(A)	Instrument Rating Instructor, Aircraft
JAR	Joint Aviation Requirements
MEP	Multiengine Piston
MGPL	Motor Glider Pilot Licence
NOTAM	Notice To Airmen
PMR	Personal Mobile Radio
PPL(A)	Private Pilot Licence, aircraft
SAIB	Swiss Accident Investigation Board
SEP	Single Engine Piston
UPL	Ultralight Pilot Licence
UTC	Universal Co-ordinated Time
VCL	Valid by day only
VDL	Correction for defective distant vision
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions



SYNOPSIS

A Jodel D18 experimental aircraft, registration OH-XAC, built by the pilot himself for his private use collided with the ground only moments after takeoff at Nummela aerodrome on Thursday 27 March, 2014.

The aircraft was fitted with a rocket-propelled ballistic parachute system. Its rocket motor became hot in the ensuing fire, which created a hazard to the rescue personnel. Those that participated in the rescue operation were unaware of the presence of a rocket motor assembly and, hence, were unable to assess the associated risks.

The accident was reported to Safety Investigation Authority, Finland (SIAF) which launched an initial investigation on the day of the accident. During the on-site investigation parts of the ballistic recovery system were found, whereafter it became apparent that the system had not been activated. An Explosives Ordnance Disposal (EOD) unit from the police was called to the site to deactivate the rocket motor.

SIAF initiated a safety investigation for the occurrence and Mr Olli Borg, MSc, was appointed as team leader for the investigation group, accompanied by Mr Timo Tähtinen, Fire Chief, as an expert member of the investigation group. Chief Air Safety Investigator Ismo Aaltonen acted as investigator-in-charge.

The aircraft was an experimental aircraft under Regulation (EC) No 216/2008 of the European Parliament and of the Council, Annex II. It is not under the control of EASA. Pursuant to Regulation (EC) No 996/2011 the obligation to investigate accidents does not apply to aircraft falling into one or more of the categories set out in Annex II. Since pyrotechnical systems and their risks are not well known, SIAF decided to launch the investigation.

SIAF notified the French and Polish air accident investigation authorities of the accident; they designated their accredited representatives to the investigation.

Comments to the draft final report were requested from Nummela flight centre (Nummelan Lentokeskus ry), the Finnish Transport Safety Authority (Trafi), the Finnish Aeronautical Association (Suomen Ilmailuliitto), Länsi-Uusimaa Rescue Department, the Emergency Response Centre Administration, the National Police Board, the European Aviation Safety Agency (EASA), the International Civil Aviation Organization (ICAO), and from the French and Polish air accident investigation authorities. Their comments were taken into consideration in the final report and the safety recommendations.

The investigation report was translated into English.

All times in this report are in Finnish standard time (UTC+2).

The material used in the investigation is archived at Safety Investigation Authority, Finland.

The investigation was completed on 2.2.2014.

1. FACTUAL INFORMATION

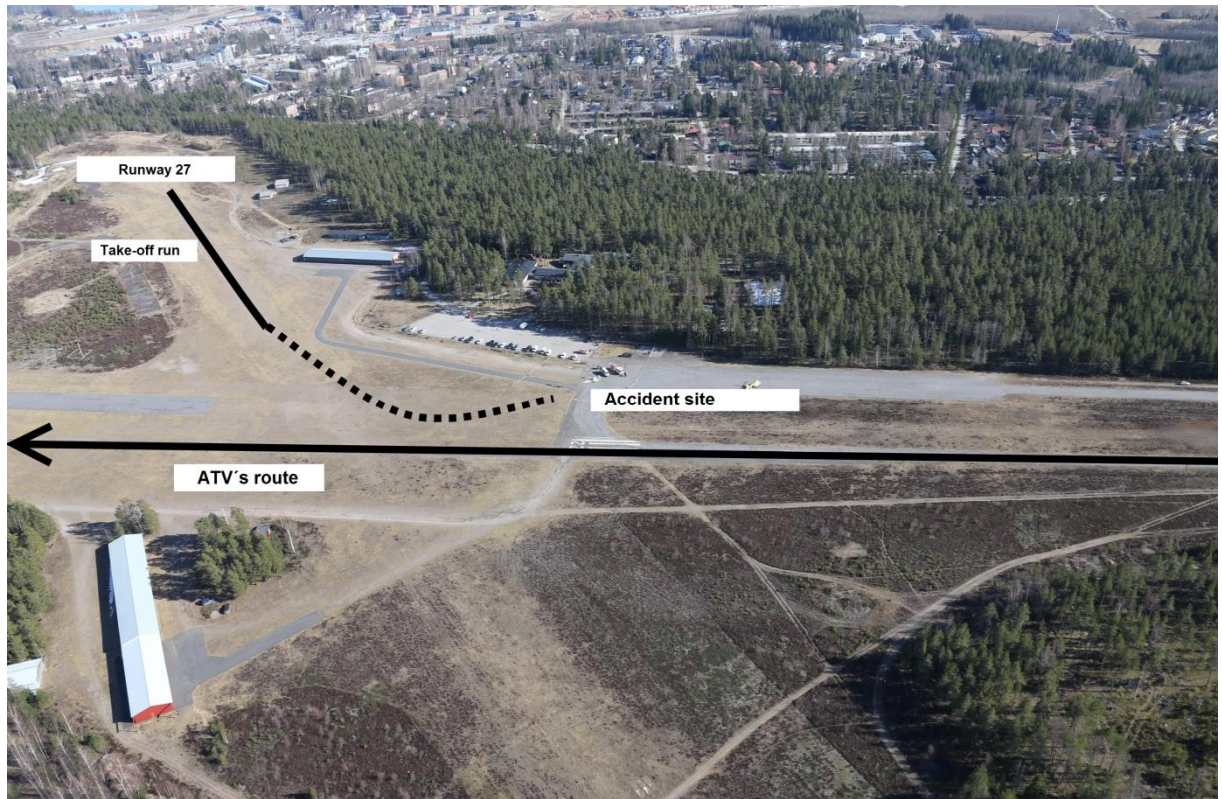


Figure 1. The grass-surface cross runway 09/27 at Nummela aerodrome, viewed from the west. The accident site, where the wreckage and rescue vehicles can be seen, is in the centre of the photo. The black dotted line represents the flight path of the aircraft, drawn as per eyewitness accounts. (Photo: Finnish Border Guard)

1.1 History of the flight

An experimental Jodel D18 aircraft, registration OH-XAC, built by the pilot for his private use took off for a test flight from Nummela aerodrome on Thursday 27 March, 2014 at approximately 13.49. The pilots intended to fly to Hyvinkää aerodrome and return to Nummela.

There were at least three eyewitnesses to the accident flight who were able to describe the sequence of events. Following takeoff, before reaching the intersection of the main runway, the aircraft was seen to make a hard turn to the left. The bank was so steep that the left wing pointed straight to the ground. The eyewitnesses estimated that the altitude was 30-50 m before the turn. While the aircraft was turning its attitude was seen to change in such a manner that it nosed down and went into a dive. During the turn the heading of the aircraft changed approximately 130 degrees to the left. The eyewitnesses

said that it appeared as if the pilots tried to avoid flying over the main runway. Some eyewitnesses said that the aircraft appeared to have stalled. Yet, the pilots nearly recovered the aircraft from the dive because it collided with the ground at an approximate angle of 30 degrees, wings level.

The aircraft was destroyed in the crash and its two occupants were seriously injured. The person who had been sitting in the passenger seat later succumbed to his injuries in hospital. Owing to his injuries the person who occupied the pilot's seat does not recall any events from the flight.

Other activity at the aerodrome

On runway 04/22 paragliding activity was going on; one paraglider was about to land south of RWY 04, approximately 300 m from the intersection of the crossing runway. Simultaneously, the all-terrain vehicle (ATV) used for towing was driving on the runway towards the snatch block pulley, which was at the end of the towing line on the extended RWY 22 centreline at the end of the movement area. The tow line lay loose on the ground. As the ATV was passing the location of the hotel car park its driver saw an aircraft lifting off from the cross runway, being at approximately 10 m over the runway. The driver of the ATV decided to accelerate so as to clear the path of the climbing aircraft. According to the driver the ATV managed to cross the crossing runway well before the climbing aircraft did, which, at that stage, was at treetop height, or so. The ATV and the climbing aircraft are clearly visible in the automatic webcam image (Figure 2) which was taken just moments before the accident occurred. After this the ATV driver did not see the climbing aircraft again until he noticed smoke billowing from its wreckage near the car park.

Events preceding the flight

The pilot stored the aircraft in the same nearby hangar where he had also completed its final assembly. The pilot said that he performed the daily inspection, filled the fuel tank and warmed up and test ran the engine. The pilot had invited his instructor pilot to accompany him on the flight; once he had arrived at the aerodrome they took off for the flight.

The flight instructor had participated in nearly all prior test flights. The flight instructor was also designated as co-pilot of the test flight programme, and he had flown the maiden flight of the aircraft in October 2013. On the following flights, however, the pilot acted as PIC and the flight instructor was recorded in the journey log book as crew member. According to the pilot the test flight programme had proceeded uneventfully and the aircraft had behaved as expected in all situations.

The intention was to conduct the flight under VFR rules. No flight plan had been filed with an ATS unit. No flight plans are required of VFR flights in uncontrolled airspace.



1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1		
Serious	1		
Minor/None			

1.3 Damage to aircraft

The aircraft was destroyed in the accident.

1.4 Personnel information

Pilot:

Age 40.

Licences: Private Pilot Licence PPL(A), valid.
Glider Pilot Licence GPL, valid.
Ultralight Pilot Licence UPL, valid.

All required ratings were valid.

Class 2 EASA medical certificate, valid.

Limitations to medical certificates: VDL and VCL (Correction for defective distant vision; Valid by day only).

The pilot's first licence had been issued in 2005. There was the marking LP (ENG) 5 on the pilot's licence, which refers to the pilot's English language proficiency. The pilot spoke no Finnish.

Flight experience (PPL)	Last 24 hours	Last 30 days	Last 90 days	Total experience
All types	Accident flight	1 flight, less than 1 h	7 flights, 4 h 11 landings	55 h 187 landings.
On this type	Accident flight	1 flight, less than 1 h	7 flights, 4h 11 landings	17 h 63 landings

In addition, the pilot had flown 71 hours and made 202 landings on gliders, and flown 71 hours and made 93 landings on ultralights.

Crew member:

Age 70.

Licences: Commercial Pilot Licence CPL(A), valid.
Motor Glider Pilot Licence MGPL, valid.
Glider Pilot Licence GPL, valid.
Ultralight Pilot Licence UPL, valid.

Flight instructor ratings: SEP (land+sea), MEP (land), CRI(A), IRI(A), night flying, towing, cloud flying rating, etc.

Class 2 EASA medical certificate, valid. Limitations to medical certificates due to age, such as the requirement to use corrective glasses for defective vision.

The flight instructor, who occupied the passenger seat, had logged thousands of hours. The flight instructor had received his first licence in 1960.

During previous years the flight instructor had instructed the pilot on ultralight and air-plane courses. Furthermore, he had given the pilot his differences training on tailwheel-type aircraft. According to the pilot, the flight instructor would often take the controls without warning, especially during stall practice.

1.5 Aircraft information

The aircraft, registration OH-XAC, was a non-certified aircraft in the experimental category. The Jodel D18 aircraft, serial number 441, was built and owned by the pilot. According to the journey log book the aircraft had flown for approximately 18 hours.

The aircraft build was completed in the autumn of 2013. OH-XAC had a temporary registration certificate and a temporary permit to fly test flights for the purpose of establishing its flight characteristics. A test flight programme which complied with Aviation Regulation AIR M5-1, Section 4.1 and Aviation Regulation AIR M5-2, Section 9.4 was approved as the aircraft's test flight programme during an airworthiness inspection carried out on 30 Sep 2013. Pursuant to the permit, a pilot in command (PIC) designated by the owner and only such personnel essential to the purpose of the test flight were allowed to act as flight crew members. On the test flight permit the owner was designated as the test pilot and the flight instructor who flew along as a crew member was mentioned as the co-pilot.

Powerplant information

Jabiru 2200 A, ser.no. 22A187, running time approximately 430 hours. Auto fuel 98E, maximum fuel load in the tank 65 litres.



Figure 2. OH-XAC on the accident flight immediately after takeoff at the onset of the turn, only seconds before the accident. The all-terrain vehicle at the left is the ATV used by paragliders. A moment before the photo was taken the ATV crossed the runway (Photo: Nummela flight centre webcam).

Propeller information

Manufactured by Poncelet, type 92 Bois 62"/44" ser.no. 03208, year of manufacture 2004. The running time of the propeller is not known.

Ballistic Recovery System

The aircraft was fitted with a rocket-propelled ballistic recovery parachute system. The canopy was of type BRS-6, model 1050 DaeC, serial number 20698, manufactured on 11/2008. The rocket motor was of type BRS 440, serial number T2B44-0908-20698 (BAM PT2 0187), manufactured on 11/2008. The system is designed for aircraft weighing less than 475 kg, and is to be deployed at airspeeds below 276 km/h.

The system is designed to lower the aircraft by parachute to the ground at a survivable rate of descent. The system comprises an activation handle within reach of the pilot which connects to the launch tube by cable. The tube contains a rocket motor which launches the parachute pack within approximately one second from activation. On OH-XAC the parachute was positioned to the front of the instrument panel, above the pilots' foot well; the rocket motor was located in the engine compartment. The activation han-

dle was in the cockpit. The suspension lines of the parachute were embedded in aircraft structures around the cockpit. On the accident flight the safety pin remained in place on the activation handle.

Comparable ballistic recovery systems are installed in approximately 80 aircraft in Finland, and their number continues to grow.

Airworthiness information

During its inspection the aircraft was approved for a test flight programme, less than half of which had been completed (18/45 h). The aircraft had undergone an airworthiness inspection, it had been weighed and its test flight programme had been approved. Insofar as these are concerned the aircraft was airworthy.

Weight, centre of gravity and performance

According to the results of the weighing done on 11 Sep 2013 and the aircraft's documents:

The empty weight of the aircraft was 310 kg and its (moment) arm was 0.279 m.

The maximum weight was 499kg.

The maximum payload (maximum weight in cockpit) was 189 kg.

The permissible range of the centre of gravity varied from 0.200 to 0.457 m from the reference datum.

On the basis of the accident investigation:

The weight of the flight crew was approximately 164 kg and its moment arm was approximately 0.6 m.

Fuel weight was approximately 26 kg and its moment arm was approximately 1.0 m.

The total payload at takeoff time on the accident flight was approximately 195 kg and the total weight was approximately 500 kg.

The centre of gravity on the accident flight was at approximately 0.450 m from the reference datum, i.e. within the permissible range, albeit close to its aft limit.

Judging by the test flights the stall speed at the maximum permissible weight, flaps up, had been approximately 84 km/h.

According to the pilot's account, on previous test flights they would take off in a clean configuration, i.e. flaps up at the airspeed of 80-90 km/h, and then continue the climb at approximately 110 km/h.

Although the aircraft was fitted with a stall warning indicator, it had been deactivated by taping shut its sensor hole on the wing. As the stall warning device had been inaccurately adjusted, it gave off a continuous warning. The pilot intended to readjust the device and take it into use later.

Nummela aerodrome is used by many sport aviation associations. It is used for gliding, motorised gliding, flying with airplanes and ultralight aircraft as well as paragliding and aeromodelling.

The aerodrome has the intersecting runways 04/22 and 09/27. The former is paved for the most part and the latter has a grass surface. The trees obstruct the view between the ends of the intersecting runways. There are no ATS services at Nummela aerodrome.

Nummela aerodrome has no AGA M1-1 based local regulations (formerly known as AGA M1-2 standing regulations). Regarding RWY 09/27 which was used by OH-XAC, there was a remark: "no windsock, no winter maintenance". Runway 04/22 which was used by paragliders, was closed as per NOTAM. The chief of aerodrome had issued a permission to the paragliders to use the main runway.

1.9 Flight recorders

The aircraft was fitted with a recordable MGL Voyager electronic flight instrument. However, at the time of the accident it had no memory card and, therefore, it did not record any flight data from the accident flight. Apart from its display having come loose in the course of the accident, it appeared to be intact. The investigation group contacted the manufacturer of the device, but they confirmed that the recording feature is inoperable without a memory card. The aircraft had no actual flight data recorder.

1.10 Wreckage and impact information

The site of the accident was at the crossroads of the taxiway and the aircraft stand on the movement area. The accident site is on hard-packed sandy ground. During the collision with the ground the aircraft broke in such a manner that the wing, landing gear included, remained close to the point of impact and the fuselage which separated from the wing continued to travel for approximately ten metres. The fuselage had broken in two just behind the firewall and the nose section had continued to travel yet another five metres away from the rest of the fuselage. The propeller had broken at its root and one of its blades was lying approximately 20 metres off to the side. All of the aircraft's peripheral parts were found at the site of the accident.

The aircraft left clear impact marks on the ground. Judging by the marks the wings had been more or less level when the aircraft collided with the ground.

Powerplant and propeller

The engine compartment was badly burnt in the fire. For example, several electric devices, wires and hoses had completely burned. The engine was not inspected in any detail. Judging by eyewitness accounts and the broken propeller it can be assumed that the engine was running at high speed all the way to the ground. The power lever was set to full power (fully forward).



Flight controls

Tail surface control cables were cut in the course of the rescue operation. The elevator cables displayed signs of having been subjected to heavy loads at the pulleys. The mounting point of one flap actuator axle had separated from the rib; otherwise the flaps were in working order. The ailerons were in working order when inspected. The inspection of the flight control system yielded the conclusion that, all in all, the flight controls had been fully functional, and that no such technical fault could be found which could have caused the accident. Even though the flight control system had sustained extensive damage, all of the damage could be attributed to the collision with the ground.

Load-bearing structures

The cockpit area of the fuselage was badly damaged. In effect, only short wood strips and small pieces of plywood remained. The rear fuselage was cut off from the cockpit during the rescue operation. The empennage, stabilisers included, remained nearly intact.

The nose section and the firewall, engine included, separated from the fuselage. Also, the entire wing had separated from the fuselage, and the landing gear attached to the wing was bent backwards under the wing. The left landing gear had completely separated from the wing. Plywood flanges on the main spar had delaminated near the centre area of the spar. Plywood-made torsion panels on the wing's leading edge were severely damaged, and several wing spars had also broken aft of the main spar. All damage to the structural elements can be attributed to the collision with the ground.

Ballistic Recovery System

The activation handle of the recovery system was installed on a holder below the instrument panel and the power lever. The investigators found that the safety pin was still in the activation handle. The pilot said that he would normally keep the safety pin in the handle on the test flights. Even though the handle holder and the instrument panel had come loose in the accident, there was no tension on the launch cable when it was inspected. By looking just at the photos taken immediately after the accident it is impossible to deduce whether there was any tension on the cable during the rescue operation. The protective lining of the cable was melted somewhat on the cockpit side, but in the engine compartment it was completely melted. The socket that connects the cable lining to the rocket launch mechanism was broken at its root. Hence, pulling from anywhere on the lining could have launched the rocket. The rocket's launch tube was installed on the firewall inside the engine compartment. It was directed to launch the parachute pack straight up. In the direction of launch there was a purpose-built hole on the engine cowling which was protected on the top by a jettisonable cover. The cover had either come loose in the accident, or been removed during the rescue operation.

At the time of installation a thin sheet of aluminium had been formed around the launch tube to act as a heat shield. It was attached to the firewall. The shield and the steel launch tube were blackened in the fire but they had retained their original form. A plastic cap on the side of the launch tube had melted. A police EOD unit had deactivated and removed the rocket, propellant included, from the launch tube.

Although an airworthiness inspection was carried out on the aircraft prior to the commencement of the test flights, the markings that warn of the presence of a pyrotechnical system did not comply with Airworthiness Directive M/3102/06.



Figure 4. There is a BRS system warning decal, approximately 50 mm wide, on the right side of OH-XAC. On the left side there is a warning decal which complies with directive M3102/06, requiring a 120 mm wide decal. There was no marking on the accident aircraft which indicated the location of the rocket motor assembly. (Photos: SIAF and Finnish Transport Safety Agency).

1.11 Medical and pathological information

The police breathalysed the pilot at the accident site; the result was zero blood alcohol. Later, in the hospital, blood samples were taken from the pilot to establish any presence of narcotics or medicines. No such substances were found in the screening.

A post-mortem examination was later performed on the crew member. No indications of any pre-existing medical seizures were found during the autopsy. He perished as a result of the injuries sustained in the collision with the ground.



1.12 Fire

When the aircraft collided with the ground the engine section was torn off of the fuselage, followed by an immediate fire in the engine compartment. Judging by the inspection of the engine compartment the fire was probably caused by the fuel hose bursting next to the fuel pump clamp, resulting in fuel spraying on hot engine parts. In addition, shorting and sparking occurred in the engine compartment which may have ignited the fuel. The fire spread throughout the entire engine compartment. The aircraft was carrying 35 litres of auto fuel. Oil, fuel, hoses, wires as well as other plastic and fibre-reinforced polymer (FRP) parts had burned in the engine compartment.

The eyewitnesses that hurried to the scene started the initial firefight with fire extinguishers at the same time they were calling the Emergency Response Centre (ERC). The engine fire was soon put out. This was done before the first rescue unit arrived at the site and the flames did not engulf any other structures of the aircraft. Also, the police that made it to the site before any rescue units arrived participated in putting out the fire with a fire extinguisher. According to eyewitnesses the fire was soon extinguished, lasting in all only some minutes.

The aircraft had no fire extinguishing system, nor is any such system required in experimental aircraft.

The first fire unit that arrived at the scene, four minutes from the alert, foamed the area around the leaking fuel tank. The purpose of foaming was to suppress the vaporisation of fuel and, hence, prevent fuel ignition. The fuel tank was positioned behind the flight crew on the fuselage, metres from the engine compartment.

The rocket motor of the ballistic parachute system, residing in the engine compartment heated up in the fire and, therefore, it can be presumed to have become unstable. According to tests (SAIB report 2148) a hot rocket motor can activate the system on its own or, if it explodes, demolish the surrounding structures and cause serious injuries to people nearby. Once the presence of the system was recognised and when the situation was realised the wreckage was cordoned off. The police then removed the rocket motor from the wreckage with the help of a robot and deactivated it.

1.13 Survival aspects

The ERC received the first call from an eyewitness at the aerodrome at 13:50:47; the caller reported a light aircraft accident at Nummela aerodrome. The call soon established the nature of the accident: light aircraft down, two persons still inside the wreckage at the edge of the car park, engine separated from the rest of the fuselage and smoke billowing out. During the emergency call the ERC operator dispatched units from Länsi-Uusimaa ERC and the police as well as a Border Guard helicopter. A little later a Helicopter Emergency Medical Service unit (air ambulance) was also dispatched. Task code 231 "aviation accident, small" was assigned to the occurrence. The subsequent emergency calls confirmed the location and nature of the accident.

There was no need to search for the wreckage because the aircraft had crashed next to the car park at Nummela aerodrome. This was accurately described by the person who reported the accident. The ERC reported the accident to Safety Investigation Authority, Finland via an SMS message. In addition, the Aeronautical Rescue Coordination Centre called the SIAF's duty officer.

Table 1. The units initially dispatched by the Emergency Response Centre (dispatch log).

Unit	Station	Type	Manning	Dispatched	On site
RLU501	Nummela	Rescue	0+1+3	13:52	13:56
RLU601	Lohja	Rescue	0+1+3	13:52	14:09
RLU32	Lohja	Command	1+0+0	13:52	14:08 (estimate)
BHR200	Helsinki	Border Guard helicopter	1+2	13:52	14:19
ELU4222		First response private	0+2	13:52	13:59
ELU4211		First response private	0+2	13:52	14:02
EFH10	Vantaa	HEMS air ambulance	1+2	13:54	14:13
PLU613		Police	1+1	13:53	13:55
PLU682		Police	1+1	13:53	14:05
PLP940		Police	1+1	13:53	13:54

Rescue action and emergency medical care

The on-call chief fire officer for the Lohja region at Länsi-Uusimaa ERC assumed overall command of the accident. In addition to the dispatched units the chief fire officer maintained contact with the ERC as well as with the Border Guard's Maritime Rescue Sub-Centre in Helsinki. The accident was reported to Helsinki ATC from where the information was relayed to Area Control Centre Finland.

The accident site was easily accessible by car through the gate which separated the car park and the movement area. The manager of the adjacent Air Hotel Nummela provided the key to the locked gate. The first rescue unit to arrive at the site made the observation that the aircraft was right side up and that the slightly smouldering nose compartment lay detached from the fuselage at a distance of a few metres. Two injured people remained partly inside and under the aircraft. Once the initial evaluation was done the injured were triaged and protective foam was sprayed. Following this, the unit sheared the fuselage in two with a battery-operated reciprocating saw and broke the windshield with a crowbar, so as to examine the casualties in more detail. Aircraft parts were lifted off the injured persons.

The rescue personnel, the police and the bystanders who assisted with the rescue were unaware of the presence of the rocket-propelled system, or any of its associated hazards.



It took some 20 minutes to stabilise the casualties prior to transport. The first patient arrived at Töölö Hospital in Helsinki at 15:07, and the second one at 15:16.

Once the rescue operation had been completed, unit 501 remained at the site to secure the investigation and to assist the police. The last remaining Rescue Department unit left the site at 20:21.

Police and the Border Guard

On-site command was delegated to police unit PLP940. Their first task was to cordon off the accident site. Their other tasks comprised the recording of eyewitness accounts, interviewing the people at the site, and launching the investigation.

The first police units were unaware of the pyrotechnical system inside the wreckage. SIAF investigators requested executive assistance from a police EOD unit to deactivate the system. The safe deactivation, coupled with the ongoing investigation, took several hours.

The Border Guard helicopter was tasked to document the accident site from the air for the purpose of the investigation.

Survival aspects

Both seats of the aircraft were fitted with 4-point harnesses, and they were in use during the flight. During the course of the rescue operation they were cut through. Some of the harness brackets had been torn off from their mounting points in the crash. The mounting points consisted of thin plywood and wood strips. Most of the aircraft structure surrounding the pilots was broken. The structures had been constructed according to the blueprints that had been approved in the permit to build. A supervisor was assigned for the build; he had inspected the structures. The structures were also found to comply with requirements in the airworthiness inspection. The strength requirements for the mounting points can be found in the experimental aircraft inspection manual which was published by the Finnish Aeronautical Association and approved by the former Finnish Civil Aviation Administration (nowadays: Finnish Transport Safety Agency).

Among other of his injuries, the passenger sustained severe head trauma in the collision with the ground, which later resulted in his death.

The aircraft was fitted with a ballistic parachute system. The safety pin of the activation handle was in its place during the flight. The flight crew did not attempt to activate the system.

1.14 Additional information

According to the people that participated in the rescue operation pyrotechnical systems are generally not known by rescue personnel. Neither the rescue sector nor any other

competent authorities have provided nationwide training for recognising and identifying these systems.

During the past decade accident investigation authorities around the world have carried out research on the risks associated with pyrotechnical systems. As a result of this research and investigations several safety recommendations have been issued, of which the following is but a sample. In addition, the list includes some domestic cases.

In 2013 the Swiss Accident Investigation Board (SAIB) completed a thematic investigation on the potential risks of ballistic parachute systems in aircraft to rescue and investigation crews. On the basis of this research SAIB issued, among other things, the following safety recommendations – mainly to Swiss operators:

- *Ballistic Parachute System (BPS) -equipped aircraft should be clearly and uniquely identifiable as such; the aircraft must be marked by a warning decal on the fuselage.*
- *If the rescue crews are in any doubt as to whether a given aircraft has a BPS on board, rescue workers must assume it has one.*
- *The [Federal Office of Civil Aviation (FOCA)'s] website should add to the details displayed in the section on aircraft registration whether an aircraft is equipped with BPS or not...SAIB/REGA staff could then check whether BPS-equipped aircraft are involved in the accident.*
- *BPS rockets must be fitted with heat indicators. ..These heat indicators change colour if they exceed a given temperature.*
- *Checking the residual shelf life of a BPS must be included in aircraft checklists and/or maintenance schedules.*
- *BPS manufacturers should check whether a cutout system could be used to separate the igniter unit from the rocket.*
- *There must be a plan of the aircraft hangars at an airfield, in its control tower and/or the fire brigade crew rooms, which clearly marks the presence of any BPS aircraft.*
- *Hangars must have maximum thermometers, so supervisors can check what temperatures have been reached.*
- *[The Federal Office of Civil Aviation] should ensure that pilot training programmes include details of how BPS work.*
- *All rescue services are to be trained on the potential risks of BPS.*

When it comes to Finland, in conjunction with safety investigation D9/2006L, SIAF issued a recommendation that the Finnish aviation authority, together with the Finnish Aeronautical Association and SIAF, design a decal to warn of the aforementioned danger and to indicate the location of the rocket motor. Also, since BPS systems will probably grow in popularity, an effective information campaign regarding the rocket system's hazards and its deactivation should commence.



Airworthiness Directive M3102/06 came to life as a result of the recommendations. According to it rocket-propelled recovery systems must be clearly marked. Since then, the clearly visible markings that comply with this directive have improved occupational safety at several accident sites.

The rescue sector's magazine published the article "Rescuer – watch out for the parachute!" (PT 6/2008)

In 2013 the National Police Board prepared instructions (Instruction ID – 15518845681(9) 2020/2013/5234) on air accident investigation, in which aircraft BPS systems are listed as a potential hazard.

At least the Australian accident investigation authority (ATSB) has recommended the introduction of internationally standardised BPS markings. Although their recommendations were directed at the ICAO and EASA, thus far they have not resulted in any action.

2 ANALYSIS¹

2.1 Purpose of the flight and task assignment between the test flight crew

The crew had flown nearly all of the flights together. The crew member was the flight instructor of the pilot, who was acting as the pilot-in-command. On earlier flights the pilot was logged as pilot-in-command, but the division of duties could vary according to the situation on the flights.

Flight crew members on test flights must have a practical function, such as the responsibility to record flight parameters. Otherwise, the test flights should, as a rule, be flown solo. According to the pilot's account they did not specifically plan the test flights. Rather, they only took to the air and did things which felt right at any given time. Test flights, including the progress of the flight as well as the roles and tasks of crew members, must be carefully planned and briefed beforehand.

The purpose of the accident flight was to fly a cross-country flight to Hyvinkää and back. Cross-country flights in this phase of a test flight programme can be considered appropriate.

2.2 Pre-flight action

The pilot said that he completed all pre-flight preparations on his own. The preparations for the flight mostly involved technical details; he did not find out whether anyone else was using the aerodrome at the time, nor did he coordinate their mutual activities. The pilot knew that the main runway had been closed and he had the impression that they would be the only users of the airfield. The pilot was unaware of the ongoing paragliding activity, or that the chief of the aerodrome had given the paragliders permission to operate off the main runway. In this regard the pilot's pre-flight action can be considered inadequate.

For the most part the crew had worked alone together at the airfield during the winter season and, apparently, they were used to the fact that they would be the only ones at the airfield. On the other hand, during previous years the pilot had also used Nummela for gliding and was, therefore, familiar with the aerodrome and its flight operations.

It is good airmanship to find out whether anyone else is using the aerodrome and to coordinate all mutual activities with them during the pre-flight briefing process.

¹ The AcciMap Approach was used in the analysis. The AcciMap Approach is a risk management system which was primarily developed for accident prevention. It can, however, be used in analysing contributing factors and for identifying and focusing on the most effective safety recommendations.

2.3 The accident flight

Due to his injuries the pilot does not recall the takeoff, nor were there any eyewitnesses to the takeoff. It can be assumed that the takeoff and the initial climb progressed normally. At least the climb seemed perfectly normal to the eyewitnesses. The pilots would normally take off in the clean configuration, i.e. flaps retracted, at 80-90 km/h and then continue the climb at approximately 110 km/h. On the basis of the test flights the aircraft's stall speed at full weight with flaps up was approximately 84 km/h.

As the aircraft climbed over the crossing runway the paragliders' all-terrain vehicle (ATV) was in the process of returning to the northeast end of the runway, i.e. to the point where the snatch block pulley was situated. The tow line lay loose on the ground. Simultaneously, a paraglider was also about to land at the southwest end of the runway.

As the aircraft reached the altitude of 30-50 m it suddenly appeared to turn left, away from the runway. During the seemingly sharp turn it stalled and went into a nosedive. Due to the low altitude the recovery was unsuccessful.

The flight crew, or one of the pilots, may have spotted the ATV which was crossing the runway centreline and the paraglider which was about to land. From the vantage point of the cockpit in a climbing aircraft the pilots may have construed this to be a towing in progress because, even in normal circumstances, the towing cable is barely visible. Moreover, according to the pilot's account neither of them had any experience in paragliding. Hence, they would not necessarily have known that the towing is done using a snatch block pulley, in which case the towing vehicle moves towards the paraglider which is being towed. Since the aircraft was equipped with dual flight controls either one of the pilots could have reacted to the situation by initiating an evasive manoeuvre upon detecting the imagined danger of a mid-air collision.

Had there been an obstruction in front of them a rapid evasive manoeuvre could be regarded as a logical reaction. The possibly evasive turn can be regarded as excessive because it appears that soon after the turn began the aircraft went into a turning stall. Nonetheless, even though the aircraft nearly recovered from the turn and the stall, it remained in a shallow dive. It turned approximately 130° to the left from its takeoff heading before it crashed into the airfield.

There is no certainty regarding the order of the turn and the stall on the flight; it is also fully possible to interpret the eyewitnesses' observations in a different manner. The aircraft may already have stalled in a shallow turn, intended to steer the aircraft over the main runway to continue the climb. During the stall the aircraft could have banked steeply to the left, which the eyewitnesses may have interpreted as a sharp turn to the left.

Judging by the photo taken of the accident flight and eyewitness accounts the turn commenced at the very same spot where the flight crew, according to the pilot, used to turn on earlier flights as well. On the accident flight the turn occurred at low altitude, into



a tailwind, and in a clean configuration. Flying into a tailwind at low altitude may give the impression of flying at a high airspeed even if, in reality, the airspeed is low.

The reasoning behind a mid-climb turn had been the option to take advantage of the entire movement area in case of sudden engine trouble or other possible malfunction. Even if the utilisation of the entire area of the airfield makes good sense on test flights it is of the utmost importance to maintain sufficient airspeed and use flaps when necessary to lower the stall speed when flying at low altitude.

2.4 Aircraft behaviour during a stall, and the stall warning system

According to the pilot they had tested stalling in different configurations on earlier flights and had noticed nothing out of the ordinary in the way the aircraft behaved. It is not known how they tested stalls with different power settings in turns because the test flight documentation is lacking in this respect. Nor was there any recorded information regarding the weight of the aircraft during stall tests.

On tests flights one should always record all critical features that affect flight performance, such as loading, flap position and the power setting, and, when it comes to turning stalls, the angle of bank and the direction of the turn.

There was a stall warning device on the aircraft. However, it had been deactivated by taping shut the sensor hole on the wing. A properly functioning and correctly adjusted stall warning device may have prevented the accident.

2.5 Flight conditions

The weather was sunny and winds were light. This facilitated flight operations from crossing runways. The weather conditions were extremely favourable for flight operations.

Since paragliders, especially student paragliders, must take off almost directly into a headwind, the winds must have been northerly at the time of the accident. In other words, the wind came from the right in relation to the takeoff direction from RWY 27.

2.6 Coordination between the users of the aerodrome

Even though the radio was apparently on the Nummela frequency, the aircraft did not transmit any traffic reports. While traffic reports are not mandatory at uncontrolled airfields, it is good aviation practice and, from the viewpoint of coordination between users, very important. By transmitting traffic reports the paragliders could possibly have been informed of the aircraft which was about to take off. Correspondingly, they could also have replied and informed the aircraft of their activity on the main runway.

Obstructions between the ends of the runways can occasionally impede ground-to-ground radiocommunication. Hence, one cannot merely rely on traffic reports. When

planning the activities for the day, each operator is required to find out whether there is any other activity at the aerodrome.

Runway 04/22, which was being used by the paragliders, was closed as per NOTAM. The chief of the aerodrome had given the paragliders permission to use RWY 04/22. Whereas the paragliders were aware of the fact that the main runway was closed for any other traffic, they erroneously assumed that the crossing runway was closed as well. In fact, there was a published NOTAM regarding the crossing runway, which contained the following remark: "no windsock, no winter maintenance". In practice this means that it is permissible to operate from the runway within these constraints at one's own responsibility. This being the case, neither were the paragliders prepared for any other activity on the crossing runway.

Consequently, the users of the airfield had differing ideas regarding the operating hours and usability of the runways. Presumably, the occupants of the aircraft and the paragliders did not make any contact with each other on the day of the accident. Obscured places in the movement area limit detection between the ends of the crossing runways.

Even during quiet hours there can be any kind of flight activity at uncontrolled aerodromes. There can also be different users who will not necessarily have any contact with each other.

Nummela aerodrome had no local regulations (formerly known as standing regulations). The different users of the airfield have no common recorded model of operations regarding the use of the airfield.

Neither is it possible to notify other potential operators of the commonly known method used at Nummela, in which permission to use a closed runway can be issued by the chief of the aerodrome.

According to Aviation Regulations local regulations are not required at uncontrolled aerodromes, but they do tend to improve safety. Local regulations should especially stipulate that all operators at the airfield establish the presence of each other and daily coordinate their activities.

2.7 Rescue action

There were several eyewitnesses to the accident and an emergency call to 112 was made immediately after the accident occurred. People who were in the surroundings hurried to the site and began to administer first aid to the occupants of the aircraft. While one of them supported the pilots' heads, another one cut their harnesses and others extinguished the fire. The initial firefighting was successfully done with a fire extinguisher fetched from a car in the adjacent car park; more fire extinguishers were brought from the hotel nearby. The firefight with dry chemical extinguishers was successful; the flames did not engulf any other structures of the aircraft or the fuel.



The rescue action carried out by the authorities began without delay. The first rescue unit treated the casualties and successfully managed to prevent the ignition of the leaking fuel by foaming the area. The emergency medical teams arrived at the site: the first one eight minutes and the second one 10 minutes from having been dispatched. The HEMS arrived after 21 minutes.

The rescue operation can be regarded as successful: the response and resources were appropriate. The injured were extracted from the wreckage and treated at the accident site before they were transported to hospital, where they arrived approximately one hour and 15 minutes after the accident.

During the rescue operation the presence of a ballistic parachute system (BPS) in the wreckage was not brought up. It posed a hazard to the authorities and bystanders alike. Although the risk of the BPS system went unnoticed, it did not cause any additional damage.

2.8 Survivability of the victims

While the pilots' harnesses survived the crash intact, some of their mounting points separated from aircraft structures. Still, the strength of the mounting points can be considered to have met the requirements of the regulations because they had been inspected by the build supervisor and the airworthiness inspector alike. The collision with the ground was probably so violent that the structural members of the aircraft were not designed to survive it.

The fact that the mounting points failed probably aggravated the injuries of the crew and diminished the passenger's survival odds. It is possible that if the harness mounting points had remained intact, at least the crew members' head injuries would have been less severe. Crash helmets or airbags could have reduced the severity of head trauma.

2.9 Dangers posed by the Ballistic Recovery System

The rescue and police authorities failed to recognise the BPS system inside the wreckage. Only when SIAF investigators arrived at the site at approximately 15:10, almost two hours after the accident, its presence was noticed and the required safety measures were taken.

The inactivated BPS system posed a hazard. The danger to rescuers and other people in the vicinity materialised when the system went unnoticed. The risk increased when the fuselage and its sections were approached, turned, sheared and moved. Even though the safety pin of the system had been inserted into the activation handle on the flight, the protective lining of the launch cable had completely melted in places, and the socket that connects the cable lining to the rocket launch mechanism was broken at its root. Hence, the socket or the activation handle no longer made any difference vis-à-vis rocket motor ignition. Consequently, tension could have built on the launch cable, which could have ignited the rocket motor.

During the rescue operation aircraft parts were moved and turned and the fuselage was cut in two, aft of the cockpit. Had the saw hit the launch cable it could have caused tension which could have ignited the rocket motor.

The attitude of the launch tube would have determined the direction in which the rocket motor would have been launched. In the initial phase the engine compartment, which housed the launch tube and the rocket motor, lay upside down but later it was turned right side up. Structural tearing or a flying rocket motor and/or fragments could have caused injuries. Also, tightening parachute suspension lines could have caused injuries.

Additional danger was created when the rocket motor inside the engine compartment became hot in the fire. According to tests the critical temperature for the propellant is approximately 90°C. When this temperature is reached the possibility of uncontrollable ignition increases. Then, in the worst case scenario, the propellant can explode inside the rocket motor, causing the fragmentation of surrounding structures. The overheated rocket motor exposed all nearby persons to the consequences of a potential explosion.

Even after the system was noticed and identified it was impossible to evaluate the likelihood of ignition or fragmentation because it was not possible to determine the degree of thermal exposure from the rocket's launch tube or propellant. Had the propellant or the launch tube been marked with heat indicators such as temperature indicator labels which change colour after reaching their calibrated temperature, the degree of thermal exposure could have been determined with more certainty.

It was critically important that the fire in the engine compartment was promptly extinguished. In hindsight it can be estimated that the temperature of the propellant did not exceed the critical temperature.

Foreign research results recommend that overheated rocket motors be cooled from a safe distance.

The risks posed by pyrotechnical systems should be taken into account in the rescue plans of all aerodromes.

The rocket motor should not be installed in the engine compartment because it is the most likely place for thermal exposure. There are no national regulations or requirements for the installation, use or storage of ballistic parachute systems.

All safety equipment used in aircraft should be uniformly regulated regarding approval, placement and markings. When it comes to the safety of all concerned, it would be important to have internationally standardised regulations regarding pyrotechnical recovery system installation, use and storage.

Not only can pyrotechnical systems pose a danger in air accidents, they can also create a hazard in hangar fires or when aircraft collide with each other on the ground. Therefore, the rescue plans of aerodromes and aircraft hangars should include pertinent in-



formation as regards the aircraft therein, any possible pyrotechnical systems as well as their risks.

2.10 Identifying a rocket-propelled parachute system

The accident aircraft only displayed the manufacturer's decals warning of the presence of the system; they did not guide the rescuers to operate in such a fashion that the hazard would have been taken into consideration. Although the airworthiness inspection had been completed prior to the start of the test flight programme, the markings did not comply with Airworthiness Directive M3102/06.

The markings that comply with Finnish requirements are larger than those on the accident aircraft. They also indicate the hazard more clearly. For example, they would have made it possible to identify the loose suspension lines of the parachute or the activation handle inside the wreckage. However, this would have required training. Generally speaking, it is difficult to recognise the presence of pyrotechnical system in an aircraft or identify its parts because so many variations exist. Moreover, warning markings and practices are not internationally standardised.

The parts of a pyrotechnical system could have easily distinguishable colours, just as the high-tension cables and systems in electric vehicles in road traffic do. Uniform international standards should be developed for marking pyrotechnical systems. Then it would be easier to recognise them and properly deal with them in a rescue situation.

At present, it is impossible to check for the presence of pyrotechnical systems in any given aircraft from a register or official source because there is no obligation to record these systems in registers, nor do registers have a field for them. The Finnish Transport Safety Authority no longer maintains an excerpt of the aircraft register on their web pages. The change took place at the end of 2014.

A register of pyrotechnical systems should be kept so as to monitor the development of their number and, if necessary, rapidly provide relevant information to protect the rescue personnel in an accident. A dedicated field for pyrotechnical system information should be included in the aircraft register.

The present flight plan form does not require any information regarding pyrotechnical systems. Still, one can voluntarily report the presence of such a system in the "other information" section. If there was a dedicated field in the flight plan form for reporting a pyrotechnical system, akin to dinghies, flotation devices or other survival equipment, ATC units could relay this information to rescue services when accidents occur.

2.11 Pyrotechnical system training

The growing popularity of pyrotechnical systems in sport aviation has increased the need to train rescue personnel in system recognition and safe handling. On the basis of the accounts of those that participated in the rescue operation it became evident that BRS systems, either in general or sport aviation, are not well known, and that there is



virtually no training. In contrast, the dangers associated with military aircraft, such as the launch mechanisms of ejection seats or canopies, are addressed on professional rescue courses. Such hazards are also normally described in the rescue plans of aerodromes.

Pyrotechnical system training is not required for the issuance of an aviation licence. Aviators would be in a key position to spread the word on the risks associated with these systems, providing they had sufficient training for it. For example, in Germany a section on the risks associated with pyrotechnical systems is a requirement for an UPL licence.

In order to guarantee the safety of an accident site the rocket motor must be deactivated. Anyone who has had the proper training can cut a taut launch cable with suitable cutters. Conversely, at present only police or Defence Forces' EOD units have the skills to safely deactivate overheated rocket motors.

When it comes to the authorities, at the least, rescue commanders must be trained to identify pyrotechnical systems and their inherent risks, and to know how to act correctly.

3 CONCLUSIONS

3.1 Findings

1. The pilot had the required licence and ratings.
2. The aircraft was in the experimental category, built by the pilot himself.
3. The aircraft had passed an airworthiness inspection and it was approved for tests flights. Insofar as these are concerned, the aircraft was airworthy.
4. The aircraft, which took off in a light crosswind for a test flight, turned into a tailwind at the altitude of 30-50 m and then it stalled.
5. The pilots did not manage to recover the stall: the aircraft nosedived, collided with the ground and was destroyed.
6. At the time of the occurrence the weather was perfect for flying.
7. Simultaneously, an all-terrain vehicle (ATV) used by paragliders was on the crossing runway, returning to the towing starting point. The tow line lay loose on the ground
8. On the other side of the aircraft, some hundreds of metres away at the other end of the main runway, a paraglider was about to land. From the vantage point of the aircraft the situation may have been interpreted as a paraglider towing in progress.
9. There was a stall warning device on the aircraft. However, it had been deactivated by taping shut the sensor hole on the wing because it was giving off a continuous warning.
10. Thanks to the rapid action of the eyewitnesses and the other onlookers that hurried to the scene, the fire, which started in the engine compartment, was promptly extinguished before it ignited the fuel which was leaking from the tank.
11. Both occupants in the aircraft sustained serious injuries; the person who had been sitting in the passenger seat succumbed to his injuries a week later in the hospital.
12. The crew had flown nearly all test flights together. The crew member was the flight instructor of the pilot, who was acting as pilot-in-command.
13. The main runway used by the paragliders was reported closed as per NOTAM. Nonetheless, the chief of the aerodrome had given the paragliders permission to use the runway.

14. Neither the paragliders nor the crew of the aircraft were aware of each other's presence and they had differing ideas regarding the operating hours and usability of the runways.
15. Even though the radio was apparently on the aerodrome's frequency, the aircraft did not transmit any traffic reports. While traffic reports are not mandatory at uncontrolled airfields, it is good airmanship and, from the viewpoint of coordination between users, very important.
16. Despite the effective rescue operation one of the patients perished – his injuries were so serious that he could not be saved.
17. The fact that the mounting points failed probably aggravated the injuries of the crew and diminished the passenger's survival odds.
18. Nummela aerodrome had no local regulations which would guide the different users of the airfield towards mutual coordination. Local regulations are not required at uncontrolled aerodromes; however, they do tend to improve safety.
19. The aircraft was fitted with a ballistic recovery system. However, its markings did not comply with Finnish requirements. Neither the rescue nor the police authorities identified the system, which is why all participants of the rescue operation were subjected to the danger of a rocket motor ignition.
20. Additional danger was created when the rocket motor, residing in the engine compartment, heated up as a result of the fire. Overheating can result in an explosion of the rocket motor, which can demolish the surrounding structures.
21. Even after the system was identified it was impossible to evaluate the likelihood of ignition or fragmentation because it was not possible to determine the degree of thermal exposure from the rocket's launch tube or propellant.
22. The growing popularity of pyrotechnical systems has increased the need for training rescue personnel in system recognition and safe handling. These systems are not known within the sphere of rescue services.
23. It is difficult to recognise the presence of pyrotechnical systems or its parts in an aircraft. The aircraft register does not indicate whether an aircraft is fitted with such systems. Neither does the flight plan form have a dedicated field for reporting pyrotechnical systems.
24. There are no regulations or requirements for the installation, use or storage of pyrotechnical systems.
25. Aerodromes' rescue plans do not take into account the risks posed by pyrotechnical systems to rescue activities such as accidents and fires.
26. The warning markings of pyrotechnical systems are not internationally standardised.



3.2 Probable causes and contributing factors

The cause of the accident was a turn at low altitude and at a low airspeed, which resulted in a stall. It is possible that the flight crew made the turn in an attempt to avoid hitting an imagined towing line of a paraglider.

The practice that the pilots had adopted, i.e. climbing at a low airspeed in a clean configuration and making a turn at low altitude, is a factor which subjected them to the accident.

Insufficient coordination between operators at an uncontrolled aerodrome was a contributing factor. The fact that there was flight activity taking place on a runway which was reported closed can also be regarded as a contributing factor.

The fact that the rescue service personnel were completely untrained on pyrotechnical systems and that it is not possible to establish the presence of such systems, for example from the aircraft register, can be regarded as a contributing factor to exposing the people who participated in the rescue operation to the risk of an explosion.

In addition, the unsatisfactory warning markings made it more difficult to recognise the dangerous components. The danger was exacerbated by the fire in the engine compartment, which heated up the rocket motor and possibly put it into an unstable state.

4 SAFETY RECOMMENDATIONS

4.1 Safety actions already implemented

On 30 Apr 2014 Safety Investigation Authority, Finland released a safety bulletin on the potential risks of pyrotechnical systems in aircraft. Furthermore, SIAF has directly informed the public of the occurrence, distributed public information and materials and given lectures at the Police University College, at a seminar arranged for Helsinki, Itä-Uusimaa and Länsi-Uusimaa Rescue Departments, and in conjunction with training sessions organised by Finavia.

In the 6/2014 issue of *Ilmailu* (Aviation) magazine, published by the Finnish Aeronautical Association, the national sports aviation association, there was an article about the hazards posed by pyrotechnical systems in sports aviation, followed by an article in its 8/2014 issue about the importance of coordination between different air sport disciplines at uncontrolled aerodromes.

As per the original safety recommendation 3b, the Finnish Transport Safety Agency (Trafi) was to require that the Finnish Aeronautical Association (FAA) include a segment in sport aviators' training curricula that addresses pyrotechnical systems. The FAA considered the recommendation during the update of the Ultralight pilot curriculum which Trafi approved on 12 December 2014.

Tapping into the SIAF bulletin and the training materials published by SIAF in the spring of 2014, the Emergency Services College added pyrotechnical system instruction in its curricula.

According to Finavia Corporation's letter dated 19 Sep 2014, the corporation has updated the regulations related to the rescue plans of the aerodromes under its management. During the symposiums arranged for aerodrome rescue personnel and for maintenance personnel in May 2014 Finavia addressed the risks related to pyrotechnical systems.

According to Finavia Corporation they have begun to translate foreign pyrotechnical system training materials into Finnish. Once the translation is complete, it will be included in the curriculum of the Emergency Services College's refresher course.

As per the original safety recommendation 4, the Finnish Transport Safety Agency should include a field on the national flight plan form, and associated instructions, where pyrotechnical systems can be reported. During the investigation Finavia Oyj accordingly amended the flight plan instructions. In accordance with the updated instructions it is possible to enter supplementary information pertaining to ballistic (pyrotechnical) recovery systems into field 19. The instructions will enter into force in February 2015.



4.2 Safety recommendations

1. It is impossible to check the presence of pyrotechnical systems in any given aircraft from aircraft registers because there is no obligation to record these systems in a register.

Safety Investigation Authority, Finland recommends that the Finnish Transport Safety Agency add relevant information describing an aircraft's pyrotechnical systems into the aircraft register in order to enable the Aeronautical Rescue Co-ordination Centre Finland or the Safety Investigation Authority, Finland to relay relevant information to guarantee the safety of a rescue operation.

2. The warning markings of pyrotechnical systems are not internationally standardised and, therefore, it is difficult to identify them during a rescue operation. While some aircraft are subject to EASA regulations, others are subject to national regulations.

Safety Investigation Authority, Finland recommends that the European Aviation Safety Agency (EASA) standardise the warning markings for pyrotechnical systems.

3. There are no national or international regulations or training requirements for the installation or use of rocket-propelled ballistic recovery systems.

a) Safety Investigation Authority, Finland recommends that the Finnish Transport Safety Agency define the minimum requirements pursuant to Regulation (EC) No 216/2008 for the safe installation and use of pyrotechnical systems.

b) Safety Investigation Authority, Finland recommends that the European Aviation Safety Agency (EASA) include a segment in LAPL(A) and PPL(A) training curricula that addresses pyrotechnical systems.

4. It is difficult to recognise pyrotechnical systems and their parts from the wreckage of an aircraft because their colours are not standardised.

Safety Investigation Authority, Finland recommends that the International Civil Aviation Organization (ICAO) standardise the colours of pyrotechnical system parts so that they are clearly distinguishable and easily identifiable.

5. Appropriate attention has not been paid to the hazards posed by pyrotechnical systems in aerodrome maintenance regulations, in local regulations or rescue plans. Rescue personnel do not receive sufficient information concerning said risks, which jeopardise the safe conduct of rescue operations.

a) Safety Investigation Authority, Finland recommends that the Finnish Transport Safety Agency give attention to pyrotechnical systems installed in aircraft, including any potential hazards to rescue operations, in aerodrome maintenance regulations.

b) Safety Investigation Authority, Finland recommends that the Finnish Transport Safety Agency recommend that operators of uncontrolled aerodromes update any rescue plans of their own, together with the local rescue authority.

6. Thermal exposure to the rocket motors of pyrotechnical systems is a key factor in determining the risk posed by the system. It is impossible to evaluate the degree of thermal exposure without appropriate indicators.

Safety Investigation Authority, Finland recommends that the Finnish Transport Safety Agency make thermal exposure indicators pursuant to Regulation (EC) No 216/2008, Annex II, compulsory for pyrotechnical systems.

4.3 Other remarks and recommendations

When it comes to pyrotechnical system warning markings, more attention to compliance with Airworthiness Directive M3102/06 must be paid in aircraft airworthiness inspections.

Runway 04/22 being used by paragliders was closed as per NOTAM, but the paragliders had the chief of the aerodrome's permission to use the main runway. The information contained in a NOTAM must be consistent with the actual flight activity at the aerodrome.

Pursuant to Aviation Regulations local instructions or rescue plans are not required at uncontrolled aerodromes, but they do have a positive effect on safety.

Helsinki 2.2.2015

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REFERENCE MATERIAL (This is included in the Finnish version only)

Data protection practices of the material comply with Article 14 (Protection of sensitive safety information) of Regulation (EU) No 996/2010 of the European Parliament and of the Council.



Summary of the comments received to the draft final report

Emergency Response Centre Administration

The draft final report does not issue any recommendations to the Emergency Response Centre Administration. The Emergency Response Centre Administration does not have any comments to the report's content *per se*.

Finnish Transport Safety Agency Trafi

Trafi's comments on the safety recommendations

Safety recommendation 1

An excerpt of the aircraft register is no longer published on Trafi's web pages, and the aircraft register only serves customers during office hours. Trafi views that there is only marginal benefit to be had from recording pyrotechnical equipment in the aircraft register. Since aircraft registers are national, the practices and access to information would vary anyway, according to each state of register. Records in the register alone do not guarantee that the information would be readily available to be relayed to a rescue effort, or that the rescue professionals would know how to obtain this information from the register.

Safety recommendation 3

Trafi's competence only extends to the installation of emergency parachutes in aircraft falling into categories set out in Regulation (EC) No 216/2008 of the European Parliament and of the Council, Annex II (EASA Regulation). When it comes to other aircraft, EASA is the competent authority. Equipment manufacturers publish instructions on the safe installation, use and storage of said equipment and, pursuant to Aviation Regulations, it is mandatory to follow them. When the airworthiness requirements of Annex II are updated, it is possible to issue more detailed instructions on the safe placement of pyrotechnical recovery systems if the equipment manufacturers' mandatory instructions are not considered to suffice. Aircraft-specific manuals provide the instructions on the use of said systems. The storage of pyrotechnical equipment when removed from aircraft is outside the purview of Trafi.

Safety recommendation 4

Finavia Oyj, the provider of Air Traffic Services, publishes and remains responsible for the content of flight plan forms. In subsection 14 of SERA 4005 (Standardised European Rules of the Air) it is mentioned that, among other things, information pertaining to 'emergency and survival equipment', considered relevant by the competent authority, should be included in the flight plan. In its Aviation Regulation OPS M1-1, which entered into force on 13 January 2014, Trafi decreed that the flight plan must include the information set out in the aforementioned section of the Standardised European Rules of the Air.

In accordance with the present flight plan filing instructions any other emergency and survival equipment, i.e. other than the 'survival equipment' mentioned in field 19, are entered in the subsection of field 19: 'Remarks' (N). This being the case, the flight plan form provides a space for entering information referred to in Safety recommendation 4, even if pyrotechnical recovery equipment is not specifically mentioned.

In field 19 of the present flight plan form, and in its instructions, the Finnish language words used for 'emergency and survival equipment', as per subsection 14 of SERA 4005, translate roughly as 'rescue equipment and rescue gear'. Trafi holds that the flight plan form and the associated instructions should use the same words as used in the Finnish translation of the SERA.

Safety recommendation 6a

The operator of an uncontrolled aerodrome is not obliged to monitor the equipment installed in aircraft operating from the aerodrome. Systems can be installed in aircraft without having to notify the aerodrome operator, and visiting aircraft fitted with the equipment in questions can arrive at the aerodrome. Local rescue authorities are responsible for rescue operations at the aerodromes. The obligation to take pyrotechnical systems into account in their contingency plans should be assigned to the rescue authorities. The most important thing is to clearly mark the aircraft with visible warning decals.

Safety recommendation 6b

Aviation Regulation AGA M1-1 does not require any rescue plans at uncontrolled aerodromes. The requirement entails a description of how the fire and rescue services are organised at the aerodrome, to be included in the annexes of the application for an aerodrome operator's licence. Uncontrolled aerodromes are not required to have any personnel with rescue skills. The required equipment comprise 2x12 kg fire extinguishers as well as an automotive first aid kit, or something similar. In practice rescue services at uncontrolled aerodromes means a phone call to the emergency number 112. The local rescue authority must take an aerodrome in their area into account, and prepare for particular conditions in their activities.

Safety recommendation 7

Trafi can study the installation of pyrotechnical recovery systems' rocket motor heat indicators, keeping in mind the indicators on the market and their technical assembly. One needs to bear in mind that Trafi's competence only extends to the installation of emergency parachutes in aircraft falling into categories set out in Regulation (EC) No 216/2008, Annex II. When it comes to other aircraft, EASA is the competent authority.

Länsi-Uusimaa Rescue Department

According to Länsi-Uusimaa Emergency Department having an uncontrolled aerodrome's rescue plan is not a viable manner of relaying information to a rescue department. The hazards posed by pyrotechnical equipment should be taken into account, for example, in the rescue department's target-specific plan. Nevertheless, education and information should absolutely be the primary means of increasing risk-awareness. Should an aircraft crash outside the area of an aerodrome, the aerodrome's rescue or target-specific plans are of no use.

Nummela flight centre

No reply.

National Police Board

The National Police Board does not have any comments to the content of the investigation report. The National Police Board concurs with the proposed safety recommendations and states that, should they materialise, they would greatly improve the health and safety considerations of police officers working at accident sites.

Finnish Aeronautical Association

The Finnish Aeronautical Association has taken into consideration the only safety recommendation issued to it.

3b): Safety Investigation Authority, Finland recommends that the Finnish Transport Safety Agency (Trafi) "Require that the Finnish Aeronautical Association include a segment in sport aviators' training curricula that addresses pyrotechnical systems." The Finnish Aeronautical Association considered the recommendation during the update of the Ultralight pilot curriculum which Trafi approved on 12 December 2014.

The Finnish Aeronautical Association noticed that each safety recommendation in the draft final report was associated with the potential explosion of a rocket-propelled, ballistic recovery parachute. Still, the rocket-propelled recovery system did not contribute to the onset of the accident. The draft final report does not propose any such safety recommendation which could prevent similar accidents in the future. The draft final report states that the cause of the accident was a turn at low altitude and at a low airspeed. As per the draft inadequate preparation for the flight was considered a contributing factor. Subparagraphs 2.6 'Coordination between the users of the aerodrome' and 3.1 'Findings' present a number of other issues which could have contributed to the decision to make a turn or, consequently, to the onset of the accident. These, however, were neither analysed nor investigated.

One such issue that addresses a contributing factor involves potential confusion about activities on the aerodrome's intersecting runways. In subparagraph 2.6 it is mentioned as follows: "Local regulations should especially stipulate that all operators at the airfield establish the presence of each other and daily coordinate their activities".

Nevertheless, the draft final report does not delve any deeper into possible gaps in regulations, instructions or training materials in these respects which should be dealt with in order to prevent similar accidents in the future. While the draft final reports does mention the absence of local instructions, it does not propose any recommendations on how to improve safety.

Other comparable issues mentioned in the draft final report include the vehicle that was moving in the runway area and the custom by which the accident aircraft would turn towards runway 22 immediately following takeoff. Furthermore, there is a grove of trees between the takeoff positions of runway's 04 and 27, in use at the time of the accident. This increased the risk level when both runways were being simultaneously used.

The Finnish Aeronautical Association proposes that SIAF in its investigations, in addition to the direct causes, would pay more attention to the indirect causes which may have contributed to accidents. After all, accidents tend to include sev-

eral such background factors; by tackling them it is possible to improve the level of safety.

European Aviation Safety Agency (EASA)

EASA states in its comments that Ballistic Recovery Systems for EASA certified aircraft are regulated in the “Certification Specifications and Acceptable Means of Compliance for Light Sport Aeroplanes” CS-LSA, which refers to the ASTM F2316-12 standard in its subpart K. EASA’s comments also state that the recognition of aircraft ballistic parachute systems during emergency operations has been included in the training syllabus of rescue and firefighting service personnel in GM1 ADR.OPS.B.010(a)(3), “Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Authority, Organisation and Operations Requirements for Aerodromes”.

Polish air accident investigation authority

No comments.

French air accident investigation authority BEA

No comments.

International Civil Aviation Organization (ICAO)

No reply.