Investigation report

B2/2010L

Ultralight aircraft accident at Jämijärvi on 30 June 2010

Translation of the original Finnish report

OH-U430

EV-97 EUROSTAR, Model 2003, version R

Onnettomuustutkintakeskus
Olycksutredningscentralen
Safety Investigation Authority, Finland

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SUMMARY

An aircraft accident took place in the vicinity of Jämijärvi airfield on Wednesday 30 June 2010 at 13.05. An EV-97 Eurostar ultralight aircraft on a cross-country flight crashed to the ground soon after take-off and was totally destroyed. Both the pilot of the aircraft and the passenger were killed.

The purpose of the flight was to pick up a passenger from Jämijärvi airfield and after that fly to Tampere-Pirkkala aerodrome. Soon after take-off the canopy of the aircraft opened and among others, documents and the pilot's and aircraft's briefcases fell from the aircraft. After the canopy opened the aircraft flew at about 120 metres altitude loosing airspeed. After a short phase of level flight the altitude diminished quickly to about 50 metres. Before hitting the ground the altitude increased a little, at the same time the airspeed diminished and the aircraft heading changed strongly to the left. The aircraft hit the ground less than a minute after the take-off in a nearly horizontal position a little over a kilometre to the west of the airfield.

The opening of the canopy was likely due to a strong and gusty wind and the locking mechanism of the canopy. The aerodynamic forces created by gusts cause momentary changes in the aircraft's structures, under these kind of circumstances, according to the manufacturer, the original locking mechanism is not sufficient. The manufacturer has tried to improve the reliability of the locking system by publishing a bulletin giving instructions to change the new parts to the locking system which prevent opening of the locking during momentary structural changes. Parts had been changed into the canopy locking mechanism of the aircraft, but one part considerably contributing to the reliability of locking had not been changed. The factor most contributing to this was that the instructions in the published bulletin for assembling the delivered alteration parts were inadequate. Another reason for not changing the part was the aircraft owners' understanding that the changed parts increased the reliability of the locking the way they expected.

The reason of the accident was loss of aircraft control after the canopy opened during flight. An open canopy causes with its airflow disturbances a strong vibration to the horizontal stabilizer and elevator as well as stick and a considerable nose down effect to flight characteristics. Also the fact that the pilot probably tried to close the canopy contributed to the loss of control of the aircraft as monitoring the flight parameters was neglected.

The aircraft canopy likely opened due to momentary changes to canopy structure caused by aerodynamic forces of the strong gusty wind. To prevent this kind of unintentional opening of the canopy the manufacturer has improved the canopy locking mechanism by new alteration parts. All new parts had not been assembled into the accident aircraft.

The investigation commission gave two safety recommendations to the manufacturer Evektor-Aerotechnik a.s. It was recommended that the manufacturer publishes in the EV-97 aircraft pilot's operating handbook procedures for the event that the canopy opens during flight. Secondly, it was recommended to the manufacturer that it publishes an instruction bulletin to correspond with the alteration work.

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ABBREVIATIONS

ACC Finland	Area control centre Finland
GAFOR	General aviation forecast
GPS	Global positioning system
hPA	Hectopascal
IAS	Indicated Air Speed
JAR	Joint Aviation Authority
METAR	Meterorological airport report
PPL(A)	Private Pilot Licence (Aircraft)
SEP	Single engine piston
TAF	Terminal aerodrome forecast
UPL	Ultralight Pilot Licence
UTC	Coordinated universal time
VFR	Visual Flight Rules

SYNOPSIS

An aircraft accident took place at 13.05 (all times are Finnish time, UTC + 3 hours) on Wednesday, 30 June 2010, in the vicinity of Jämijärvi airfield. A privately owned EV-97 Eurostar ultralight aircraft crashed to the ground and was completely destroyed. Both the pilot of the aircraft and the passenger were killed. The accident took place soon after take-off with intention to fly cross-country to Tampere-Pirkkala aerodrome. The aircraft manufacturer is Czech Evektor-Aerotechnik a.s. and the aircraft had been manufactured in 2003.

Accident Investigation Board of Finland appointed an Investigation Commission on resolution number B2/2010L on 2 July 2010 to investigate the accident. Investigator Juhani Hipeli was appointed investigator-in-charge accompanied by investigators Jorma Laine and Kalle Brusi.

The Investigation Commission informed the manufacturer by a letter, mailed on 18 November 2010 that the Mandatory Bulletin EV-97-009a, 3 Jan 2006, with assembly instructions for alterations for the canopy locking mechanism, published by the manufacturer, was inadequate with regard to the alteration parts delivered.

The Investigation Commission sent the draft report for comments to the Finnish Transport Safety Authority Trafi, Finavia Corporation, the aircraft owners, the Investigation Authority of the Czech Republic and the aircraft manufacturer Evekto-Aerotechnik a.s., Area Control of Finland, Finnish Aeronautical Association and those concerned. The comments were received by 7 September 2011. The comments have been taken into account in the finalisation of the investigation report. A summary of the comments has been attached to the investigation report (Annex 1).

The investigation report was translated into English. The investigation was completed on 21 November 2011.

The material used in the investigation is stored at the Accident Investigation Board of Finland.

1 FACTUAL INFORMATION

1.1 The Accident Flight

1.1.1 Preceding Events

Before the accident flight the pilot had flown from Tampere-Pirkkala (EFTP) aerodrome to Jämijärvi (EFJM) airfield. The purpose of the flight was to pick up a passenger from Jämijärvi and return with her back to Tampere-Pirkkala. The pilot had made en-route and fuel calculations for both flights. He had filed a flight plan for route EFTP – Siuro – EFJM. After take-off from Tampere-Pirkkala the pilot reported at control zone boundary "Siuro outbound", which the controller acknowledged. After this the pilot was not in contact with the ATC. To terminate the flight plan the pilot had planned to give arrival report by phone to Tampere Area Control Centre (currently Finland Area Control Centre).

The pilot landed at Jämijärvi airfield runway 27 at 12.32. He did not terminate the flight plan after landing, and therefore Tampere Area Control Centre began a search for the aircraft at 13.10. The search was terminated at about 13.30 after the Area Control had received information by another aircraft taken off from Jämijärvi that the accident aircraft had been at Jämijärvi and taken off with two persons on board. A new flight plan had not been filed.

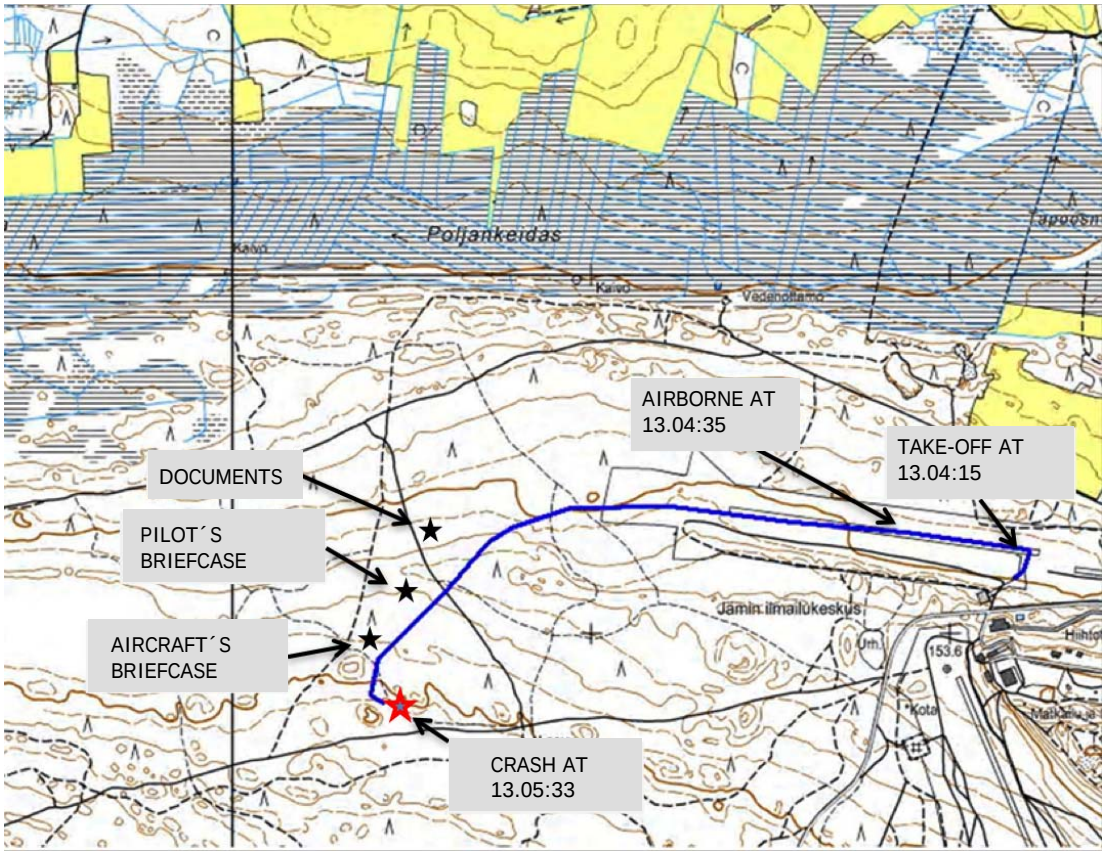
1.1.2 The Accident Flight

There were no eyewitnesses to preparations for flight at Jämijärvi airfield. As the pilot was getting ready to board the aircraft, another aviator arrived to make preparations for his flight. He exchanged a few words about the weather and the runway in use. The aviator did not discuss with the passenger. After this he began the daily inspection of his own aircraft.

After a while the aviator paid attention to the engine start of the aircraft and a little later it's taxiing to runway 27. Afterwards he could not recall whether the pilot had performed engine run-up before take-off. The aviator's attention had been drawn to the pilot's very rapid opening of the throttle at take-off. It took place approximately within less than half a second. The aviator watched the take-off until the aircraft reached about 5 metres altitude. According to the aviator the take-off looked normal. After this he went about his own preparations.

The take-off of the aircraft from Jämijärvi took place at 13.04. According to information extracted from the aircraft's GPS satellite locator, the initial climb took place on runway heading to about 300 ft (100 m) altitude above ground. After this the pilot commenced a shallow left turn continuing climb to about 400 ft (120 m) altitude. This altitude was maintained rather stable for about 10 seconds with minor changes in heading, but the aircraft's ground speed decelerated from about 140 km/h to 105 km/h. After this the altitude decreased within a few seconds over 200 ft (70 m) and the ground speed in-

creased to about 120 km/h. During the less than 10 seconds after the dive, the aircraft heading started to veer strongly to the left. The altitude increased about 70 ft (20 m) and the speed diminished quickly. In less than a minute from take-off the aircraft crashed into the ground in an almost horizontal position a little over a kilometre to the west from Jämijärvi airfield. Documents, briefcases and other items fallen from the aircraft were found along the flight route. There were no eyewitnesses to the crash.



Picture 1. The flight route of the ultralight aircraft extracted from the on board GPS satellite locator. (The map: KTJ/Oikeusministeriö/MML)

1.1.3 Succeeding Events

The aviator who had watched the take-off of the accident aircraft took off about 24 minutes later. According to the aviator, the wind was not disturbing at take-off but a little higher the wind and turbulence rocked the aircraft rather strongly. The Piper PA-28 in question is about twice as heavy as the accident aircraft.

On the previous day the pilot had agreed with the aircraft's other owner on flights to be flown on 30 June 2010 and promised to return the aircraft to Tampere-Pirkkala by 15.00 for further flights. As the pilot had not returned according to plan from Jämijärvi to Tampere-Pirkkala, his family started missing him and finally contacted Tampere Control at about 17.00 o'clock. After this contact the Aeronautical Rescue Co-ordination Centre

(ARCC) began to search for the aircraft. The accident was discovered by persons who just happened to be there. They informed the ARCC of the accident at 17.24.

1.2 Injuries to persons

Both the pilot of the aircraft and the passenger were killed in the crash.

Injuries	*Crew*	*Passengers*	*Others*
Fatal	1	1	-
Serious	-	-	-
Minor/None	-	-	-

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

One small and one medium-sized pine tree were broken. One small pine tree was damaged. A small amount, just a few litres, of petrol leaked to the ground.

1.5 Personnel information

Pilot: Age 41 years

Licences: JAR PPL(A), valid until 5 Nov 2012
UPL, valid until 3 June 2015
JAR medical certificate, class 2, valid until 14 Nov 2010

Ratings: JAR –SEP class rating, land, valid until 31 Oct 2011
JAR Night rating, aircraft, indefinite
JAR Radiotelephone Operator VFR, English
Radiotelephone Operator, English

Flight experience	*Last 24 hours*	*Last 30 days*	*Last 90 days*	*Total experience*
All types	30 min 1 landing	1 h 35 min 5 landings	6 h 20 min 28 landings	102 h 25 min 353 landings
Type Concerned	30 min 1 landing	1 h 35 min 5 landings	4 h 30 min 22 landings	4 h 30 min 22 landings

1.6 Aircraft information

1.6.1 Basic Information

EV-97 Eurostar is a metal structure side-by-side twin seat low wing commercially manufactured ultralight aircraft.

The Aircraft:

Type:	EV-97 Eurostar, Model 2003, version R
Registration:	OH-U430
Registration number:	U430
Manufacturer:	Evektor-Aerotechnik, a.s
Serial number:	2003 1716
Year of Manufacture:	2003
Maximum take-off weight:	450 kg
Owners and operators:	Private persons
Total flight time:	623 h

Engine:

Type:	Rotax 912ULS
Serial number:	4426764
Manufacturer:	Bombardier-Rotax GMBH
Total runing time:	623 h
Fuel:	98E

Propeller:

Type:	Klassic 170-3-R, 3-bladed
Serial number:	4-49068 3R
Manufacturer:	Woodcomp
Total running time:	367 h

1.6.2 Airworthiness

The registration certificate had been issued on 23 December 2004. Based on a 29 May 2009 conducted inspection a licence for aviation was valid until 30 June 2012. Required insurances were valid.

On 11 December the aircraft manufacturer had issued Mandatory Bulletin number EV-97-013a, according to which it will check the strength of the wing spar on every EV-97 Eurostar aircraft. The manufacturer issued a temporary restriction on the aircraft. It restricted the manoeuvring speed, airspeed in gusty winds and maximum airspeed by 30 km/h until the aircraft was found totally airworthy after the wing spar strength inspection. The aircraft owner was to post a sign in the cockpit to indicate the restricted speeds.

Based on the manufacturer's bulletin, Trafi Aviation had issued airworthiness directive M 3130/10 on 29 January 2010, and revision 1 to the directive on 27 October 2010. The airworthiness directive was effective from 5 February and its revision 1 from 15 November 2010. According to the aircraft logbook, the sign indicating the speed limitations had been posted in the aircraft cockpit on 14 February 2010. The wing span inspection had been planned to take place on 2 July 2010. At the time of the accident the temporary speed restrictions were in place, thus the aircraft was airworthy.

There were over five year old rubber hoses in the engine's fuel, lubrication and cooling systems. According to the engine maintenance manual Rotax Maintenance Manual, chapter 05-10-00, paragraph 2.1 hoses should have been changed after five years' use. In this respect the aircraft was not airworthy.

There was no entry in the aircraft logbook of actions taken to inspect the elevator trim system as required by the Evektor-Aerotechnik a.s. Mandatory Bulletin EV-97-006a, 8 April 2004. Another missing entry concerns the EV-97-009a bulletin. There is no entry in the aircraft logbook of the 2009 annual inspection. Because of the missing entries the aircraft was not airworthy.

1.6.3 Weight and Balance

The aircraft had been weighed on 4 June 2008 and its weight had been 291,5 kg. At take-off the weight was calculated at 441,5 kg. The maximum take-off weight of the aircraft is 450 kg.

Balance was within limits at 0,354 m, the approved front limit being 0,250 and rear limit 0,425.

1.7 Meteorological information

According to weather study by Finnish Meteorological Institute, Fennoscandia belonged to a low pressure area. The low pressure centre was in Central Sweden. The associated cold front, extending from west of Stockholm to the western parts of Poland, moved slowly eastward. In front of the cold front – northern parts of the Baltic Sea, Gulf of

Bothnia and the Finnish west coast – a southern gusty airflow was prevailing during the accident.

According to observations by Kankaanpää Niinisalo airfield, at 12.40 - 13.40 the surface wind was from the south (varying between 188 and 201 degrees) and the speed (10 minute mean wind) varied between 5,7 and 6,6 m/s. The shortest gust strengths were between 9,9 and 11,3 m/s. Niinisalo airfield is located approximately 14 km to west-northwest of Jämijärvi airfield.

According to wind information from a parachute club's weather station operating at Jämijärvi airfield, at the same time period the strongest short-time gusts were between 5 and 15 m/s. The wind direction varied between south-southeast and southwest. The parachute club weather station is located about a kilometre to the east of the accident site.

According to the wind measurements of Näsinneula tower in Tampere, at 135 metres altitude the wind was from the south at 8,0 – 9,8 m/s. The strongest wind speed was 12,3 m/s.

GAFOR forecast for south western Finland between 6.00 and 15.00 o'clock was surface wind varying between 140 and 200 degrees at 3 to 12 knots (1,5 – 6,0 m/s). At 2000 ft (600 m) altitude the wind direction was forecast between 170 and 220 degrees at 15 to 30 knots (7,5 – 15 m/s). Local moderate gusting was forecast from the surface to 5000 ft (1500 m).

According to Tampere-Pirkkala aerodrome METAR, at noon the wind was 170 – 180 degrees at 8 – 9 kt (4 – 4,5 m/s). The wind direction varied between 120 and 230 degrees. The weather was CAVOK (no significant weather phenomena below 1500 m). TAF forecast the wind 180 degrees at 9 kt (4,5 m/s).

According to an experienced aviator in the Jämijärvi airfield personnel, south-southwestern wind was strong with fierce variations in strength. He thought the weather was not suitable for ultralight operations

At the time of the flight no weather information was available at Jämijärvi airfield.

1.8 Aids to navigation

Aids to navigation had no effect on the accident.

1.9 Communications

Communications had no effect on the accident.

1.10 Aerodrome information

Jämijärvi airfield (EFJM) is an uncontrolled airfield for general aviation. It is located approximately 60 km northwest of Tampere-Pirkkala aerodrome. The airfield has two run-

ways: 09/27 and 15/33. The runway in use at the time was 27 which is asphalt-paved, 830 m long and 18 m wide. The airfield elevation is 505 ft (154 m) above sea level.

1.11 Flight recorders

There were no flight recorders on board. The flight route information of the accident flight was recorded on a GPS satellite locator in the aircraft.

1.12 Wreckage and impact information

The ultralight aircraft had crashed into the ground a little over a kilometre from the end of the used runway, coordinates 61 46,572 N 022 41,097 E. The terrain in the area is easy to access pine-forested moor. The impact had occurred in almost horizontal position, slightly banked to the right in a rotation to the left. Before the impact the right wing of the aircraft had flown between two about wrist-thick pines, the one behind had broken and the one in front was peeled. The lower surface of the left wing had hit a mid-sized pine at the aileron at about three metres height in rotation to the left. The left wing had bent strongly upwards at the point of impact. The pine had been broken at about five metre's height. The aircraft was nose in the ground with wings supported by trees in a position corresponding to a 45 degree glide.

All peripheral parts of the aircraft were in their places. As a consequence of the impact the front of the aircraft had collapsed and consequently the front of the cockpit floor (foot well) had risen strongly inward. The canopy had been thrown over its front hinges over the engine and been broken. The canopy frame lower structure had been broken behind the attachment points of the gas pistons (gas pistons support the canopy in the open position). The gas pistons had been broken at the root of their upper attachment points. The locking handle of the canopy was in the open position. Almost all pieces of the canopy Plexiglas were found close to the aircraft, in front of it.

The tip of the right wing leading edge had hit the ground with force, and the upper surface of the wing had been dented all over. The rear fuselage of the aircraft had been bent behind the cockpit to the right and upward. The rear fuselage and flight controls including stabilizers were intact at visual inspection. The left wing had been twisted forward, causing the rear bracket to be torn off the fuselage. The controls were in their places and they had been functional before the impact. The flaps were retracted and the flap selector in the cockpit was in the retracted position. The landing gear were in their places but bent under the aircraft and damaged.

In the cockpit all the aircraft and engine controls were in their places. The fuel valve was open, fuel pump switch in the ON position, the refill hose of the fuel tank had come loose from the tank and there was fuel in the tank. The throttle lever was 4,5 cm open and the handle friction lock was functional. The main electric switch was in the ON position, the left magneto switch was in the ON position and the right one in the OFF position. The altimeter pressure setting was 1016 hPa (hectopascal). The elevator trim actuator was close to the mid-position. Both occupants had had their seat belts fastened and the belts were functional.

On the aircraft's approach route to about 500 m distance from the accident site there were papers and items fallen from the aircraft, among others the aircraft's and the pilot's briefcases. Some of the items and their locations are shown in picture 1.

1.13 Medical and pathological information

According to forensic medicine autopsy report the deaths of the pilot and the passenger were caused by the impact and consequently were accidental.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 Search, Emergency Reports and Alerting

Contrary to the flight preparations and flight plan the pilot did not call Tampere Area Control Centre (ACC) to report the termination of his flight after arrival at Jämijärvi airfield. Therefore the Control (after the beginning of the search, the Aeronautical Rescue Co-ordination Centre of South Finland, currently the Aeronautical Rescue Co-ordination Centre of Finland) began the search for the aircraft at about 13.10, approximately half an hour after the estimated time of arrival. During the search the time of last contact of the aircraft to ATC was determined. After this they tried to contact the pilot by radio and by mobile phone. At 13.28 the ACC asked the Emergency Response Centre of Satakunta (ERC) for executive assistance to search Jämijärvi airfield. The search was terminated when eyewitness reports confirmed that the aircraft had been at Jämijärvi airfield and taken off again. The Aeronautical Rescue Co-ordination Centre (ARCC) received confirmation of the aircraft's flight from Tampere-Pirkkala to Jämijärvi airfield from radar files.

The ARCC began the search again at 17.00 when a pilot's relative telephoned the ARCC and reported the aircraft missing. The ARCC asked the Satakunta ERC to locate the pilot's mobile phone. Two persons passing the accident site by car on a close by road saw the site first and informed the ERC at 17.24. Satakunta ERC alerted five rescue units from Jämijärvi and Kankaanpää at 17.27. The ERC informed the ARCC of finding the aircraft at 17.30.

1.15.2 Search and Rescue Operations

The persons who had found the accident site remained on the site to wait for the rescue units and to guide them to the site. One of the persons is a member of Kankaanpää voluntary fire brigade. No rescue or resuscitation measures were taken as there were no signs of life in the pilot or the passenger. The rescue unit acting as first aid unit reached the site first at 17.48, but there was nothing to be done to save the victims. Additional rescue measures were not needed. The police cordoned off the area. The Accident In-

vestigation Board received executive assistance from Niinisalo garrison to guard the site.

During the flight documents and other items fell from the aircraft. The police technical investigation uncovered a major number of them already on the date of the accident. The Accident Investigation Board received executive assistance from Niinisalo garrison for terrain search. During the following days very likely all other items fallen from the aircraft were found.

1.16 Test and research

1.16.1 Technical Inspection of the Ultralight

The Aircraft

In the inspection of the aircraft at the accident site the aircraft flight controls were found to have been functional before the accident. Based on the fallen items from the aircraft it can be concluded that the canopy was open during flight. Therefore the technical inspection focussed, in addition to the engine, on the canopy and its locking mechanism.

Engine and Propeller

The technical inspection of the engine was done by Aerotecno Oy with representatives of the Investigation Commission present. The condition of the engine before the accident was defined by totally disassembling the engine.

The most essential findings are the following:

The engine had suffered external damages and among others the oil filter with its attachments had broken loose and the starter engine was partly broken. Exhaust pipes and the cooler had been totally destroyed. Propeller blade number 3 had been broken at its root, blade number 2 was almost broken and its surface had scratches caused by rotation. Blade number 1 was almost intact.

The transmission rotated normally when rotated by hand. The overload clutch of the transmission had received the impact and had slipped a little. There were some aluminium chips in the sprocket wheel of the vacuum pump.

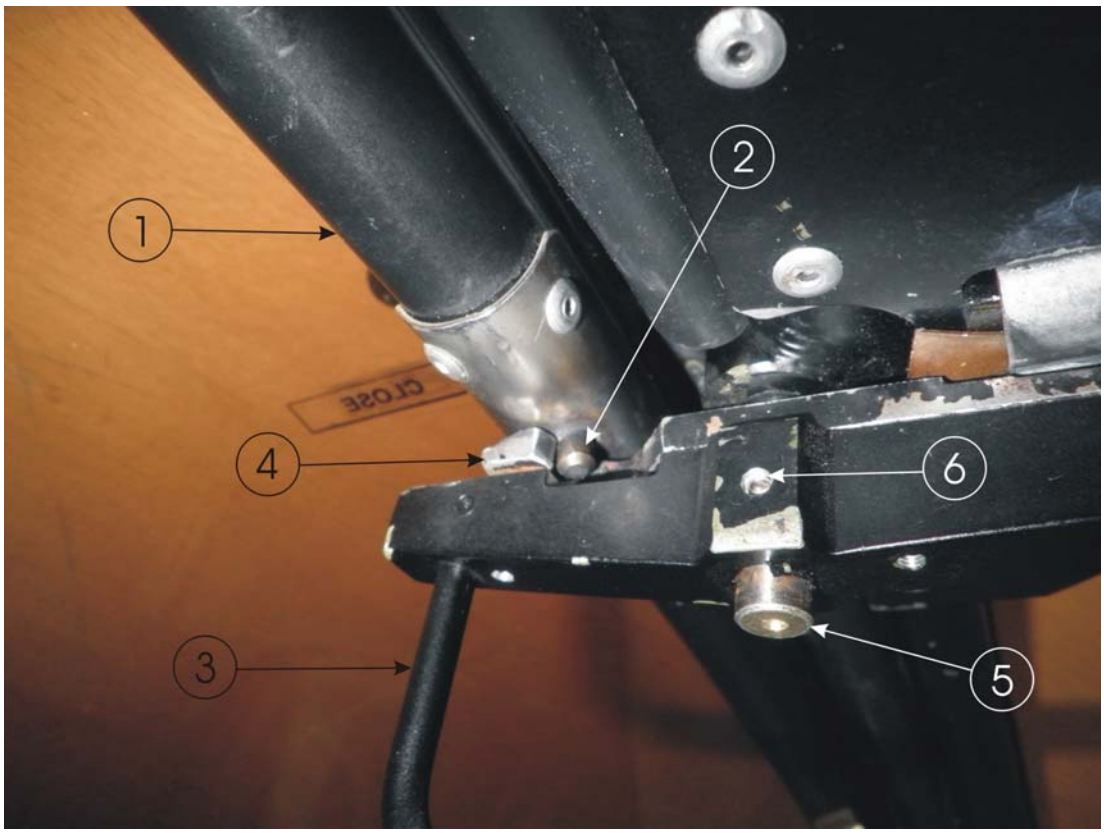
The ignition system was removed and tested in test bench. The ignition system worked normally in all aspects. The fuel equipment was functional. There were minor impurities in the float chambers of both carburettors but the fuel nozzles were clean. The lubrication system was functional but the five year life limit of some oil pipes had been exceeded. The cylinders, pistons and valve gear were intact. The five year life limit of the cooling liquid pipes had been exceeded. The crankshaft and camshaft and their bearings were intact. There was a clear mark, as if scratched by a chipping blade, in the crankshaft casing on the gearbox side. The mark had been caused by the drive gear of the vacuum pump at the end of propeller axel as it hit the crankshaft casing at impact.

By this mark it can be safely concluded that the engine was running when the impact took place. The running speed had been low, probably close to idle. Because of the reduction gear in the Rotax 912 series, engines do not windmill.

The overhaul period of the engine is 1500 hours or 12 years (Rotax SB-912-057UL). The engine had been running less than half of this time, 623 hours and was in very good condition.

The Canopy and its Locking Mechanism

There are two different width cockpits and canopies in EV-97 ultralight aircraft registered in Finland. The width of the more common cockpit is 104 cm (outer width) and the broader model 113 cm. The broader model can have clear top (as in the accident aircraft) or it may have a strengthening metal sheet longitudinally in the centre line. Differing from the more common cockpit, the lower frame of the broader canopy has guiding pins guiding to the holes in the lower railing of the canopy. A bubble cockpit shape, especially when looked from the side, is prominent in an aircraft equipped with the wider canopy. The wider canopy is flatter on top than the normal canopy. In all models the cockpit canopy is hinged at its front to the sides of the cockpit. The canopy opens forward and gas springs on both sides keep it in the open position. At the rear end of the canopy there is a locking handle where a hook locks behind a small locking pin (in the accident aircraft 5 mm x 4,8) at the rear end of the cockpit (picture 2). There are small differences in the locking mechanisms of the canopy between aircraft, notwithstanding the width of the canopy.



Picture 2. The locking of the accident aircraft in the closed position. 1. fixed support frame, 2. locking pin, 3. inner handle, 4. locking hook, 5. axel for outer handle, 6. metal pin functioning as locking pin.

1.16.2 Alteration Work of the Canopy Locking Mechanism

The owners of the aircraft considered the canopy locking mechanism unreliable. During the 300 hour maintenance in May 2005 the play found in the locking handle was logged into the maintenance list. In spite of the play the locking was determined functional. The problem was the joint between the canopy's outer and inner handle which was loosened. The growth of the play was considered a risk because the axel of the outer handle might break at the joint. The joint was done with a 3 mm thick pipe locking pin. Because the outer handle had a 6 mm thick axel, a thicker locking pin could not be attached to eliminate the play.

To solve the problem the owners of the aircraft had contacted the importer of the aircraft. The importer delivered the parts needed for the alteration work, the outer and inner handle and a new flanged locking pin. The owners thought that the delivery did not include the new locking hook. Picture 3 shows the alteration parts for another EV-97 Eurostar canopy locking alteration work delivered by the manufacturer. It includes the locking hook.

Picture 3. Canopy locking alteration parts delivered for another EV-97 Eurostar aircraft canopy alteration work. 1. outer handle, 2. inner handle, 3. locking hook to be attached to the inner handle, 4. flanged locking pin.

The locking mechanism was repaired by changing the outer and inner handle and attaching the old locking hook into the inner handle. In the new handle the axel was 8 mm thick which made it necessary to make the canopy axel hole bigger. The pipe locking pin was replaced by a machined metal pin which was widened at the other end and the other end was secured with a locking wire.

A new flanged locking pin to the fixed frame was not assembled. The most essential change in the new locking pin compared to the old one was the wide flange at its end. When the canopy is locked the hook attached to the handle winds under the flange. The purpose of the flange is to prevent the hook from rising and slipping from the pin and thereby to make sure of the safety of the locking during loads on the canopy and possible changes in shape. The aircraft owners thought that assembling a flanged locking pin would have required machining of the inner handle suitable for the flange on the locking pin. Machining was impossible because the fixing screw of the locking hook was exactly at the same place as where the machining should have taken place. According to those who had flown the aircraft, the locking felt clearly better after the alteration work and the risk of the axel breaking was eliminated.

There is no note of the alteration work in the aircraft logbook or maintenance records. The investigation could not determine the time when the aircraft owners contacted the

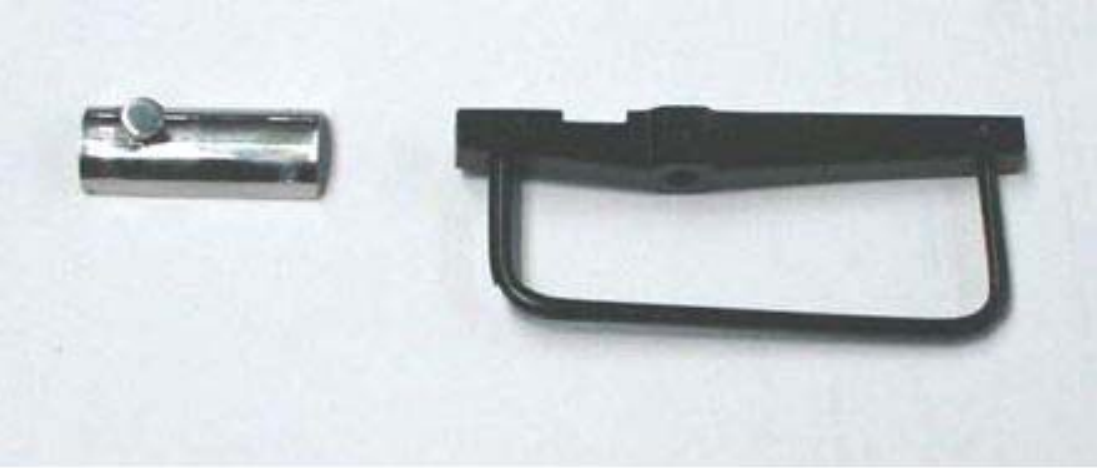
importer about the problem and when the alteration work was performed. However, the owners were confident that the alteration work was done using the aircraft manufacturer's 3 January 2006 published bulletin as working guide in its applicable parts.

During the alteration work the owner performing the work strengthened the spring keeping the canopy locking handle in the closed position by assembling an additional plate under the actual spring. According to the owner the alteration made the locking feel better. In interviews the owners thought the feeling from the locking handle was good after the alteration (picture 4).

Picture 4. The canopy locking handle, the locking spring holding the handle in the closed position and the additional plate assembled under it. 1. Locking spring, 2. additional plate.

1.16.3 The Aircraft Manufacturer's Bulletin

The aircraft manufacturer Evektor-Aerotechnik a.s. has published a bulletin on 3 January 2006 (Mandatory bulletin number EV-97-009a) concerning aircraft with the wide canopy. The reason for publishing this bulletin was information of repeated unintentional openings of canopy during flight. The manufacturer considers the most likely reason for the opening the inadequate design of the locking mechanism. The locking is not considered adequate under all air loads that may affect the canopy during flight. The bulletin gives alteration work instructions for the locking mechanism and shows the parts needed for the work (picture 5). The parts to be changed were the inner handle and locking pin with flange. The manufacturer promises to deliver the parts without charge. The bulletin is mandatory. The schedule for the work is "as soon as the parts arrive". However, the bulletin does not limit flying before changing the parts as long as the pilot ensures careful locking of the canopy before flight. In uncertain cases the locking can be confirmed following the instructions in the bulletin.



Picture 5. The parts to be changed to the locking mechanism according to bulletin number EV-97-009a.

During the investigation it was found that the manufacturer's bulletin does not cover all EV-97 Eurostar aircraft in Finland. According to the bulletin only the inner handle and the flanged locking pin are to be changed in the locking handle alteration work. It can be judged by the parts to be changed and the contents of the bulletin that the reliability of the locking mechanism is improved by changing the locking pin to a flanged one which prevents the locking hook from rising and slipping off the pin. The bulletin states*:"The stop of the pin installed on the rear fixed canopy frame prevents canopy unprompted opening"*. The inner handle with an indentation has to be changed to have the flange of the locking pin settle right into the locking hook.

In conflict with the content of the bulletin the manufacturer and importer have delivered the parts in figure 3 (the locking hook was not delivered to the accident aircraft) for the alteration work of the locking handle. In addition to the parts mentioned in the bulletin, a new outer handle, with a thicker axel than the original, and a new model locking hook

have been delivered. The bulletin does not include instructions for the assembly of these parts. There is a clear conflict between the content of the bulletin and the delivered parts to be changed. The Investigation Commission sent a letter to the manufacturer on the matter on 18 November 2010. The manufacturer informed of considering taking corrective action.

The Finnish Transport Safety Agency issued on 30 August airworthiness directive M 3133/10 regarding the change of the EV-97 Eurostar aircrafts' canopy locking mechanism. The directive was issued on the basis of the manufacturer's bulletin, Evektor-Aerotechnik a.s. Mandatory Bulletin number EV-97-009a, and the experience of use gained in Finland. The directive took effect on 15 September 2010.

1.16.4 The Maintenance History of the Aircraft

The aircraft owners had performed the scheduled maintenance and annual inspections by themselves ever since the aircraft came to their possession in late 2003. Almost all aircraft and engine maintenance records were entered into the scheduled maintenance lists published by the manufacturer. The annual inspection of 2009 has not been entered into the aircraft's logbook or other maintenance documents of the aircraft.

The 300 hour maintenance and annual inspection had been performed 14 – 15 May and 17 May 2005. On two days three and one day two of the owners had participated in the maintenance. On the inspection of the condition of the canopy locking mechanism there was a comment "weared (should be "worn") but works".

1.16.5 Inspection of Canopy Opening During Flight

The Investigation Commission asked for possible factors related to canopy opening during flight, the behaviour of open canopy and their possible effects from the manufacturer Evektor-Aerotechnik a.s. In addition it was intended to fly a simulation flight on an aircraft similar to the accident aircraft. The flight could not be flown because a suitable aircraft was not available. The behaviour of an unlocked canopy on ground was investigated with an aircraft fitted with the narrower canopy. The Investigation Commission received information on canopy opening in flight from interviews of Finnish aviators.

After the draft investigation report was completed, the Investigation Commission had a chance to investigate the behaviour of an unlocked and partly/inadequately locked canopy on an aircraft equipped with the broader canopy. At engine run-up rpm of 3850, an unlocked canopy opened at its rear end from a few centimetres to about 20 centimetres. A similar opening took place when taxiing with the canopy unlocked. At simulation of take-off acceleration the canopy opened to about 40 centimetres. In similar simulations a partly/inadequately locked canopy did not open.

When testing the possible opening of the canopy with an aircraft with a narrower canopy (no guiding pins), it opened about 30 cm at > 3500 rpm.

Information Received from the Manufacturer Evektor-Aerotechnik a.s.

According to the answer received from Evektor-Aerotechnik a.s., the opening of the canopy during flight has led to three accidents; one in Switzerland, one in the Czech Republic and the one now investigated in Finland. It is the manufacturer's understanding that no accident has taken place because of a correctly closed canopy opening in flight. According to its report, the manufacturer is not aware of flight conditions under which correctly closed canopy would open in flight. This information can be considered conflicting with the manufacturer Mandatory Bulletin number EV-97-009a, which states that the locking is not considered adequate in all load conditions affecting the canopy during flight.

According to the manufacturer, during flight the bubble shaped canopy is affected by a force lifting the canopy, meaning lift caused by vacuum. Usually this force is stronger than the force of drag pushing the canopy downward. This means that a canopy hinged at its front edge and not locked (at its rear edge) tends to rise at its rear edge. If the canopy is not closed and locked properly, the locking handle may turn open and the canopy opens due to vibration in flight.

The manufacturer has conducted test flights with a broad canopy aircraft in 2004 to study the effects of an open canopy on aircraft flight characteristics. The test flights proved that despite the open canopy the controllability and handling of the aircraft remained acceptable. In idle glide with flap retracted at IAS 100 – 120 km/h the canopy opened about 55 – 57 cm measured between the rear edge and the canopy fixed frame highest points. In climb with maximum power at IAS 100 – 120 km/h the canopy opened 37 – 39 cm. An open canopy grows broader in width approximately 10 – 20 mm on both sides. When closing the canopy with engine shut at IAS 110 km/h, the widening of the canopy is so wide that the canopy guiding pins went outside the side frame. Slowing the speed diminishes the widening. When the canopy is being closed, it shudders sideways. The force needed to close the canopy is about 10 – 20 kp. The disturbed airflow caused by an open canopy causes vibration to the horizontal stabilizer and elevator, with an amplitude of +/- 50 – 70 mm at the elevator tip. The vibration is strongest at full power. The vibration of the elevator can be felt as vibration also on the stick.

According to the manufacturer, trying to close the canopy on a solo flight might require extra effort and skill from the pilot to control the situation and the effort might have a negative effect on the safety of the flight. The problem in the closing of the canopy is its widening in flight, causing the guiding pins to miss their holes in the railing. To close the canopy the locking handle has to be kept in the OPEN position and simultaneously press the canopy frame backward with it in order to close the lock properly. This is due to the fact that as the canopy widens, the back of its frame moves forward. According to the manufacturer, trying to close the canopy with a two man crew is not as detrimental to safety as when flying alone.

There are no instruction in the pilot's operating handbook on how to act if the canopy is open. The Investigation Commission asked the manufacturer to define instructions for this. The instructions were the following:

1. Take a firm grip on the vibrating stick. This will reduce the vibration caused by the open canopy to the horizontal stabilizer and elevator.

2. Reduce the throttle and speed to about 120 km/h.

3. On a solo flight pull the open canopy down by one frame and on both if there are two persons on board. This will reduce the detrimental airflow to the horizontal stabilizer and elevator and makes aircraft controllability better.

4. Try to close and lock the canopy. This should be possible if there are two persons on board. If you are alone, hold the canopy down with one hand.

5. Make a safe landing.

6. The condition and locking mechanism of the canopy has to be checked after landing. Also the horizontal stabilizer and elevator need to be checked.

7. Detected faults need to be repaired before next flight.

Experiences Gained on Canopy Opening during Flight in Finland

At least two openings of the canopy during flight have taken place in Finland for EV-97 Eurostar aircraft equipped with the wider canopy. According to a pilot, an unintended opening of the canopy which took place on landing circuit at IAS 140 km/h, was connected to a strong downward airflow. The aircraft "plunged" in the airflow strongly and at the same time the canopy opened. The opening of the canopy caused a strong nose down effect. The position of the canopy varied between closed and about 40 cm open. The piloting of the aircraft required determined use of longitudinal control as the aircraft tended to pitch in the pace of the canopy closing and opening. According to the pilot the need for strong pull on the stick was noteworthy when the canopy was open. This is prominent especially during the final approach, if the canopy cannot be locked and flying requires both hands.

In another instance the pilot had another person to help close the canopy. After opening the canopy widened so much that when closing, the canopy guiding pins were on the outside of the frame. The pilot thought that closing and locking of the canopy when flying solo is difficult or even impossible.

According to the pilot, if the canopy opens e.g. by a force caused by strong upward airflow, the canopy locking lever does not turn to the open position, and the inner handle slips from under the canopy fixed frame. In the inspection of the locking mechanism after the incident no clear reason for the opening could be determined.

1.16.6 Aviation Experience of the Pilot

The pilot had started his aviation hobby in 2003 with motor gliders. Between 2003 -2006 the pilot flew altogether 32 training flights with a motor glider, accumulating 25 flight hours and 131 landings.

The pilot flew the flight training required for private pilot licence in 2007. Between 2007 – 2010 the pilot accumulated 72 flight hours' and 200 landings' flight experience as a private pilot.

The pilot started flying ultralights in May 2010. According to Aviation Regulation PEL M2-70, 5 May 2009, Ultralight Pilot Licence, a person with a licence for aircraft, is required to fly at least two training flights on an ultralight aircraft to receive a licence. In addition a certificate on an accepted inspection flight on an ultralight is required. No theoretical training or proof thereof is required from a person with a licence for aircraft. The pilot flew the required training flights on 19 and 25 May 2010 and the inspection flight on 29 May 2010. He was issued an Ultralight Pilot Licence on 3 June 2010. After this he had flown three flights on the aircraft. The pilot's flight experience on ultralights before the accident was 6 flights, flight time 4 hours 30 minutes including 22 landings.

1.16.7 Airworthiness and Inspection Procedure

According to Aviation Act (1194/2009), Art. 22, an aircraft used for aviation has to be airworthy. According to the same act, Art. 23, the owner, holder or operator is responsible for the aircraft's airworthiness. According to Aviation Regulation AIR M1-5, *The General Maintenance Operation Requirements of Aviation Equipment,* 15 February 1996, in the maintenance of aviation equipment the required and up to date manufacturer's maintenance instructions or other accepted instructions need to be used and followed in the maintenance of aviation equipment. Maintenance instructions mean i.a. Service Bulletins. The instructions in service bulletins have to be followed in the maintenance if they include maintenance instructions complementing or changing those in the manuals. According to Aviation Regulation AIR M5-10, *Airworthiness, Manufacture, Registration and Maintenance of Ultralight Aircraft*, 26 January 2004, in maintenance operations the owner, holder or operator has to see to that actions required by airworthiness requirements, such as inspections and alterations necessary for the continuous airworthiness of the aircraft and which the Civil Aviation Administration (currently the Finnish Transport Safety Agency) orders to be done, are executed.

Different manufacturers manufacturing ultralight aircraft have different ways of informing alteration work on aircraft or changes in maintenance instructions. On the other hand the manufacturers are not required to issue bulletins, so the users of aircraft of different manufacturers are in different position.

The airworthiness of an ultralight aircraft is controlled by aircraft inspections. According to Aviation Regulation AIR T16-4, *Airworthiness Inspections and Aircraft Inspections,* 13 April 2010, the Finnish Aeronautical Association supports the Aviation Authority among others by inspecting the ultralight aircraft in Finland. According to the regulation, aircraft

inspection is an inspection in accordance with the national aviation regulations, it is not done to issue or prolong an EASA aircraft airworthiness licence or licence for aviation. According to Aviation Regulation AIR M16-1, *Inspection of Aircraft and other Control of Airworthiness,* 15 February 1996, the purpose of aircraft inspection activities is to control that aircraft and their parts, components and equipment fulfil airworthiness requirements.

The accident aircraft had been inspected on 9 June 2006 and 29 May 2009. According to the owner attending the inspections, the first inspection focussed on checking the fulfilment of the regulations affecting airworthiness. The inspection comments required the checking of the implementation of certain airworthiness regulations and entering the information into the aircraft logbook. The entries have been signed off on 29 June 2006. According to the same owner, in the second inspection a similar check was not done. There is no entry in the aircraft logbook of the actions on checking the elevator trim system as required by manufacturer Evektor-Aerotechnik a.s. Mandatory Bulletin EV-97-006a, on 8 April 2004. Another missing entry is related to the EV-97-009a bulletin.

1.17 Organizational and management information

The accident aircraft was owned by four private persons. The pilot had bought a share of the aircraft in May 2010. The person who sold the share had known the pilot for years and considered him a considerate and composed aviator and therefore was able to recommend him to the other owners. The pilot previously had a Private Pilot Licence PPL(A), therefore he was issued an UPL after two hours flight training. Also the flight instructor who trained him to ultralight pilot described him as calm and composed pilot.

1.18 Additional information

1.18.1 Information on EV-97 Eurostar Aircraft with Similar Canopy in Finland

According to information received by the Investigation Commission from importers altogether four EV-97 Eurostar aircraft with wide canopy have been imported to Finland. According to information from aviators, unintentional openings of canopy have taken place also in Finland. Openings have occurred on both the normal and wider canopy type. Only one report in accordance with Aviation Regulation GEN M1-4, *Reporting on Accidents, Serious Incidents and Occurances,* 30 August 2006, has been filed. According to information received, the openings have taken place in gusty weather conditions and/or negative acceleration.

The Investigation Commission familiarized itself with the other EV-97 Eurostar aircraft with the same canopy in Finland. An own application had been made to one aircraft to ensure locking, to another the alteration work had been partly done and to the third one the alteration work had not been done.

1.18.2 Information on Similar Accidents

A similar accident took place in Switzerland on 29 July 2006, where an EV-97 Eurostar aircraft crashed into a lake shortly after take-off. The pilot lost control of the aircraft in early climb after he noticed a strong nose down tendency in the aircraft. A sailor on the lake noticed the low-flying aircraft and saw the canopy to be open. After the aircraft hit the water the pilot exited the wreck on his own despite of serious injuries. Soon after this he received help from the sailor. The inspection of the accident found that the pilot had closed the canopy before flight but had forgotten to lock it.

An aviation accident took place in the Czech Republic on 20 August 2010, where an EV-97 Eurostar crashed on the ground during approach. The pilot was seriously injured in the accident and the aircraft was badly damaged. According to information received from the manufacturer, the aircraft canopy opened in flight because the locking mechanism opened. The opening of the locking mechanism was considered possible because a spring holding the locking handle in the closed position was missing from the mechanism. Without the spring it is also possible that when locking the canopy, the locking is not complete because of the lack of the locking feeling that the spring produces.

2 ANALYSIS

2.1 Background Information on the Accident Flight

The pilot's purpose was to fly with a passenger from Jämijärvi to Tampere-Pirkkala aerodrome. The pilot had promised the flight to the passenger as a present and the flight had been agreed on the previous day.

According to the METAR and TAF weather information at Tampere-Pirkkala aerodrome the weather on the accident day seemed good and the flights possible to execute. Impeding factors for flying according to GAFOR forecast were the heavy wind above 2000 ft (600 m) and local turbulence up to 5000 ft (1500 m). It is likely that the pilot did not consider these to prevent flying as the surface wind speed was not forecast to exceed 12 knots (6 m/s).

According to the recorded information of the anemometer at Jämijärvi airfield, wind speed varied during 12.30 – 13.10 between 6 – 29 knots (3 – 15 m/s) with the direction varying between south-southeast and southwest. From the information recorded by the anemometer it can be deduced that the wind speed varied quickly, meaning the wind was gusty. The wind speed at Jämijärvi clearly exceeded the surface wind speed given in the area forecast. According to an aviator in the Jämijärvi airfield personnel, the south-southwestern wind was strong and there were strong variations in the speed. He thought the weather was not suitable for ultralight flying.

The pilot made the preparations for the flights at home and filed a flight plan for the flight to Jämijärvi by telephone. He probably obtained the weather information from the internet. It is likely that the pilot did not have the parachuters' anemometer information at his disposal. It is not known whether he searched for Jämijärvi weather information elsewhere, e.g. the internet. If the pilot had during the preparations obtained the information of the heavy and gusty wind at Jämijärvi he might have considered postponing the flight to a more suitable time. On the other hand, an in advance agreed flight for this date may have caused pressures to execute it despite the heavy wind. The pilot's experience on evaluating weather information effect on flying was based on flight experience on heavier Cessna 150 and 172 aircraft.

2.2 The Accident Flight

There are only some observations by another aviator about the preparations for flight at Jämijärvi. The pilot and the aviator discussed briefly about the weather and the runway in use. When asked about the weather, the pilot had told that the weather (flight to Jämijärvi) had been rather bad without specifying whether he meant the wind or possible thermal. According to the aviator's estimate, the south-southwestern surface wind in the runway 09/27 (lower runway) area was 4 - 6 knots (2 – 3 m/s) and 10 knots (5 m/s) in runway 15/33 area, so he had told that he would use runway 27 for take-off.

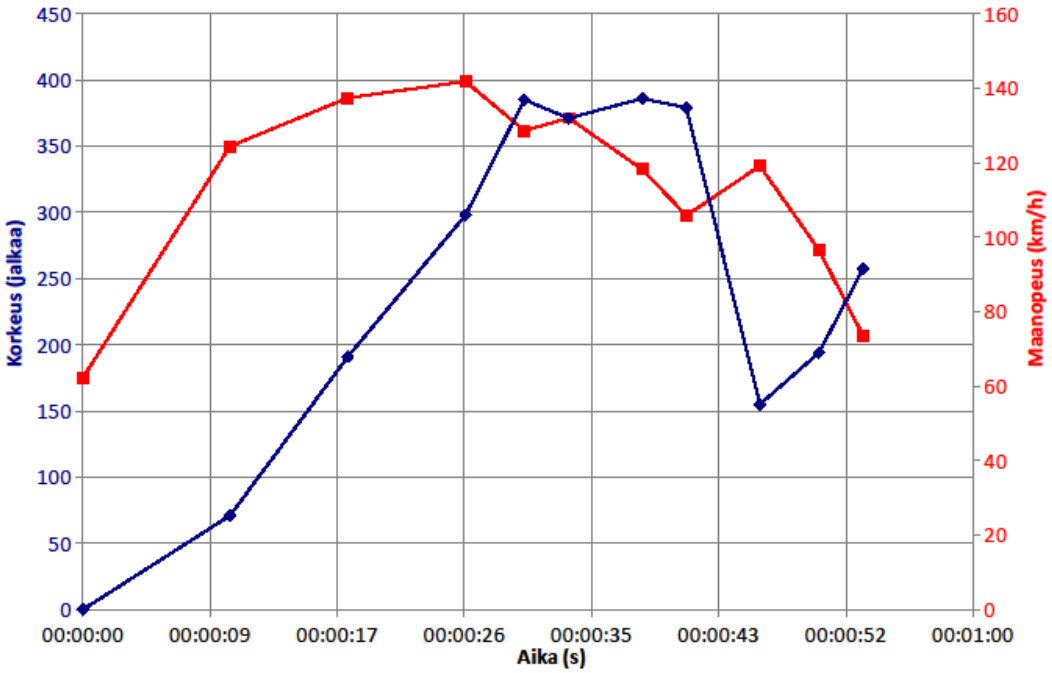
After the discussion the aviator's next observation of the accident aircraft was its engine start and taxiing into position 27. According to the aviator it is possible that the pilot did not do the engine run-up before take-off. This may be the case, since after taxiing into position, according to GPS information, it only took the pilot 7 seconds before he started the take-off. The run-up should have taken place on the apron beside the aircraft used by the aviator, in which case noticing the run-up would have been likely.

The aviator's last observation of the aircraft was its take-off which seemed normal under the circumstances. The aviator has no further information on the aircraft's flight. The process of the flight was analyzed by information extracted from the GPS satellite locator.

It is likely that the cockpit canopy opened as the pilot started a left turn after the take-off. The most significant reason for the opening was strong and gusty wind. The opening of the canopy has taken the pilot by surprise at about 300 – 400 (90 – 120 m) feet altitude, probably as the aircraft was still in climb. An open canopy causes strong disturbed airflow to horizontal stabilizer and elevator and, at the same time, a nose down effect. As a consequence of this and the gusty weather conditions, items on the "hat shelf" behind the seats, among others documents, the pilot's and the aircraft's briefcases fell out of the cockpit. The aircraft remained in almost level flight at about 400 feet (120 m) altitude for about 10 seconds. During this phase the aircraft's speed reduced considerably. In the accident site investigation the aircraft throttle handle was found to be about 4.5 cm open and the friction lock functioning. The position of the throttle corresponds near idle power setting. Based on the reduced speed it is likely that the pilot has reduced power considerably after the opening of the canopy. After that he probably has tried to close the canopy.

After the level flight phase the altitude of the aircraft diminished quickly over 200 feet (about 70 m). It is possible that the pilot tried to close the canopy with both hands, having to let go of the stick. Both the reduced airspeed and open canopy cause a nose down effect. Releasing the stick leads the nose to dive and loss of altitude. After noticing the rapid loss of altitude the pilot levelled the glide into climb by pulling the stick but not increasing engine power. As a consequence of the steering actions and the rapid loss of airspeed the aircraft started to bank heavily to the left, resulting in the pilot's loss of aircraft control.

Picture 6 shows the diagrams of ground speed and altitude extracted from the GPS recording. Based on the relative changes in the diagrams the changes in the flight can be assessed. Individual figures, especially altitude figures, in the diagrams may include inaccuracy due to satellite geometry.



Picture 6. The diagrams of ground speed and altitude extracted from the GPS recording. Ground speed is in red and altitude in blue.

2.3 Opening of the Canopy during Flight

2.3.1 Opening Mechanisms of the Canopy

According to information received, unintentional openings of EV-97 Eurostar aircraft canopies have taken place explicitly in strongly gusty weather or in abnormal flight conditions with negative acceleration (g). According to the manufacturer's bulletin EV-97-009a, the locking mechanism of the canopy is not considered adequate under all air loads that may affect the canopy during flight. According to this bulletin, classified compulsory, the reliability of the locking mechanism will be improved by changing new parts, inner handle and a flanged locking pin, delivered by the manufacturer (picture 5).

The opening of the canopy in flight is possible if the locking opens during flight or the canopy is left unlocked before flight. The opening of the canopy can be assessed based either on correct or incorrect locking. The aircraft manufacturer was not aware of any incident, where a correctly closed and locked canopy had opened in flight and caused an accident. The manufacturer was not aware of any incident where the canopy has opened in flight without causing an accident.

According to information from Finland, the wider canopy has opened in flight at least twice. In one case the canopy opened at IAS 140 km/h due to force caused by a strong downward airflow ("a plunge"). There was an old model locking pin without flange in the locking mechanism of the aircraft in question. Based on familiarization with the locking mechanism there is no reason to doubt that the canopy had been correctly locked. The

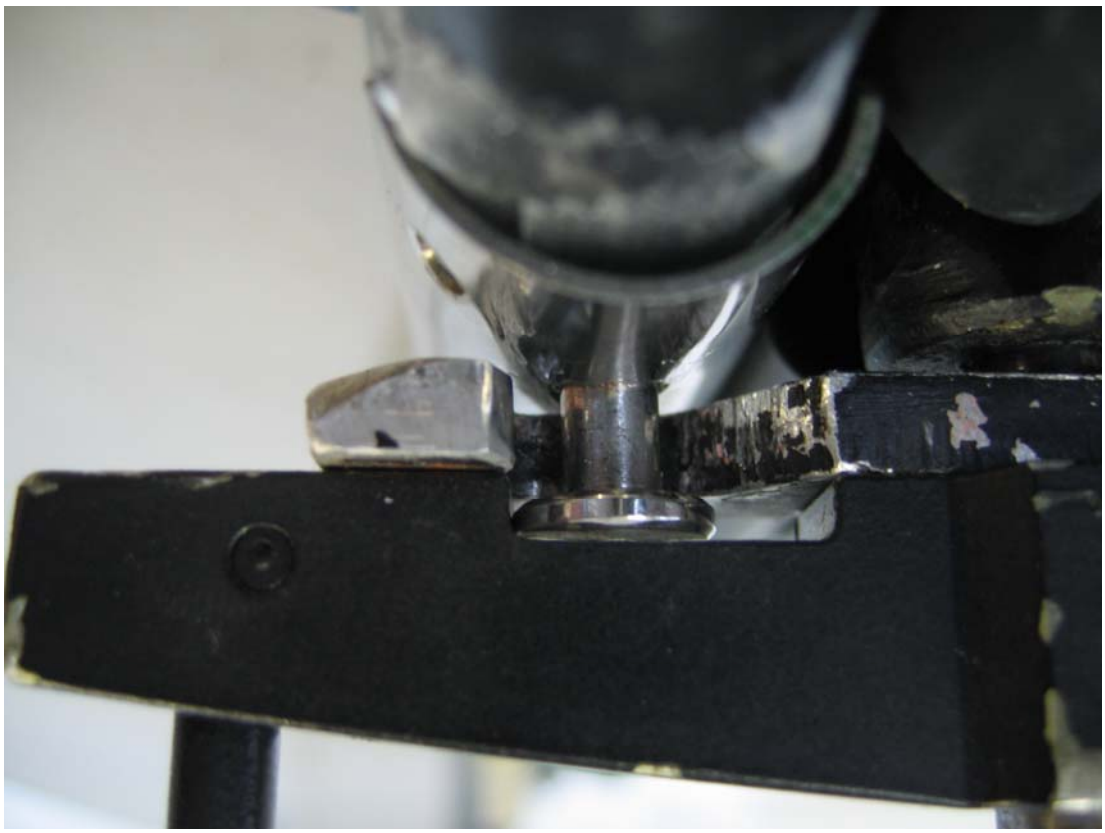
locking spring gave a good locking feeling on the inner handle. If the locking of the canopy had been done incorrectly, the canopy would probably have opened in flight earlier.

The understanding of the Investigation Commission is that strong shock-like quick changes in acceleration cause a momentary change in shape to the aircraft structure and, as a consequence, the locking hook may slip upwards over the 5 mm long locking pin. After this the inner locking handle may either slip from under the rear frame or turn into the open position making it possible for the canopy to open. Momentary changes in shape are apparent due e.g. to strong and gusty wind and the light structure of the canopy. The Investigation Commission considers this opening mechanism of the canopy locking system as most likely also on the accident flight.

Inadequate locking may lead to the opening of the canopy locking e.g. due to vibrations in the aircraft causing the locking handle to turn to the open position. Inadequate locking means that the inner handle is not attached to the slot in the spring holding it closed. When turning the locking handle of the accident aircraft into the closed position, the locking feeling, i.e. the settling of the inner handle into the slot, was clearly felt. The owners of the aircraft agreed to this. The locking feeling had been improved with an additional disc assembled under the locking spring (picture 4). According to performed tests, the Investigation Commission does not consider likely a possibility of turning the locking handle into such a position where the inner handle does not settle into the slot.

It is also possible that the canopy has been left totally unlocked before take-off. Based on results of performed tests, the Investigation Commission does not consider this alternative likely. If the canopy had been left unlocked before take-off, it would probably have opened already during taxi or in the take-off run, at the latest in initial climb. On ground the pilot would have had time to abort take-off. If the canopy had opened in the initial climb, the pilot would probably have not started a turn toward Tampere-Pirkkala aerodrome. According to the aviator monitoring the take-off on ground, the opening of the throttle was very fast, and would have caused the canopy likely to open already on ground.

The alteration work for the accident aircraft was partly done, but the flanged locking pin to the canopy fixed frame had not been assembled. According to the view of the owners, who had done the alteration work, the flanged locking pin was not compatible with the inner handle without machining. The purpose of the flange in the locking pin is to prevent the locking hook from slipping from the locking pin upward during momentary, non-permanent changes in the canopy shape caused by aerodynamic forces (picture 7). According to the Investigation Committee's perceived understanding, assembling the flanged locking pin would have considerably improved the reliability of the locking mechanism.



Picture 7. The settling of the flanged locking pin to the inner handle and the original locking hook.

2.3.2 The Effects of an open Canopy

According to the information received on the opening of the canopy, an open canopy, with its disturbed airflow, causes strong vibration to the horizontal stabilizer and elevator and a considerable nose down effect in flight characteristics. The vibration from the elevator to the stick, the nose down effect and the disturbing airflow in the cockpit may, when occurring suddenly, have considerably detrimental effect on the pilot's performance. Attention is easily drawn to the canopy and its behaviour and the most important, piloting and controlling the aircraft may be neglected. Windy and gusty weather conditions make controlling the aircraft additionally difficult.

Without the knowledge of the possibility of unintentional opening of the canopy, the sudden situation may be very difficult. Because of this, in the conclusions of the manufacturer's test flights in 2004, it was recommended that procedures for the opening of the canopy during flight be added to pilot's operating handbook. However, the manufacturer did not issue a revision on the matter into the operating handbook. The Investigation Commission asked for the instructions from the manufacturer and they are included in this report in paragraph 1.16.5.

The Investigation Commission considers justified that the EV-97 Eurostar aircraft pilot's operating handbook be amended with procedures for the opening of the canopy during

flight. In addition to the manufacturer's instructions, the procedures should emphasise the control of the aircraft as the primary and most important action. If there are two persons on board, the pilot should focus on the safe piloting of the aircraft and the other person to holding the canopy down.

2.4 Closing the Canopy during Flight

According to the findings of the investigation, the pilot tried to close the canopy during flight. The main problem in trying to close the canopy on your own is the fact that due to aerodynamic forces the canopy widens and therefore getting the guiding pins in the edge of the canopy to their holes in the side frame is difficult. As the manufacturer states, trying to close the canopy on your own, may require extra effort and skill from the pilot to control the situation and may have detrimental effect on the safety of the flight. To close the canopy the locking handle must be kept in the OPEN position and at the same time push with it the canopy frame backwards in order for the lock to close properly. When closing the canopy from the pilot's seat, you have to reach back and right with your right hand. In this situation it is very easy to pull on the stick with your left hand. If you simultaneously need to twist your body to the right you may unintentionally apply left foot. At a low speed the aircraft goes into left spin and due to low altitude there is no time for corrective action. The accident site investigation clearly proved that the aircraft had impacted in a nearly horizontal position and in rotation to the left.

It is the Investigation Commission's understanding, that the pilot could not close and lock the canopy. The opening of the canopy in flight was totally unknown to the pilot. The opening of the canopy took place after the take-off in a still critical phase as far as altitude is concerned and in very difficult wind conditions. Because of the demanding situation, the time to solve the problem was too short for the pilot.

2.5 Weather Conditions

Heavy and gusty wind was typical that day. According Jämijärvi weather report, during the time when the aircraft was in Jämijärvi, the strength of the gusty wind varied between 6 – 29 knots (3 – 15 m/s). At the time of the accident the wind was 12 – 20 knots (6 – 10 m/s). According to Niinisalo weather station the south-southwest wind varied in strength between 11 – 13 knots (5,7 – 6,6 m/s), with maximum gusts at 22 knots (11,3 m/s).

As the pilot arrived at Jämijärvi, the prevailing wind direction was 180 – 200 degrees. This wind direction is awkward with regard to the Jämijärvi runways. For runway 27 the wind is from the left and for runway 15 from the right. Runway 09/27 of the airfield is close to Soininharju (a ridge) and clearly below it. Based on experience, on southern and south-western winds the ridge causes strong turbulence to the approach sector of runway 27. When approaching runway 27 the pilot had made a 360 degree orbit to the right, possibly because of the wind conditions. The strong wind may have affected the approach so that touch-down was fairly far from the threshold and turning back took place almost at the end of the 830 m long runway.

According to the aviator witnessing the take-off from runway 27, it seemed normal. He thought that the wind on runway 09/27 was clearly weaker than on the higher locating runway 15/33. According to the aviator, with the prevailing wind, the higher ground shields runway 09/27 area from the surface wind. The aviator did not consider the surface wind especially gusty with regard to the strength of the wind.

Area forecast for Western Finland forecasted local moderate turbulence from the surface to 5000 feet (1500 m). The aviator who took off about 24 minutes after the accident aircraft told that the wind did not disturb take-off on the runway but after turning from the airfield area turbulent wind shook the aircraft rather violently. At that point the altitude was 300 – 400 feet (90 – 120 m) above ground which corresponds to the altitude that the accident aircraft was flying. Because the mass of the aircraft in question is about twice that of the EV-97 Aerostar, the effect of the wind and turbulence on the accident aircraft can be considered considerably stronger.

According to the understanding of the Investigation Commission, the prevailing wind conditions have made take-off from runway 27 challenging. Despite the pilot's minor experience on ultralight aircraft, in this respect he succeeded well on both flights.

The left turn after take-off was against the wind. According to the speed information extracted from the GPS satellite locator and estimated wind information, the airspeed of the aircraft at the time of the opening of the canopy was about IAS 140 – 160 km/h. This speed regime corresponds with normal cruise speed. Based on the manufacturer's bulletin EV-97-009a and experience from aviators, it can be assessed that a strong and gusty wind causes aerodynamic forces and momentary, non-permanent changes in the shape of the aircraft and the canopy, making it possible for the canopy to open.

2.6 Technical Condition of the Ultralight

Investigation of the aircraft at the accident site found the flight controls functional at the time of the accident. Investigation of the engine found it to have been in extremely good condition. The engine fuel, lubrication and cooling systems had over five year old rubber hoses. Some hoses had been changed during the alteration and repair work performed in 2007. According to the engine maintenance manual, Rotax Maintenance Manual chapter 05-10-00 paragraph 2.1, the hoses should have been changed after five years. The over aged rubber parts did not have any effect on the functioning of the engine and they had no effect on the accident. Because of the over aged rubber parts, the aircraft was not airworthy.

In May 2005 the owners regarded the canopy locking so uncertain that they asked the importer of the aircraft for help. The time of the contact with the importer could not be determined. The problem was a fear of the breaking of the locking handle axel, because it was worn. In January 2006 the aircraft manufacturer issued a bulletin according to which the reliability of the locking mechanism would be improved by changing the inner handle and a flanged locking pin. The purpose of the alteration work was to prevent the unintentional opening of the canopy during flight. After receiving the parts delivered by the importer, the owners changed both the inner and outer handles, but not the flanged

locking pin. This took place after the manufacturer had issued the bulletin. With the alteration work the owners' worry of the breaking of the handle axel was removed. The alteration work did not remove the problem of the unintentional opening of the canopy that the manufacturer had meant. The owners did not regard the changing of the flanged locking pin important though the manufacturer's bulletin states that the flanged locking pin prevents the unintentional opening of the canopy. The original text of the bulletin says: *"The stop of the pin installed on the rear fixed canopy frame prevents canopy unprompted opening."* The purpose of the locking pin flange is to prevent the locking hook from slipping upwards from the locking pin during momentary changes in the canopy shape caused by aerodynamic forces.

One reason for the inadequate execution of the alteration work may be the poor and conflicting instructions as compared with the delivered alteration parts. In conflict with the instructions, the alteration part delivery included the outer handle and, for some aircraft, also a new model locking hook was delivered. The alteration assembly included a lot of work that was not instructed at all. This may have contributed to the blurring of the entire purpose of the alteration work, especially when taking into account the aircraft owners' initial worry about the reliability of the locking mechanism.

The Investigation Commission finds that the unintentional opening of the locking mechanism in flight is a significant contributing factor to the accident.

2.7 Airworthiness and Inspection

According to Aviation Act (1194/2009) and Aviation Regulation AIR M5-10, the aircraft owner, holder or operator is responsible for the airworthiness of the aircraft and has to see to that alterations necessary for continuous airworthiness are done. In practise this means that the requirement for ultralight aircraft airworthiness is that the aircraft owner is aware of the bulletins affecting airworthiness. When the Aviation Authority issues an Airworthiness Directive based on a bulletin, the alteration work has to be done in accordance with the said directive. All alteration work in bulletins is not required to be done. On the other hand, the manufacturers are not required to publish maintenance or alteration bulletins, therefore the operators of aircraft of different manufacturers are in different position. Evektor-Aerotechnik a.s. had meant the issued bulletin to be followed. According to the practise in Finland, it became necessary only after the Finnish Transport Safety Agency issued the related Airworthiness Directive M 3133/10, 30 August 2010.

The aircraft was not airworthy because of the missing entries in the logbook of the manufacturer's bulletins (Evektor-Aerotechnik a.s. Mandatory Bulletin EV-97-006a and 009a) and the annual inspection of 2009. The fact that the aircraft was not airworthy because of the missing entries had no effect on the accident.

According to Aviation Regulation M16-1, the purpose of aircraft inspection is to control that the aircraft comply with the airworthiness requirements. There is no entry of the manufacturer's bulletin EV-97-009a, issued on 3 January 2006, in the logbook of the aircraft or in any other maintenance records. The aircraft has been inspected after the issuance of the bulletin, on 6 June 2006 and 29 May 2009. According to an owner attend-

ing the inspections, in the 2006 inspection attention was paid to the checking of the regulations affecting airworthiness. Checking the alteration work on the canopy locking mechanism probably was not included even on document level. According to the Traffic Safety Agency, an aircraft inspection is performed on a random check basis, and all deficiencies in the aircraft airworthiness cannot be detected.

To improve flight safety through inspection activities, the Investigation Commission proposes development of inspection activities in the control of airworthiness. From the feedback from aviators during the investigation it can be concluded that aviators are not necessarily aware of all the airworthiness requirements. For example missing inspection or action entries are not considered effecting airworthiness. The inspections should be able to control that operation is in accordance with the manufacturer's maintenance and alteration bulletins. The aircraft owner should be aware of the manufacturer's bulletins even though he does not intend to implement them. From airworthiness control point of view, also the inspector should be aware of the bulletins. Starting to use a technical diary and instructing its updating improve the chances for the maintenance of airworthiness of the owner and of control of airworthiness of the inspector.

2.8 The Pilot's Experience

The total 100 flight hour's experience of the pilot can be considered reasonable. During the last year the pilot had flown 8 flights on Cessna 172 and 150 aircraft and 6 ultralight flights, altogether 13 flight hours. The pilot had started ultralight aircraft flying about one and a half months earlier and received the licence four weeks before the accident.

In Finland an Ultralight Pilot Licence can be obtained with very small ultralight aircraft experience. The required minimum of two hours' training flight experience for an aircraft pilot licence holder, if given as such, does not provide routine for the handling of the aircraft in various circumstances. The pilot's skills were adequate for normal operation in the prevailing conditions but the unexpected opening of the canopy soon after take-off has required so much of the pilot's capacity that piloting the aircraft has been neglected resulting in loss of control. Low type experience is a common factor in ultralight aviation (Safety Study by Accident Investigation Board, Finland S1/2009L).

2.9 Search and Rescue

The Aeronautical Rescue Co-ordination Centre of South Finland (ARCC) began the search for the aircraft about half an hour after the arrival time in the flight plan had passed and the pilot had not filed an arrival report to Tampere Area Control Centre. The procedure is in accordance with aviation search and rescue for flights flown with flight plan. When an eyewitness observation confirmed the arrival of the searched aircraft at Jämijärvi the search was terminated.

The ARCC began the search again, when a pilot's relative reported the aircraft missing after about three and a half hours later. The pilot had not filed a flight plan for this flight before the flight. His intention has probably been to file the flight plan during flight by radio to Tampere-Pirkkala Air Traffic Control (ATC) for the part of the flight requiring a

flight plan. In practise this means Tampere-Pirkkala Control Zone. Search and rescue operations did not start automatically, as any ATC had no information about the flight. There was an uncertainty situation at the start of the second search, which is the ACC defined alerting phase of aviation danger situation, when there is uncertainty on the safety of people in aviation, or there is otherwise reason to take action to find out possible need for assistance (Aviation Search and Rescue Manual (ASRM) 1/D/LPKK/FA/2010).

Actual search and rescue operations (flight and terrain search) had no time to get started, as the accident site was accidentally located by people passing by it soon after the second phase of the search began. Because of the seriousness of the injuries to the deceased, the time of finding the accident site had no consequence as to their lives. The co-operation between authorities during both the search and rescue operations was good.

3 CONCLUSIONS

3.1 Findings

1. The aircraft registration licence, licence for aviation and the required insurances were valid.

2. Because the wing spar had not been checked, the manoeuvring speed of the aircraft was limited to 130 km/h, airspeed in gusty wind to 160 km/h and the maximum airspeed to 240 km/h.

3. The aircraft was not airworthy because the engine fuel, lubrication and cooling systems had over five year old rubber hoses. According to the engine maintenance manual the hoses should have been changed after five years.

4. The aircraft was not airworthy because of missing entries of manufacturer's bulletins (Evektor-Aerotechnik a.s. Mandatory Bulletins EV-97-006a and 009a) and the annual inspection of 2009.

5. The pilot had a valid JAR Private Pilot Licence, Ultralight Pilot Licence and JAR Medical Certificate, class 2.

6. The pilot's total flight experience was 102 hours. The pilot had flown 6 flights, altogether 4,5 hours on the accident aircraft.

7. Before the accident flight the pilot flew alone from Tampere-Pirkkala aerodrome to Jämijärvi airfield.

8. The pilot had not terminated his flight plan after landing at Jämijärvi, which caused Tampere Area Control Centre to begin search for the aircraft.

9. The search was terminated, as the ACC received information from another aircraft taken off from Jämijärvi airfield that the aircraft had been at Jämijärvi and taken off with two persons on board.

10. The pilot did not file a flight plan beforehand for his planned flight from Jämijärvi airfield to Tampere-Pirkkala aerodrome.

11. The southern wind at Jämijärvi airfield was strong and gusty, with the strength varying between 6 – 29 knots (3 – 15 m/s). At the time of the accident the strength of the wind varied between 12 – 20 knots (6 – 10 m/s).

12. GAFOR forecasted heavy wind above 2000 feet (600 m) and locally moderate turbulence from surface to 5000 feet (1500 m).

13. An aviator who had taken off from Jämijärvi about 24 minutes after the aircraft told that after leaving the airfield area the wind had been relatively turbulent.

14. The last observation of the aircraft was its take-off, which to an aviator observing from the ground seemed normal under the circumstances.

15. It is likely that after the take-off, when the pilot began a turn to the left at about 300 – 400 feet (90 – 120 m), the cockpit canopy opened.

16. According to the understanding of the Investigation Commission the most significant factor contributing to the opening of the canopy was the strong and gusty wind. The understanding is based on experience from the aircraft manufacturer and aviators who have flown the similar aircraft type.

17. Another factor contributing to the opening of the canopy was the locking mechanism of the canopy. Its 5 mm long locking pin makes it possible for the locking hook to slip upwards over the pin during momentary, non-permanent changes in canopy shape caused by aerodynamic forces.

18. As a consequence of the opening of the canopy and gusty weather conditions, items on the aircraft's "hat shelf" behind the seats, among others documents, the pilot's and the aircraft's briefcases and an aviation map fell from the cockpit.

19. After the opening of the canopy the aircraft remained in almost level flight at about 400 feet (120 m) altitude for about 10 seconds. During this phase the speed of the aircraft diminished considerably.

20. In the accident site investigation the throttle was found to be about 4,5 cm open and the friction lock functional. The position of the throttle corresponds to close to idle power setting.

21. Judging by the diminishing speed, it is likely that the pilot has reduced power considerably after the opening of the canopy.

22. Judging by the behaviour of the aircraft, it is likely that the pilot tried to close the canopy, but did not succeed.

23. The pilot lost control of the aircraft, which consequently hit the ground in an almost horizontal position in rotation to the left.

24. Both persons on board perished due to injuries in the impact.

25. An open canopy causes a strong vibration to the horizontal stabilizer and elevator through its disturbance to the airflow and a considerable nose down effect to flight characteristics.

26. The vibration from the elevator to the stick, nose down effect and the disturbing airflow in the cockpit may in their suddenness have a considerably detrimental effect on the pilot's performance. Attention is easily drawn to the canopy and its behaviour and the most important, piloting the aircraft may suffer.

27. Windy and gusty weather conditions make control of the aircraft difficult when the canopy is open.

28. The controls and the engine of the aircraft were functional at the time of the accident. The engine was running at a low power setting.

29. The over aged rubber hoses of the engine had no effect on the functioning of the engine and had no effect on the accident.

30. In May 2005 the owners regarded the canopy locking so uncertain that they asked the importer of the aircraft for help. The problem was a fear of the breaking of the locking handle axel, because it was worn.

31. In January 2006 the aircraft manufacturer Evektor-Aerotechnik a.s. issued Mandatory Bulletin number EV-97-009a, according to which the reliability of the locking mechanism would be improved by changing the inner handle and a flanged locking pin. The purpose of the alteration work was to prevent the unintentional opening of the canopy during flight.

32. The information in the bulletin was not in accordance with alteration parts kit delivered by the manufacturer. This caused difficulties in the alteration work.

33. After receiving the alteration parts delivered by the importer, the aircraft owners changed both the inner and outer handles, but not the new model flanged locking pin.

34. Changing the outer handle removed the owners' worry about the possible breaking of the locking handle axel.

35. The owners' understanding was that the flanged locking pin did not fit in the locking mechanism without machining.

36. The owners did not consider changing the flanged locking pin important even though the manufacturer's bulletin states that the flanged locking pin prevents the canopy from opening unintentionally.

37. Evektor-Aerotechnik a.s. had meant the issued Mandatory Bulletin number EV-97-009a to be executed. According to the practise in Finland, it became necessary only after the Finnish Transport Safety Agency issued the related Airworthiness Directive M 3133/10, 30 August 2010.

38. There was no entry in the aircraft logbook or in any other maintenance records on the alteration work of the canopy locking mechanism.

39. According to the Finnish Transport Safety Agency, aircraft inspection is done on a random check basis and all deficiencies in the aircraft airworthiness cannot be detected.

40. The ARCC began the search again, when a pilot's relative reported the aircraft missing after about three and a half hours later.

41. Actual search and rescue operations (flight and terrain search) had no time to get started, as the accident site was accidentally located by people passing by it soon after the second phase of the search began.

3.2 Probable causes and contributing factors

The accident was caused by the loss of aircraft control after the canopy had opened during flight. An open canopy, with its airflow disturbances, causes strong vibration to the horizontal stabilizer and the elevator and a considerable nose down effect to flight characteristics. The fact that the pilot had probably tried to close the canopy and consequently neglected monitoring flight parameters, had contributed to the loss of aircraft control.

It is likely that the aircraft canopy opened because of momentary changes in the canopy shape, caused by aerodynamic forces of the strong and gusty wind. In order to prevent this kind of unintentional opening of the canopy, the manufacturer has improved the canopy locking mechanism by new parts. All new parts had not been assembled into the accident aircraft.

4 SAFETY RECOMMENDATIONS

4.1 Safety actions already implemented

The Finnish Transport Safety Agency Trafi issued on 30 August 2010 airworthiness directive M3133/10 regarding the change in the locking mechanism of the EV-97 Eurostar aircraft. The directive was issued based on the manufacturer Evektor-Aerotechnik a.s. Mandatory Bulletin number EV-97-009a and experience of use from Finland. The directive took effect on 15 September 2010. The directive compels the aircraft owner, holder or operator to execute the actions required by the bulletin.

The Investigation Commission sent on 18 November 2010 a letter to the manufacturer informing the manufacturer about the discrepancies between the Mandatory Bulletin number EV-97-009a, issued on 3 January 2006, on the alteration work on the cockpit canopy locking mechanism and the delivered alteration parts. According to its answer on 22 November 2010, the manufacturer reported considering taking corrective action on the bulletin.

In the safety recommendations based on investigation D9/2010L, it was recommended that Trafi should require the use of a technical diary also for ultralight aircraft. According to Trafi reply on 28 October 2011, aviation regulation AIR M1-5, being currently updated, shall include a requirement for separate technical record-keeping for ultralight aircraft.

The Investigation Commission had decided to recommend (the recommendation was in the draft investigation report for comments), that Trafi publishes an airworthiness directive with procedures for the case of canopy opening during flight, be added to the Pilot's Flight and Operating Manuals. Trafi published the recommended airworthiness directive M 3146/11 on 17 November 2011, Evektor, Amendment to Flight and Operation Manual.

4.2 Safety recommendations

1. There are no instructions in the EV-97 Eurostar aircraft pilot's operating handbook for procedures in case the canopy opens during flight.

> *The Investigation Commission recommends that the aircraft manufacturer Evektor-Aerotechnik a.s. publish procedures in the EV-97 Eurostar aircraft pilot's operating handbook for the event that the canopy opens during flight.*

2. The Mandatory Bulletin on the alteration work on the aircraft canopy locking mechanism issued by the manufacturer Evektor-Aerotechnik a.s. and the parts delivered for the alteration work are in conflict with each other.

> *The Investigation Commission recommends that Evektor-Aerotechnik a.s. publish the above mentioned bulletin corrected to comply with the actions needed in the alteration work.*

Helsinki, 21 November 2011

Juhani Hipeli

Jorma Laine

Kalle Brusi

Summary of Comments

Finnish Transport Safety Agency Trafi

Trafi Aviation had nothing to comment on the safety recommendations of the investigation report.

Finavia Corporation

Finavia had nothing to comment on the investigation report.

Finnish Aeronautical Association

The Experimental and Ultralight Commission of the Finnish Aeronautical Association had no comments on the investgation as such. It agreed with the given recommendations. The Commission would add paragraphs for imposing technical diary compulsory, development of Finnish language check lists and development of training programmes for flight preparation and inspection of airworthiness.

Aircraft Manufacturer Evektor-Aerotechnik a.s. (EVAT)

EVAT was not aware of any problems concerning the implementation of the alteration work according to Mandatory Bulletin n:o EV-97-009a, because no contact by the aircraft owners, operators or other Finnish actors had been made to the manufacturer. EVAT considers that “non-installation of the rear locking pin with the flange as required by the bulletin was the factor which contributed to the canopy opening in flight”.

EVAT considers a practise where the implementation of a compulsory bulletin is necessary only after the publication of a directive by Authority as potentially dangerous. Bulletin EV-97-009a had been published in January 2006, the accident took place in June 2010 and the Authority’s directive was published in August 2010.

EVAT agrees with the given safety recommendations. In order to implement the first safety recommendation EVAT shall publish a Mandatory Bulletin where emergency instructions for opening of the canopy during flight are added to the aircraft pilot’s Flight and Operation Manual. EVAT is considering the implementation of the second safety recommendation, but consideres its meanignfulness questionable due to the long time since the publication of the bulletin. EVAT shall contact all known Eurostar aircraft owners in Finland to find out if actions are needed to repair canopy locking in individual aircraft.

Air Accident Investigation Institute of the Czech Republic, AAII

AAII agrees with the given safety recommendations. In addition AAII agrees with EVAT that a practise where implementing a compulsory bulletin is necessary only after a directive by Authority, may be a dangerous one.

Other Requested Comments

None of the others to whom the report was sent for comments had anything to comment.