Safety study

S1/2009L

Ultralight Aviation Safety and its Improvement through Accident Investigation

Translation of the Finnish original safety study

Onnettomuustutkintakeskus
Centralen för undersökning av olyckor
Accident Investigation Board

Osoite / Address:	Sörnäisten rantatie 33 C FIN-00500 HELSINKI	**Adress:**	Sörnäs strandväg 33 C 00500 HELSINGFORS

Puhelin / Telefon: (09) 1606 7643
Telephone: +358 9 1606 7643

Fax: (09) 1606 7811
Fax: +358 9 1606 7811

Sähköposti: onnettomuustutkinta@om.fi tai etunimi.sukunimi@om.fi
E-post: onnettomuustutkinta@om.fi eller förnamn.släktnamn@om.fi
Email: onnettomuustutkinta@om.fi or first name.last name@om.fi

Internet: www.onnettomuustutkinta.fi

Henkilöstö / Personal / Personnel:

Johtaja / Direktör / Director	Veli-Pekka Nurmi
Hallintopäällikkö / Förvaltningsdirektör / Administrative Director	Pirjo Valkama-Joutsen
Osastosihteeri / Avdelningssekreterare / Assistant	Sini Järvi
Toimistosihteeri / Byråsekreterare / Assistant	Leena Leskelä
Ilmailuonnettomuudet / Flygolyckor / Aviation accidents	
Johtava tutkija / Ledande utredare / Chief Air Accident Investigator	Markus Bergman
Erikoistutkija / Utredare / Air Accident Investigator	Tii-Maria Siitonen
Raideliikenneonnettomuudet / Spårtrafikolyckor / Rail accidents	
Johtava tutkija / Ledande utredare / Chief Rail Accident Investigator	Esko Värttiö
Erikoistutkija / Utredare / Rail Accident Investigator	Reijo Mynttinen
Vesiliikenneonnettomuudet / Sjöfartsolyckor / Marine accidents	
Johtava tutkija / Ledande utredare / Chief Marine Accident Investigator	Martti Heikkilä
Erikoistutkija / Utredare / Marine Accident Investigator	Risto Repo
Muut onnettomuudet / Övriga olyckor / Other accidents	
Johtava tutkija / Ledande utredare / Chief Accident Investigator	Kai Valonen

---

Translation: R&J Language Service

ABSTRACT

ULTRALIGHT AVIATION SAFETY AND ITS IMPROVEMENT THROUGH ACCIDENT INVESTIGATION

In a relatively short period of time in 2009 there were more serious accidents in Finnish ultralight aviation than in previous years. As a result, Accident Investigation Board of Finland (AIB) began to investigate five ultralight aviation accidents that occurred in 2009. AIB also wanted to establish whether there were any common contributing factors behind ultralight accidents, minor accidents and serious incidents. The primary aim of this study was to research and analyse the human factors that contributed to the occurrences in ultralight aviation. The study was restricted to class B ultralight incidents that the AIB had investigated between 2000–2009. Another aim of the study was to analyse and assess the significance of accident investigation with regard to improvements in ultralight aviation safety.

The most important research method used in the analysis of the AIB investigation reports on ultralight accidents, minor accidents and serious incidents was the systematic application of the SHELL-model. The research material included altogether 20 investigation reports. To an extent, information in investigation reports was augmented by means of conversations with investigators and the AIB's archives. The effectiveness of accident investigation on the improvement of ultralight safety was mainly researched through the analysis of AIB's safety recommendations and by interviewing the recipients of said safety recommendations. The development of the present safety level in Finnish ultralight aviation was also established. A further goal of the study was to establish how ultralight accidents and incidents are being investigated in foreign countries.

Judging by accident investigation reports and conversations with the investigators, it was the pilot's limited flight experience that contributed to most occurrences. In almost half of the cases the pilot's poor flying skills and his unsound course of action contributed to the event. Also inadequate aircraft construction or repair skills and unfavourable weather conditions played a role in many occurrences. Other human factors influencing the occurrences included the pilot's inadequate flight training, an inadequate flight manual, substandard aircraft construction, incorrect aircraft loading and the pilot's poor skills in using cockpit equipment. In one quarter of the examined cases the immediate cause of the occurrence was a stall at low altitude. The pilot failed to recognise the symptoms of the approaching stall.

On average, ultralight aviation safety improved during the 2000s, on the basis of this study. The research showed that some safety actions concerning ultralight aviation have only been implemented as a consequence of accident investigation. Nearly all safety actions have been implemented as an outcome of accident investigation but there have also been other contributing factors. This being the case, accident investigation has improved ultralight aviation safety. However, it is very difficult to estimate the level of its impact because there are also many other factors that affect the improvement of ultralight aviation safety. In Finland every ultralight aviation accident and serious incident is investigated. Judging by this study, at least one third of the European countries also investigates ultralight aviation accidents and incidents.

TABLE OF CONTENTS

ABBREVIATIONS

AAASII	The Agency for Aircraft Accident and Serious Incident Investigation, the Croatian accident investigation authority
AAIU	Air Accident Investigation Unit, the Irish accident investigation authority
AIBN	Accident Investigation Board Norway
AIB DK	Accident Investigation Board Denmark
BFU	Bundesstelle für Flugunfalluntersuchung. The German accident investigation authority
CAAIIB	Cyprus Aircraft Accident and Incident Investigation Board
CAS	Calibrated Air Speed
CIAIAC	Comisión de Investigación de Accidentes e Incidentes de Aviación Civil. The Spanish accident investigation authority
DEGER	Reporting point at the eastern border of Helsinki-Malmi control zone
DSB	Dutch Safety Board
EASA	European Aviation Safety Agency
ECAC	European Civil Aviation Conference
ELA	European Light Aircraft
EU	European Union
FAA	The Finnish Aeronautical Association
FSAI	Finnish Sport Aviation Institute Ltd
GPIAA	Gabinete de Prevenção e Investigação de Acidentes com Aeronaves. The Portuguese accident investigation authority
GPS	Global Positioning System
JAA	Joint Aviation Authorities
JAR	Joint Aviation Regulations
ICAO	International Civil Aviation Organization
IAS	Indicated Air Speed
ILL	Finnish Civil Aviation Authority
MTOM	Maximum Takeoff Mass
MAC	Mean Aerodynamic Chord
NLF	Norwegian Air Sports Federation
NOKKA	Reporting point at the southern border of Helsinki-Malmi control zone
OTKES	Accident Investigation Board of Finland
PPL	Private Pilot Licence
QFE	The barometric altimeter setting at the reference datum of a particular airfield
QNE	The indicated altitude equivalent to the air pressure at mean sea level
QNH	The barometric altimeter setting at airfield elevation

RFAE	Real Federación Aeronáutica Española. The Spanish Aeronautical Sport Association
SHK	Statens haverikommission. The Swedish accident investigation authority
SHELL	The model to analyse human factors (S = Software, H = Hardware, E = Environment, L = Liveware and L = Liveware)
SUIO	Finnish Sport Aviation Institute Ltd
TMG	Touring Motor Glider
Trafi	Transport Safety Agency
TSB	Transportation Safety Board Canada
USA	United States of America
UTA CAD	Civil Aviation Department of the United Transport Administration. Georgia's accident investigation authority
VFR	Visual Flight Rules
VHF	Very High Frequency (30–300 MHz)

SYNOPSIS

In 2009 more serious accidents occurred in Finnish ultralight aviation within a short period of time than had during previous years. In January 2009 at Lahti-Vesivehmaa airfield an accident occurred when a class B ultralight aircraft stalled after takeoff and collided with the ground. The pilot was seriously injured and the aircraft was badly damaged. In April 2009 three ultralight accidents occurred. The first accident happened to a class A weight-shift controlled ultralight at Hyvinkää airfield; the pilot died and the aircraft was destroyed. Approximately one week later an accident happened at Helsinki-Malmi aerodrome; a class B ultralight was badly damaged in a landing. One week after this an accident took place at Inkoo; a class B ultralight was destroyed in a forced landing. In early August 2009 an accident occurred at Kauhava aerodrome; a class B ultralight stalled at low altitude while trying to turn back to the runway following takeoff. Both pilots in the aircraft were killed and the aircraft was destroyed.

As a result, the Accident Investigation Board of Finland (AIB) began an investigation of five ultralight aviation accidents that occurred in 2009. The AIB also wanted to establish whether there were any common contributing factors behind ultralight accidents, minor accidents and serious incidents. For that purpose, AIB decided to launch Safety Study S1/2009L. The study was based on class B ultralight incidents that the AIB had investigated in the 2000s. The second aim of the study was to analyse and assess the impact of accident investigation with regard to improvements in ultralight aviation safety.

Commissioned by the AIB, MSc Erja Savela conducted the Safety Study S1/2009L, *Ultralight Aviation safety and its Improvement by Accident Investigation* as her master's thesis for the Aalto University School of Science and Technology. Hannu Melaranta, Chief Air Accident Investigator (on leave of absence) and Esko Lähteenmäki, former Chief Air Accident Investigator were designated to assist the Safety Study as experts. Their comments on the thesis have been taken into consideration in the study. In addition, comments were received from Tuomo Karppinen, previous Director of AIB who retired in May 2010; Veli-Pekka Nurmi, Director of AIB; Markus Bergman, Chief Air Accident Investigator; Tii-Maria Siitonen, Air Accident Investigator as well as Investigators Olli Borg, Jorma Laine, Ismo Aaltonen and Kalle Brusi. The study was completed in June 2010.

1 INTRODUCTION

Ultralight aviation is a relatively young field in comparison to traditional general aviation or gliding and powered gliding. Ultralight aviation was first introduced in Finland in the beginning of the 1980s, along with the arrival of the first ultralight aircraft. These aircraft were of simple design and were controlled through weight-shifting. The progression of their design features, however, began to mirror those of more traditional aircraft that incorporated control surfaces. These days the performance and structural materials of many ultralight aircraft already exceed those of traditional type-certified amateur-built aircraft. There are many types of ultralight aircraft and they are used year round in sport aviation, fitted on wheels, floats or skids. Nevertheless, the required training for an Ultralight Pilot Licence (UPL) is less demanding and, as a consequence, also cheaper than a Private Pilot Licence (PPL), for example. This may be one of the reasons why ultralight aviation has become so popular.

In Finland ultralight aviation was one of the fastest growing types of sport aviation during this past decade. Although some accidents occurred in ultralight aviation in the 2000s, more happened in a relatively short period of time in 2009 than during the earlier years of the 2000 decade. As a result, Accident Investigation Board of Finland (AIB) initiated an investigation of five ultralight aviation accidents that occurred in 2009. Furthermore, AIB wanted to establish whether there were any common factors that contributed to ultralight accidents. If such factors could be found, it might be possible to improve ultralight aviation safety and prevent similar future accidents by implementing some safety improvements. The primary aim of this study is to research and analyse the human factors that contributed to ultralight accidents, minor accidents and serious incidents.

The goal of accident and incident investigation is the improvement of safety and the prevention of accidents. This goal will materialise in ultralight safety if AIB can positively influence ultralight safety through the investigation of ultralight accidents, minor accidents and serious incidents. It is a generally held belief that accident investigation generates results that improve safety. Nevertheless, there are many factors which contribute to safety. The secondary aim of the study is to analyse and assess the extent to which accident investigation resulted in improvements in ultralight aviation safety.

In the study it was considered necessary to establish the development and present safety level of ultralight aviation. Moreover, there was a desire to compare the development of ultralight aviation safety level to that of gliding and powered gliding as well as general aviation. It was decided to determine this by using accident and minor accident statistics. The AIB's archives containing, among other things, the annual number of ultralight, glider and powered glider as well as general aviation accidents and minor accidents were used to compile these statistics. With regard to certain years this information was gathered from old Civil Aviation Authority (CAA) Finland publications. The total volume of flight hours for each type of aviation was also collected, to which the number of accidents and minor accidents was scaled. Since a 20-year period was considered statistically sufficient for the purpose of establishing safety development, the accident and damage statistics were limited to the period between 1990–2009. Then again, considering the goals of this study, it was neither possible nor feasible to obtain reliable and comparable ultralight statistics from the pre-1990s period.

The most important research method was the analysis of AIB investigation reports on ultralight accidents, minor accidents and serious incidents. The research material comprised of altogether 20 investigation reports. The decision was made to limit the study to ultralight accidents, minor accidents and serious incidents investigated by the AIB between the period of 2000–2009. Hence, while the number of reports to be analysed did not become excessive, the material was still extensive enough for the purpose of discovering common human factors. The study wanted to concentrate on the most important human factors at present, and so it would have been point-less to analyse older cases. Furthermore, there was a desire to focus on surface-controlled class B ultralight aircraft safety as they are presently of greater consequence to ultralight safety than the weight-shift controlled class A ultralights. Therefore, only the investigation reports that involved surface-controlled ultralight aircraft were included in the research material.

A systematic analysis of the investigation reports was needed. The SHELL model (S = Software, H = Hardware, E = Environment, L = Liveware and L = Liveware) was selected as the basis for the analysis, which is used by, among others, the International Civil Aviation Organization (ICAO) for analysing human factors in aircraft accidents. Due to the systematic features of the SHELL model, it was possible to better categorise the human factors which contributed to accidents, minor accidents and serious incidents. Information in the investigation reports was supplemented on the basis of discussions with the investigators. These talks touched on, among others, such things as potential contributing factors which, after reading the investigation reports, had spawned questions or which remained ambiguous on the basis of information included in the reports. In addition, at some places some of the AIB's archives were used to augment the information included in the investigation reports.

Document research was used to study the assessment of the impact of accident investigation in general. It also largely determined the salient research points with regard to ultralight aviation. Improving ultralight safety through accident investigation was mainly researched by analysing the AIB's safety recommendations and their implementation. The impact of accident investigation on implementation of safety actions was evaluated by interviewing the recipients of safety recommendations. Since the bulk of the recommendations were directed at the Finnish civil aviation authority (presently Trafi Aviation) and the Finnish Aeronautical Association (FAA), these interviews were limited to them. Other factors that were assessed included the volume and categories of investigations launched by the AIB as well as the time and costs allocated to the ultralight investigations. In addition, improving ultralight safety through accident investigation was analysed by evaluating whether the human factors that contribute to ultralight accidents, minor accidents and serious incidents had changed during the period of 2000–2009. If this was the case, the goal was to assess whether any links to accident investigation, such as the implementation of safety recommendations, could be found.

Yet another goal of the study was to establish how ultralight accidents and incidents are being investigated abroad. It was decided to limit the foreign countries to European Civil Aviation Conference (ECAC) member states and Canada. When it comes to ECAC countries, ultralight accident investigation in Nordic countries was the main point of interest. In the autumn of 2009 the author of this study participated in the annual Nordic AIG Meeting. Among other things, the agenda included a discussion on Nordic ultralight accident and incident investigation practices as well as respective experiences regarding the significance of ultralight accident investigation. The research method used in the actual survey was a questionnaire sent to select ECAC member states and Canada. Nevertheless, discussions in the annual meeting laid a partial foundation for the questions included in the questionnaire.

To start with, the following chapter presents a brief assessment of ultralight aviation history during its first decade. The aim is to provide the reader with some background information regarding the aviation regulations, flight training, aircraft and safety levels on which ultralight aviation took to the air in Finland. Chapter 3 lists international and domestic actors involved in ultralight aviation. The most important domestic actors are Trafi Aviation, the Finnish Aeronautical Association and Accident Investigation Board of Finland. Chapter 4 presents the requirements for ultralight aircraft in light of aviation regulations. Chapter 5 deals with ultralight flight training, for the most part on the basis of aviation regulations and training curricula. Chapter 6 evaluates the development of ultralight safety in light of accident and minor accident statistics by comparing it to the development of safety in general aviation as well as that in gliding and powered gliding. Chapter 7 presents the

AIB investigation reports included in the research material, the SHELL model, the reason it was selected as the model for analysis as well as a précis of results from the SHELL analyses. Chapter 8 deals with improving ultralight safety through accident investigation. Chapter 9 explains how ultralight accident investigation is arranged in other countries. Chapter 10 presents the conclusions. Summaries and SHELL analyses of the investigation reports included in the research material are appended to this document.

2 ULTRALIGHT AVIATION HISTORY

The first ultralight aircraft came to Finland in the beginning of the 1980s from the United States, the then leading nation of ultralight aviation. In the USA ultralight aviation had gained great popularity as a type of aviation for everybody and an opportunity to fly freely and inexpensively. The United States required no pilot licence for a large number of ultralight aircraft types. One just needed to buy an ultralight assembly kit, put it together and take off. Ultralight aircraft had been excluded from aviation regulations, as if they were some kind of non-aircraft. Many manufacturers in the USA made ultralight aircraft and many of them had turned the process into an industry, constructing them on assembly lines. This helped propagate the spread of ultralight aviation, which ultimately reached even Finland. The first ultralight aircraft came to Finland as prefabricated kits which the enthusiasts could assemble using regular tools and with the help of precise part numbers and assembly instructions. The Vector 600 was the first actual ultralight in Finland, ordered from the United States as a kit. Assembly began during the Experimental Winter Meeting at Räyskälä in February 1982. The aviation authorities granted a special certificate for the aircraft, which facilitated the first test flights in the spring of 1982 in Finland. During the spring of 1982 another ultralight aircraft, the Quicksilver MX, was also assembled and test flown in Finland. (1, 2, 3)

Being a new category of aircraft in Finland, ultralight aircraft ran into legal hurdles. Finland's aviation law classified ultralight aircraft as aircraft that were subject to the very same obligations concerning airworthiness, registration, licences and flight rules as the other aircraft categories. At that time the former aviation authority, the Finnish Civil Aviation Administration, had no aviation regulations for ultralight aircraft. They were either pending or being drafted. It was even proposed that ultralight aviation should be banned in Finland. The spread of ultralight aviation was also held back by problems caused by the reallocation of duties between CAA Finland and the Finnish Aeronautical Association (FAA). Many negotiations were arranged between CAA and FAA with the intention of gradually transferring sport aviation oversight to the FAA. In turn, CAA Finland would only retain ultimate supervision of the system. The negotiations dragged on and CAA Finland prepared several drafts for the agreement as well as aviation regulations for ultralight aircraft before the FAA finally approved them in the beginning of 1983. At the time CAA Finland also maintained an amateur-built aircraft register. However, it refused to register ultralight aircraft before the FAA had an organisation in place for overseeing the operations of ultralight enthusiasts. (1, 4, 5)

The agreement on ultralight aviation oversight and the first ultralight aviation regulations: AIR M5-2, OPS M2-8 and PEL M2-70 entered into force in the beginning of March 1983. Pursuant to the agreement the FAA would publish explanatory guidelines in support of the aviation regulations, assist CAA Finland by processing ultralight aircraft type certificates, keep in contact with aircraft inspectors certified by CAA Finland and arrange aircraft annual inspections. The FAA was also tasked to propose suitable persons to be trained as certified aircraft inspectors. As per the agreement, CAA Finland authorised the FAA to issue ultralight flight training approvals to its own members. Consequently, the FAA issued such approvals to five of its member clubs. In order to get this approval, a club had to have a CAA Finland -certified training organisation in place. (4, 7, 8)

The first ultralight aviation regulations

As per aviation regulation AIR M5-2 an ultralight aircraft was an aeroplane with a wing load not exceeding 25 kg/m², having no more than two seats and an empty weight, without the weight of the floats, skids and fuel, not exceeding 150 kg for a single seater and 175 kg for a two-seater. The maximum stall speed without engine power was 55 km/h. In addition, ultralight aircraft were primarily to be controlled by moving control surfaces. Therefore, all weight-shift controlled aircraft were excluded from the ultralight category. For example, the weight-shift controlled Eagle, with a wing loading that exceeded the 10 kg/m² limit given to hang gliders, was classified as a powered hang glider. Still, an Ultralight Pilot Licence (UPL) was required to fly it. As ultralight aircraft have continued to develop, the definition of an ultralight aircraft has changed several times after this first definition. (7, 9)

Pursuant to aviation regulation AIR M5-2 ultralight aircraft had to be registered and display nationality and registration markings, just like any other aircraft. The marking comprised the letters OH, signifying Finland, followed by the letter U and a three-digit number. Ultralight registration required compliance with certain aircraft inspection requirements. These requirements were much more relaxed than the ones required of type-certified aircraft. The inspection was performed by a CAA Finland -certified inspector, after which CAA Finland would issue a type certificate for an ultralight aircraft, akin to ones issued to type-certified aircraft. Nevertheless, since ultralight aircraft were not type-certified, it was impossible to issue type certificates to them. Instead, they were issued with a Permit to Fly. As a reminder of this, ultralight aircraft had to carry cockpit placards with the following text: *WARNING. This aircraft is a non-type certified ultralight aircraft*. Ultralight aircraft registration, nationality and registration markings were applied for from CAA Finland through the Finnish Aeronautical Association. (7, 9)

The requirements for a UPL licence were placed below those of the then least demanding one, the glider pilot licence. As per aviation regulation PEL M2-70 the requirements for a UPL licence were divided into three parts, on the basis of the applicant's prior flying experience. What follows only applies to an applicant who did not have prior aeroplane or glider pilot licence. The requirements included a satisfactory command of the 14 subjects listed in the aviation requirement as well as a minimum of 15 hours of flying experience, three hours of which solo on an ultralight aircraft amassed on no less than 20 flights. The minimum number of flights was 45. In practice the theoretical instruction for a UPL licence mirrored the theoretical instruction for a Motor Glider Pilot Licence. However, it was curtailed into less than half of it, fewer than 40 hours. (7, 10)

When the aviation regulation entered into force all ultralight aircraft were still single-seaters. No two-seater training aircraft even existed. Flight training could be carried out in such a manner that the student pilot only flew the required three hours on an ultralight, during which time he accrued the required 20 landings. The remaining minimum of 12 hours the student could fly with an instructor on a glider, powered glider or aeroplane. This made it possible for the student pilot to practice controlling the aircraft in a safer manner. Ultralight training culminated in a skill test, just as with other licence requirements. The medical requirements for a person applying for a UPL corresponded to those of a glider pilot. A UPL could be issued to a person no less than 18 years old. (7, 10)

When applying for a UPL all prior flying experience, including glider experience, was considered a plus. However, ultralight experience did not count when applying for higher-level licences. Notwithstanding the common Nordic background of aviation regulations, a UPL was only valid in Finland. When abroad, the licence was only valid with the local aviation authorities' endorsement. In addition, a holder of a UPL could operate as a pilot and pilot-in-command on non-commercial ultralight flights. In order to obtain a passenger carrying rating the UPL licence holder had to have at least 30 hours flying experience, no less than 15 of which solo on ultralight aircraft. If the licence holder had not flown on the particular type within the past 90 days, he was only permitted to carry passengers after having flown a training flight, including at least five takeoffs, or an instruction flight with a licensed ultralight flight instructor. (7, 10)

When the licence holder was under 40 years of age, the UPL was valid for 24 months. And, when the licence holder was under 40 years of age and the licence was regularly revalidated every 24 months, licence renewal required that the pilot had flown at least three hours as an ultralight pilot on no less than 10 flights during the past 12 months, or that the pilot had successfully completed a skill test. In addition, successfully completed aviation regulation and flight rules tests as well as a valid medical certificate were required. For persons older than 40 years of age the licence was valid for 12 months. If the licence was regularly revalidated every 12 months, every other revalidation would be done on the basis of a valid medical certificate. (6, 7, 10)

Ultralight training in the early days

At first, aeroplane and glider instructors who held valid UPL licences as well as persons specifically authorised by the FAA could operate as ultralight instructors. The first exploratory ultralight course was started in February 1983 at Räyskälä, by CAA Finland's special permission. The course was flown on a single-seater Eagle 430B which, at the time, was categorised as a powered hang glider. There were six students on the course. The course was conducted by fairly closely following the manufacturer's training syllabus with which the instructors had familiarised themselves on a weeklong course in the USA. Flight training was done by towing the aircraft into the air by car. The student pilot sat in the aircraft and the flight instructor sat in the back seat of the car, monitoring the student's performance and giving instructions to the student and the driver of the tow vehicle. In an emergency the flight instructor could immediately release the towrope from the car. Since flight instruction was only given during weekends, the course progressed rather slowly. The student pilots flew their first solo flights as late as April. During the summer of 1983 three corresponding courses were organised. (7, 8, 11)

In July 1983 the FAA set up an ultralight working group whose most important task was to prepare an ultralight training curriculum. The FAA had, in fact, already drafted the so-called basic training instructions, approved by CAA Finland, upon which two ultralight training courses were started in the summer of 1983. The working group comprised experienced glider instructors who later intended to lead ultralight training courses at their respective domiciles. The working group prepared three training curricula which were completed at the end of 1983. The first curriculum was intended for persons who held no licence at all, the second was for those who held a Glider Pilot Licence, and the third was for those who held a Motor Glider Pilot or a Private Pilot Licence. The purpose of these curricula was to lighten the load of flight instructors and to standardise the level of instruction. (8, 12)

In 1983 ultralight aviation did not grow as fast as expected because of the lack of two-seater ultralight aircraft suited for flight training. At the end of 1983 there were 41 valid UPL licences in Finland. Moreover, there were not that many imported ultralight aircraft to begin with and they exhibited wear and tear from training activities. It was difficult to repair them because spare parts were not easily accessible. A shortage of enthusiastic ultralight flight instructors constituted another hindrance. The first ultralight flight instructor course was organised in the spring of 1984 at Räyskälä. The course was conducted under the auspices of the FAA, organised by the Finnish Sport Aviation Institute Ltd. (4, 12, 13)

Segregation of ultralight aircraft into class A and class B aircraft

In 1984, in accordance with JAA models, a plan was started to categorise all weight-shift controlled powered gliders as ultralight aircraft. Another underlying motive for this was that by doing so the number of ultralight aircraft and enthusiasts would almost triple, which would significantly improve the conditions for expanding this type of flying. This change was put into action in 1986. At the same time the aircraft were segregated into class A and class B ultralight aircraft, on the basis of their control mechanism. Class A comprised ultralight aircraft that were completely or partially weight-shift controlled. Class B comprised ultralight aircraft controlled via control surfaces. The previously mentioned aviation regulation AIR M5-2 definition was still in force with the exception that it now also included weight-shift controlled ultralight aircraft. (4)

Simultaneously, along with the new class structure, the oversight agreement between CAA Finland and the FAA was expanded. The FAA began to catalogue ultralight aircraft in use as well as issue and revalidate permits to fly. In the early days of ultralight aviation class A ultralights outnumbered the class B aircraft. In the 1980s aeroplane-like ultralight aircraft became more popular. The first phase of the strongest growth in class B aircraft can be dated to the period between 1984 and 1987 and the second one, which was even stronger, to the post-1988 period. At the end of 1987 the catalogue comprised 91 class A and 30 class B ultralights. There were 88 valid class A and 13 class B permits to fly. At the end of 1991 the catalogue comprised 110 class A and 200 class B ultralights. At that time there were 118 valid class A and 250 class B permits to fly. (4, 14, 15)

Ultralight aircraft forced landings

As ultralight aviation grew in popularity its risks, too, were exposed. Particularly the year 1990 was a dark period for ultralight aviation. Many ultralight aircraft made forced landings then, at the rate of 100 or so per year. The forced landings were caused by the ultralights' 2-stroke engine failures or other engine malfunctions. At the time almost all ultralight engines were 2-stroke engines, Rotax being the dominant make. Since they were not type-certified for aviation, there were no requirements for reliability and the aircraft operator was fully responsible for any damage caused by potential engine malfunction. Serious design and construction flaws were discovered in the fuel systems of ultralight aircraft. This caused a number of the engine malfunctions experienced on the ultralights. As a result, in 1990 CAA Finland issued an airworthiness directive which ordered the inspection of ultralight aircraft fuel systems. (4, 16, 17)

In 1991 the aviation authority, having changed its name from CAA Finland to the CAA Flight Safety Authority, set up an investigation commission to study the causes of engine malfunctions on ultralight aircraft. The investigation commission had access to several years' worth of pilot reports concerning accidents, minor accidents, forced landings and engine malfunctions. The study was completed at the end of 1992. During the review period, from the beginning of 1990 to the end of October 1991, damage to 22 ultralight aircraft engines were reported to the CAA Flight Safety Authority. The investigation commission estimated that approximately 30 % of all occurrences were not reported during the review period. This being the case the real number of engine failures during the period would have amounted to approximately 30. (4, 17, 18)

According to the investigation the lion's share of engine failures happened to liquid-cooled 2-stroke Rotax engines. Most of the ultralight aircraft were imported to Finland as kits, assembled by the importer, i.e. a private person or a company operating in this field. In most cases the importer had no experience or training in aircraft construction. Neither were all aircraft mechanics or aircraft inspectors sufficiently knowledgeable about liquid-cooled 2-stroke engines serving as aircraft powerplants. The investigation revealed several causes for engine failure. It was the opinion of the investigation commission that the crux of the problem was the fact that this particular engine type was too highly tuned for use in aviation. This resulted in an engine load that pushed the engine to its limits even in optimum conditions. In addition, flawed practices in operation, such as inadequate warm-up prior to takeoff as well as faulty assembly of engine components, had caused engine failures. The investigation commission recommended, among other things, that new ultralight aircraft should be fitted with 4-stroke engines.

When the investigation was completed there were no 4-stroke aircraft engines in the market suitable for ultralight aircraft. Furthermore, ultralight structures that were designed to house the 2-stroke engines were too weak to support the heavier 4-stroke versions. Later in the 1990s 4-stroke engines came onto the market, along with newer aircraft types, designed for 4-stroke engines, leading to 2-stroke engines gradually giving way to 4-stroke engines. Already at the turn of the millennium most ultralight aircraft engines were 4-stroke engines. While a 4-stroke engine was more expensive to purchase than a 2-stroke engine, in the long run this was compensated by the 4-stroke engine's superior reliability, lower operating costs and longer time between overhaul. After 1990 and 1991 there was a steep drop in the number of ultralight forced landings. From 1993 to 1999, according to official statistics, ultralight aircraft made 1–8 forced landings per year. (16, 19)

In addition to the forced landings, this chapter has dealt with some of the most important milestones in the history of Finnish ultralight aviation. Its first stages were primarily the focus, such as the first imported ultralight aircraft, the initial aviation regulations and the first ultralight flight training courses. Since the early days both ultralight aircraft and the operating environment of ultralight aviation have continually evolved. Among other things, aviation regulations concerning ultralight aviation and training instructions have been amended several times since ultralight aviation grew from its infancy to the 2000s.

3 ACTORS IN ULTRALIGHT AVIATION

3.1 International bodies

Aviation, in essence, is very international and, therefore, universal rules adopted by states are needed to promote the safety and efficiency of aviation. Several aviation organisations operate in the international arena, practicing worldwide cooperation and issuing common aviation standards. Internationally binding conventions and standards that have been issued pursuant to them are not usually directly binding on Finland. Rather, separate national statutes are required in order to enter them into force. However, certain regulations issued by the EU and the European Aviation Safety Agency are directly binding on Finland. The Finnish civil aviation authority participates in international cooperation in order to improve flight safety. As regards Finland the most important civil aviation cooperation partners are the International Civil Aviation Organization, the European Civil Aviation Conference, the Joint Aviation Authorities, the European Aviation Safety Agency and Eurocontrol. Nordic cooperation, too, is close. (20)

International Civil Aviation Organization

The International Civil Aviation Organization (ICAO), a specialised agency of the UN, influences Finnish aviation legislation and aviation regulations. It was founded in 1944 with the adoption of the Convention on International Civil Aviation, the Chicago Convention. Finland complies with the articles and annexes to the Convention as well as related international agreements. ICAO sets minimum standards and recommended practices for international aviation, which are specified by national and regional requirements. When applicable, certain national exceptions to the ICAO's standards and recommended practices are permitted. Finland also participates in the Nordic Delegation to ICAO. (20, 21)

European Civil Aviation Conference

The European Civil Aviation Conference (ECAC) is an international organisation, founded in 1955, with the object of promoting the co-ordination, the better utilisation, and the orderly development of such air transport. At present, the ECAC has 44 member states, covering almost all European countries. Finland is one of the ECAC's founding member states. In addition to working with European civil aviation organisations, the ECAC closely cooperates with organisations outside Europe. (22)

Joint Aviation Authorities

The Joint Aviation Authorities (JAA) was an associated body of 38 member states' aviation authorities. It was disbanded in September 2009. The Finnish civil aviation authority, having participated in the activities of the JAA since the 1970s, was one of the founding members. Cooperation under the auspices of the JAA produced several JAR regulations on continued airworthiness, maintenance, flight standards and licensing. The JAA's standards were not directly binding. Rather, the member states enacted them through their national standards regime. Some standards also entered into force through EU directives, applicable to all EU Member States. In addition to harmonisation of standards the JAA performed type certification of new aircraft on behalf of its member states. Little by little the JAA's activities migrated to the European Aviation Safety Agency. (20)

European Aviation Safety Agency

The European Aviation Safety Agency is the EU's common civil aviation authority. Its core mission is to promote the highest common standards of safety in civil aviation. Other goals include, inter alia, ensuring a high level of environmental protection, promoting free movement, promoting the cost-effectiveness of approvals and standards as well as cooperation with third-country operators and international organisations. The EASA became operational in 2003 on the basis of a European Parliament and Council Regulation of 2002. (20)

Through the EASA the competence of national authorities, as bodies that implement standards, has been transferred to the European Community which, in the future, will publish all rules related to airworthiness, maintenance, flight standards and licences. Pursuant to the EASA's Basic Regulation Member States shall recognise certificates issued in accordance with this Regulation. The Finnish civil aviation authority, together with the Ministry of Transport and Communications, has actively participated in EU cooperation with regard to setting up the EASA. For example, the Finnish civil aviation authority has drafted written opinions and participated in the work of the High Level Group on aviation regulation, advising the European Commission. (20)

A certain degree of national competence will transfer to the EASA which, in the initial stage, will be responsible for type certification of aircraft and other aeronautical products as well as technical standards. Gradually the competence of the EASA will also include rulemaking for flight standards, maintenance operations, pilot training and licensing as well as the harmonisation of national authorities. Apart from type certification and standards the Finnish civil aviation authority will continue to carry out its national duties. Furthermore, the ambition of the Finnish civil aviation authority is to actively participate in EASA's rulemaking. (20)

European Parliament and Council Regulation 1592/2002 was the first one that applied to civil aircraft. It included ultralight aircraft in its Annex II, which defined the aircraft that the EU Regulation and its implementing rules as well as EASA's proposed rules excluded. Annex II included aeroplanes having no more than two seats and a maximum takeoff mass (MTOM) of no more than 300 kg for a land plane, single-seater; or 450 kg for a land plane, two-seater. Also the following Regulation, 216/2008, included ultralight aircraft in the aforementioned manner in its Annex II. However, the MTOM was increased by 15 kg for a single-seater and 22.5 kg for a two-seater land plane equipped with an airframe mounted total recovery parachute system, respectively. (23)

Hawk Information Services Ltd is presently conducting a study for the EASA. The purpose of the study is to establish the current national regulations applying to ultralight aircraft within different Member States of the EU. The goals of the study include, at least, airworthiness, pilot training and licensing, medical requirements and rules related to operations and airspace access. Then the consequences of said regulations will be compared, in particular, to the desired safety level. The results will then be used as a basis for recommendations regarding the possible modification of the regulations for the proposed European Light Aircraft (ELA1) category. The ELA1 is intended to be an aeroplane with a MTOM less than 1200 kg that is not classified as a complex motor-powered aircraft. It is not the objective of the study to amend the present Annex II with regard to the ultralight class. The following EU Member States are to be included in the study: the Netherlands, Italy, France, Sweden (or Norway), Germany, the Czech Republic and the United Kingdom. The goal is to implement the final phase of the study in the autumn of 2010. (23)

Eurocontrol

The Organisation for the Safety of Air Navigation, Eurocontrol, operates alongside the EASA. Eurocontrol's mission is to harmonise and integrate air navigation services in Europe in order to achieve the safe, secure, orderly, expeditious and economic flow of traffic. Eurocontrol was originally established in 1960 and presently it has 38 member states. (20)

3.2 Finland's civil aviation authority

Throughout the history of Finnish ultralight aviation the activities of Finland's civil aviation authority have been reorganised in many ways, including a couple of name changes. Civil Aviation Administration Finland was established in 1972. As the volume of aviation continued to grow the administrative branch identified the need for rapid and independent financial decision-making. The new Finavia Corporation was established in 1991. Finavia was allowed to independently determine its investments and financing. At that time the official functions were segregated from business operations, thus creating the CAA Flight Safety Authority. In 2006 the functions of Finnish Civil Aviation Authority were transferred to Civil Aviation Administration, totally independent of Finavia, which only increased the independence of the civil aviation authority.

As of 1 January 2010 civil aviation regulatory issues in Finland have been handled by the Aviation Sector of the Finnish Transport Safety Agency (Trafi Aviation). Trafi Aviation is a part of the Transport Safety Agency, which is also in charge of regulatory issues in the fields of road traffic, railways and maritime safety. Trafi Aviation handles the functions of the former Civil Aviation Authority. From the standpoint of ultralight aviation the key tasks include aviation regulations and airworthiness directives, licences and certificates, oversight of ultralight aircraft construction and maintenance as well as the oversight of ultralight training. In addition, Trafi Aviation oversees airspace use and aerodromes and participates in international cooperation. (20, 25)

In this study the term civil aviation authority refers specifically to Finland's civil aviation authority, the present Trafi Aviation.

3.3 Finnish Aeronautical Association

The Finnish Aeronautical Association (FAA), founded in 1919, is the central organisation of sport aviation in Finland. The goal of the FAA is to promote sport aviation and experimental aviation in Finland and to act as the central organisation of its members. For this purpose the FAA advances and develops the interests of sport and recreational aviation, participates in the work of international and national organisations as well as competitive activities and, together with the aviation authority, promotes the safety of aviation. In addition, it is active in communications and training in the field of aviation. The FAA also assists the civil aviation authority in sport aviation oversight. The spheres of activity of the FAA include the following air sport disciplines: powered flying, gliding, experimental flying, ultralight flying, hang gliding, paragliding, parachuting, ballooning, ascending parachutes and aeromodelling. The FAA has different air sport commissions for each discipline. The Experimental and Ultralight Commission represents ultralight aviation. (21, 25)

In April 2006 the civil aviation authority, the then Civil Aviation Administration, and the FAA signed an agreement for assistance in sport aviation oversight. According to this agreement the FAA provides expert assistance to the civil aviation authority in sport aviation activities and training as well as in supervising the equipment used in said activities. The agreement stipulates the duties in oversight assistance. In addition, the annex of the agreement specifies some of the oversight duties within the framework of the agreement. The agreement and its annex define ultralight oversight assistance duties as follows:

The FAA

- Prepares the training curricula and submits them to the civil aviation authority for adoption, handles the required communications regarding the curricula and disseminates them to its members or member clubs.
- Participates in training inspections and assists the civil aviation authority as required. When the aviation authority conducts training inspections a member of the FAA is always present when the FAA considers it to be appropriate. Inspections are scheduled well in advance.

When working in the field the FAA's officer in question monitors compliance with aviation regulations in training.

- Provides comments to the civil aviation authority regarding ultralight construction permit applications.
- Organises the ultralight aircraft annual inspections, keeps in touch with the aviation authority or the inspectors certified by the aviation authority and pays them the agreed fees and expenses. Annual inspections are requested from the FAA which, in turn, pays the inspectors. The FAA will not cover the costs of any inspections that are not ordered through it. The FAA prepares instructions for the remuneration of inspection fees and costs. The FAA insures the inspectors for accident and liability with regard to their duties.
- Participates in the preparation of ultralight aircraft regulations and standards, and
- Provides assistance in inspections related to importing and constructing ultralight aircraft, and organises the type certification events of ultralight aircraft. Experimental aircraft inspectors conduct the type certification of imported ultralight aircraft. (26)

3.4 Accident Investigation Board of Finland

Aviation accidents and incidents have been investigated in Finland throughout the history of Finnish aviation. During the existence of the civil aviation authority, prior to the founding of the Accident Investigation Board of Finland (AIB), the aviation authority investigated aviation accidents and incidents under the Convention on International Civil Aviation. From the beginnings of ultralight aviation until 1990 the Accident Investigation Section of the Civil Aviation Authority's Flight Safety Division investigated accidents and serious incidents in ultralight aviation. From 1991 to 1995 they were investigated by the Accident Investigation Section of CAA's Flight Safety Authority. (16)

Accident Investigation Board of Finland was founded in 1996 within the Ministry of Justice. The tasks of the Accident Investigation Board are detailed by the relevant Act and Decree which also provide overall directions on the characteristics of the accidents to be investigated, including the methods of investigation. In addition to national legislation accident investigation is governed by European Parliament and Council Regulations as well as international conventions and recommended practices. Aviation accidents are investigated in accordance with European Council Directive 94/56/EC and the Convention on International Civil Aviation. (26)

The relevant European Council Directive 94/56/EC contains the fundamental principles governing the investigation of civil aviation accidents and incidents which have occurred in the territory of the Member States. They are more or less analogous to the ones detailed in Annex 13 to the Convention on International Civil Aviation. The Decree on Accident Investigation (79/1996) lays down that aviation accidents and incidents be investigated pursuant to said directive. According to the directive every accident and serious incident has to be investigated. Hence, the AIB is obligated to investigate every accident and serious incident in ultralight aviation. As per the directive, the sole objective of investigation is the prevention of future accidents and incidents. The investigation shall not apportion blame or liability. Any investigation shall be the subject of a report in a form appropriate to the type and seriousness of the accident. The final accident report shall be made public in the shortest possible time, and if possible within 12 months of the date of the accident. (28)

Through its investigative activities the AIB aims to improve public safety and prevent accidents. An investigation report is generated as a result of an accident investigation. The report contains safety recommendations for the competent authorities and other parties concerned. The safety recommendations crystallise the investigators' views on how to prevent similar accidents in the future. The AIB follows up the implementation of the recommendations. The input mechanism of accident investigation is explained in more detail in chapter 8. Accident investigation exclusively focuses on the improvement of safety with no stances taken as for questions of blame, responsibility or liability for damages. (27)

According to the proposal for a Regulation of the European Parliament and of the Council on investigation and prevention of accidents and incidents in civil aviation, dated March 2010, every civil aviation accident involving aircraft other than specified in Annex II shall be the subject of a safety investigation in the Member State in the territory of which the accident occurred. Every serious incident involving aircraft with a Maximum Takeoff Mass exceeding 2250 kg shall be the subject of a safety investigation in the Member State in the territory of which the serious incident occurred. The proposed regulation intends to use the term Safety Investigation for accident investigation. When the proposed regulation enters into force, it directly binds Finland. Judging by the proposed regulation the investigation of accidents and serious incidents involving ultralight aircraft will no longer be obligatory. It is likely that ultralight aircraft will be included in Annex II in the future as well, in which case the regulation will not require ultralight accident investigation. Since the MTOM of ultralight aircraft is clearly below 2250 kg, the regulation will not require the investigation of their serious incidents either. Nevertheless, pursuant to the regulation, safety investigation authorities may decide to investigate ultralight accidents and serious incidents, in accordance with the national legislation of the Member States, when they expect to draw safety lessons from them. (29)

4 REQUIREMENTS FOR ULTRALIGHT AIRCRAFT

According to the present definition, effective as of 1 Sept 2004, an ultralight aircraft is one designed to carry not more than two persons, has a stall speed of not greater than 65 km/h CAS, a maximum takeoff mass (MTOM) not exceeding 300 kg for single seat aeroplanes or 450 kg for two-seater aeroplanes, 330 kg for a single seat amphibian or floatplane or 495 kg for a two-seater floatplane or amphibian. According to the previous definition, effective 1 Jan 1997, an ultralight aircraft was one designed to carry not more than two persons, with a stall speed of not greater than 65 km/h CAS, a MTOM not exceeding 450 kg for aeroplanes or 500 kg for floatplanes, and a stall speed of not greater than 65 km/h CAS. Stall speed refers to the stall speed in standard atmosphere at sea-level conditions in the landing configuration with the engine idling or engine off at the MTOM. (30, 31)

Ultralight aircraft can operate as landplanes or floatplanes, provided that its MTOM in both cases complies with the aforementioned mass limitations. Ultralight aircraft are vehicles in the experimental and sport aviation category. Based on their flight control system, ultralight aircraft are divided into two classes. Class A ultralights are either completely or partly controlled by weight-shift and class B ultralights are controlled by control surfaces. (30)

4.1 Airworthiness

Airworthiness requirements

Ultralight airworthiness requirements include requirements for structural integrity, stall speed, loading and other characteristics. Structural requirements stipulate that the structure must, at the very least, be able to support limit loads in normal operations. The maximum positive load is +3.8 g and the negative maximum load is -1.5 g. In addition, the structure must withstand the gust load factors as defined in JAR 22. Safety factors as per JAR 22 must be used in structural design. Structural integrity under required maximum limit loads must be demonstrated in a sufficient manner. The aforementioned structural requirements do not apply to single seat ultralight aircraft whose empty weight does not exceed 115 kg. Nevertheless, in flight they must withstand the expected manoeuvring and gust loads in the conditions and situations for which the ultralight aircraft in question has been designed. (30)

According to stall speed requirements the stall speed of ultralight aircraft in standard atmosphere at sea-level conditions in the landing configuration with the engine idling or engine off at the MTOM shall not be greater than 65 km/h CAS. If no clear stall speed for an ultralight aircraft is obtainable, stall speed means the speed at which the aircraft is still controllable with a rate of descent of 4 m/s (800 ft/min). According to loading requirements ultralight aircraft shall have a minimum useful load of 175 kg (two-seater) and 95 kg (single-seater). (30)

When it comes to airworthiness requirements regarding other characteristics, the operating directions of the primary flight controls in class B ultralight aircraft must comply with JAR 22 requirements. Ultralight aircraft must not exhibit any abnormal or dangerous characteristics or other such characteristics which the pilot cannot control without special skills. Such characteristics include, among other things, a sudden excessive bank or an uncontrollable departure into a tailspin during stalling. (30)

In addition to the aforementioned airworthiness requirements amateur-built ultralight aircraft assembled from kits must comply with the airworthiness requirements of aviation regulation AIR M5-1. Commercially built ultralight aircraft must also comply with the type certification criteria provided in the Finnish Aeronautical Association's Finnish ultralight aircraft inspection manual, approved by the civil aviation authority. (30)

According to the airworthiness requirements specified in aviation regulation AIR M5-1, issued in 1996 and still in force, it must be possible to safely control and manoeuvre an ultralight aircraft in all flight conditions for which it is designed. It must be possible to make a smooth transition from one flight condition to another with no more than average piloting skill, alertness or strength. Control forces must not reverse in normal flight conditions. When airspeed approaches the stall speed it must be possible to increase airspeed by pitching the nose downwards at any power setting or in any configuration. (32)

An ultralight aircraft must give clear and distinctive stall warning, both in straight and turning flight with the wing flaps and landing gear in any normal position. The stall warning may be furnished either through the inherent aerodynamic qualities of the aircraft or by a device that will give clearly distinguishable indications. (32)

If the aeroplane's pitch control is disturbed from the trimmed condition, airspeed must correspondingly increase or decrease. The airspeed of an ultralight aircraft must return near to the original trim speed when the flight control is slowly returned to its original trimmed condition. This must also apply at various power settings, wing flap settings and at the minimum steady flight speed. (32)

Ultralight aircraft must be designed to protect each occupant in small accidents in which the aircraft is damaged due to excessive loads. Equipment and gear attachments must be designed to withstand small accidents without coming loose and injuring the occupants. (32)

Windshields and windows if fitted must be constructed of a material that will not become opaque and will not result in serious injury due to splintering. The controls must be located and arranged so that the pilot, when strapped in, has full and unrestricted movement of each control without interference from either the seat harness or from the cockpit structure. In aeroplanes with dual controls it must be possible to operate the primary controls and the throttle lever from each of the two pilots' seats. (32)

The engine does not have to be type-certified, provided that the engine and its installation function in a satisfactory manner and that it can be safely operated. The same applies to the propeller. Fire protection must be taken into consideration in the design and construction of the engine compartment. This applies to the selection of materials and special shrouds such as the firewall between the engine compartment and the frame. The fuel system must be constructed and arranged to ensure a flow of fuel for proper engine functioning under any normal operating condition. Where the fuel system is prone to sedimentation or condensed water a sediment bowl or chamber that is accessible for drainage must be fitted. At a suitable location, before reaching the engine, fuel must pass through a filter. (32)

Each operating limitation for ultralight aircraft must be established and stated in the flight manual and made available to the pilot by means of coloured markings on flight instruments and powerplant instruments. All airspeed limitations must be given by keeping in mind the accuracy at which airspeed can be monitored. The airspeed indicator must indicate the never-exceed speed, the stall speed and the maximum speed for flaps extended. In addition, the flight manual must define the maximum manoeuvring speed and, when necessary, the maximum speed for the landing gear extended, neither of which need to be marked on the airspeed indicator. Powerplant limitations must be established in such manner that they do not exceed the engine and propeller limitations specified by the manufacturer. (32)

Requirements for equipment

Neither flight instruments nor powerplant instruments on ultralight aircraft have to be type-certified. Still, they have to be right and proper for their designed function. Seat harnesses and other attachments must be of similar construction and quality as the equipment certified for aviation or motor vehicles. All parts of the seat harness must release from the rotary buckle in a manner that does not prevent deplaning. Seat harnesses must be installed in the manner generally accepted for aviation. As of 2005 class B ultralights must have at least a four-point seat harness. (30)

Test flights

In certain cases a flight test programme, approved by the civil aviation authority, is required for ultralight aircraft. A flight test programme of no less than 45 hours is required for the purpose of obtaining type certification for ultralight aircraft types which do not carry foreign type certifications that would fulfil the requirements of the aviation authority, and all amateur-built ultralight aircraft. A 10 hour-long type-certification flight test programme must be flown on ultralight aircraft that already have a type certification from the aviation authority or an organisation certified by it. The airworthiness requirements that enabled the type certification must be comparable to Finnish requirements. In addition, a 10 hour-long flight test programme must be flown in order to obtain approval for a floatplane configuration or corresponding major modifications. Major modifications mean such conversions on the ultralight aircraft which can essentially affect its characteristics and, particularly, structural integrity, performance, mass, centre of gravity, flight characteristics or other airworthiness features. (30)

The test flights must demonstrate that the performance and other characteristics of ultralight aircraft comply with the requirements of aviation regulations. Flight test results must be recorded in such a way that they can be used to show compliance with the requirements and establish sufficient basic information and limitations for the flight manual. Should the test flights demonstrate that the designed limitations or basic design features need changed, the new limitations must be established on the basis of the results from flight testing. (30)

Flight Manual

Ultralight aircraft are not required to have an Aircraft Operations Manual (AOM) approved by the aviation authority. Rather, an ultralight aircraft must carry a flight manual written in the Finnish language and approved by the aircraft inspector, which indicates the information needed for the safe operation of the aircraft, loading instructions, operational limitations, possible special characteristics and pre-flight inspection instructions. The flight manual's type-specific information as well as the operational limitations must correspond to the ultralight aircraft's type-specific information as well as the flight test report. No flight manual is required on test flights flown for the purpose of preparing the manual itself. (30)

The following sections are recommended to be included in the flight manual: general, limitations, emergency procedures, normal procedures and engine, performance, weight and balance and appendices. When ultralight aircraft manuals are being prepared the recommendation is to use the FAA's template for an ultralight flight manual. (30)

4.2 Construction

In Finland it is only permissible to construct or commercially assemble ultralight aircraft, assembly kits or parts thereof under the aviation authority's approval. The rules regarding the construction of amateur-built ultralight aircraft are provided in aviation regulation AIR M5-1: "The fabrication of amateur-built aircraft", dated 25 Nov 1996 and still in force. By definition, an amateur-built aircraft is an aircraft which the permit holder has constructed alone, either as a hobby or for the purpose of accruing more skills. (30, 33)

One must obtain permission from the aviation authority to construct an amateur-built ultralight aircraft. It is recommended that the permit be applied for by using the FAA's application form. The application and its appendices must be submitted to the FAA for comments. The FAA, in turn, will forward the application, including comments, to the aviation authority. Should the FAA or the aviation authority require additional information, the applicant is obliged to provide it. Depending on the case, the permit can include various conditions. (33)

If a major modification is made during the construction of the ultralight aircraft, such as structural changes or one related to performance or flight characteristics, or pertains to a new powerplant type, and if it is essentially at variance from the information in the permit or the application, the modification must be approved by using the same method of obtaining the original construction permit. If the builder of the ultralight aircraft, still under construction, changes, the new builder must apply for an amendment to the permit. The application must include the supervisor's report regarding the phase of the build. (33)

The permit holder must do the greater part of the work himself. In this case, prefabricated equipment or components, such as the engine, propeller and landing gear are not regarded as part of the build. It is possible to issue a permit for an ultralight which is assembled from a kit as long as the permit holder does the main part of the assembly. Construction must meet the terms of generally accepted work practices used in aviation and the quality of the work must comply with the general conventions in aviation. (33)

A report must be submitted on work performed on the engine. An expert must inspect any engine modification or engine type, including its installation, which has not previously been used in Finnish aircraft. The expert's statement must be included in the construction report. Type-certified aviation engines that have been overhauled as per the manufacturer's recommendations can be used in amateur-built ultralight aircraft as long as their condition so permits. The condition of the engine must be inspected and monitored. The inspections can only be made by an aircraft maintenance technician or a person specifically certified by the aviation authority. (33)

The builder is responsible for the construction and airworthiness of his ultralight aircraft. The builder must also see to it that the supervisor of the build is able to sufficiently oversee the build. The supervisor's responsibility is to control that the construction complies with aviation regulations and the conditions of the permit. He must also take corrective action regarding any detected nonconformities. From the onset, he must supervise the build and flight testing until the aircraft receives a limited airworthiness certificate. (33)

A construction report is required. The report must include the most important events during the build, such as who performed what work, the supervisor's notes, tests results from material samples, mass and balance information, measurements, test loadings, test runs, any possible modifications to the original assembly instructions as well as any possible modifications to the engine. The report must be personally signed by the constructor and approved by the supervisor. The construction report must be submitted to the aircraft inspector at the time of the first aircraft inspection. A copy of the report must be forwarded to the civil aviation authority. (33)

An amateur-built ultralight aircraft must be inspected before it is taken into use. If the inspection finds that the aircraft meets the terms of aviation regulations and the construction permit, a certificate for flight testing is issued. If the flight testing certificate expires before the flight test programme has been completed, the aircraft must again be inspected in order to continue the programme. When the flight test programme has been flown the ultralight aircraft must be reinspected to obtain a limited duration airworthiness certificate. This certificate is valid for a limited time only and an aircraft inspection is required to revalidate it. (33)

4.3 Registration and markings

Ultralight aircraft must be registered and marked with nationality and registration markings. The marking comprises of the letters OH, signifying Finland, supplemented with the letter U and a three or four-digit number. Ultralight aircraft must carry the following placard, visible to the pilot and the passenger:

WARNING This aircraft is a non-type certified ultralight aircraft

The text *EXPERIMENTAL* must be marked outside an ultralight aircraft, close to the cockpit. The letters must be a minimum of 30 mm high. Ultralight aircraft must display a load limitation placard, visible to the pilot and passenger, which shall list at the least the following information: maximum takeoff mass, empty weight, maximum allowed baggage and a table of maximum allowed cockpit loads at 25 %, 50 %, 75 % and 100 % fuel volumes. If there is a baggage compartment, the weight of baggage must be taken into account with 0 %, 50 % and 100 % baggage loads. If the centre of gravity limits cockpit loads or requires balancing weights, this must be indicated on the load limitation placard. The load limitation placard must be installed during the next weighing. It is recommended that the FAA's guide on load limitation tables be used when load limitation tables are written. (30)

4.4 Permit to Fly and a Limited Airworthiness Certificate

Pursuant to AIR M1-3, a permit to fly and a limited airworthiness certificate can be issued to an ultralight aircraft. The limited airworthiness certificate can be issued after an aircraft inspection so long as the ultralight aircraft meets the requirements provided in aviation regulation AIR M5-10 and that the aircraft complies with the information included in the type certificate and flight manual. (30)

In order to obtain a permit to fly an amateur-built ultralight aircraft one must submit the following documents to the aviation authority: the construction report, weighing certificate, inspection report, a copy of liability insurance, flight test programme, journey logbook, component cards for time-limited components and the engine logbook. In order to obtain a limited airworthiness certificate one must submit the following documents to the aviation authority: the flight test report, flight manual including appendices, maintenance instructions and inspection report from the post-flight test aircraft inspection. Upon application, the aviation authority can waive some of the aforementioned requirements if it is deemed that the exceptions are warranted and that the corresponding safety level can be achieved in the manner presented by the applicant. (33)

4.5 Flight operations

Class B ultralight aircraft must be fitted with an altimeter, airspeed indicator, magnetic compass, slip indicator, tachometer, exhaust gas temperature or cylinder head temperature indicator on 2-stroke engines and seat harnesses for each person in the ultralight aircraft. The seat harness must have shoulder restraints. In addition, there must be a fuel gauge unless the fuel volume can otherwise be reliably monitored in flight. (34)

Each occupant must wear an appropriate crash helmet when flying in an open cockpit ultralight aircraft. If there is no windshield, each occupant must also wear safety goggles. When flying over water and no land or ice can be reached in a glide, each occupant must don a life jacket or some other flotation device. (34)

An ultralight aircraft used in flight operations must have a certificate of registration or a comparable temporary permit, limited airworthiness certificate or a corresponding limited duration permit, flight manual with a weighing certificate as its appendix, journey logbook, aircraft inspection report and a record of liability insurance. If the ultralight aircraft is fitted with a radio transceiver, it must also have an aircraft radio licence. Whereas it is not necessary to carry the documents on local flights, they must be kept at an airfield which is arranged for flight operations and presented to the authorities upon request. (34)

Ultralight aircraft must be operated in accordance with their flight manuals. Ultralight operations are only permitted in non-icing day VFR conditions. Commercial operations with ultralight aircraft are not permitted. (34)

Before the ultralight pilot can take off he must make sure that several things are in order. The ultralight aircraft must be airworthy and the required maintenance must have been performed. The pilot must check the aforementioned documents and confirm that the equipment is appropriate for the intended flight. The fuel load must be sufficient for the duration of the flight, including necessary reserves, taking into account winds enroute or other things that may cause delays. The pilot must be certain that the intended flight can be flown in accordance with the flight manual’s performance values, and that any cargo is within permitted limits and that it is placed and fastened as per the flight manual. The pilot must check that the necessary aviation charts for the intended route are onboard. Finally, he must ensure that the prevailing meteorological conditions facilitate the safe conduct of flight. (34)

5 ULTRALIGHT FLIGHT TRAINING

The present requirements for sport aviation are provided in aviation regulation TRG M1-7, dated 5 May 2009. In addition to ultralight training, the regulation applies to glider, powered glider, autogyro, hot air and gas balloon flight training. The aviation regulation does not apply to differences or familiarisation training. The previous version of the regulation for sport aviation flight training was published on 20 Dec 2007. Prior to this the regulations pertaining to different types of sport aviation were scattered among individual aviation regulations. The following paragraphs examine the present ultralight flight training requirements. (35)

Ultralight flight training can only be provided under the civil aviation authority's certificate. The aviation regulation determines the flight training certificate's requirements for personnel and, for example, the premises, internal auditing, airfields and aircraft. The head of training carries overall responsibility for training. He must see to it that the terms of the certificate, valid rules and regulations as well as the guidelines issued by the authorities and the flight training certificate holder are followed in training. He must also ensure that the training is arranged in accordance with the approved curriculum. The head of training must monitor the progress of training and instruction and immediately take corrective action regarding nonconformities to regulations, terms of the certificate and the flight training certificate holder's own guidelines and requirements. (35)

Ultralight flight training must be arranged in accordance with the curriculum approved by the aviation authority. A chief flying instructor must be designated for ultralight flight training. As the flight training is being provided, the chief flying instructor must have a valid ultralight instructor licence. The chief flying instructor is responsible for monitoring ultralight flight instructors and student pilots in flight training. (35)

A flight instructor or student flight instructor approved by the head of training may provide instruction detailed in the flight training certificate. The head of training may approve a flight instructor or student flight instructor to provide theoretical instruction for a specific subject even if their ratings are not valid, or some other expert in aviation if he is considered to be suitable to instruct on the basis of his experience, knowledge, skills or aptitude. The aviation regulation also provides for the duration and content of flight instructors' refresher training. (35)

5.1 Ultralight Pilot Licence requirements

The present requirements for an ultralight pilot licence (UPL), the rights and limitations of a UPL holder, the period of validity, renewal and revalidation, ultralight pilot differences and familiarisation training as well as the requirements for floatplane operations are defined in aviation regulation PEL M2-70, issued on 5 May 2009. This chapter only examines the case most pertinent as regards the research material for this study: the applicant for, or the holder of a UPL licence who has no balloon pilot licence, glider pilot licence, motor glider pilot licence or autogiro pilot licence, no class or type rating for aeroplanes, type rating for helicopters or any successfully completed theoretical instruction for any of the aforementioned licences. Unless otherwise stated the following paragraphs consider the present UPL licence requirements. (36)

The applicant for a UPL licence must meet the aviation authority's requirements for theoretical knowledge instruction, flight training and flying experience as well as flying skills. In addition, the applicant must be at least 17 years of age and meet the necessary medical requirements. (36)

The applicant for a UPL licence must have completed the theoretical knowledge instruction provided by a certified flight training organisation. The applicant must submit proof of having successfully passed the following associated theoretical knowledge examinations required of an ultralight pilot: aviation rules and regulations, ultralight aircraft structures and engine, instruments, aerodynamics, principles of flight, human factors as well as flight procedures. In addition to these subjects the applicant must have a Restricted Radio Operator's Permit or valid training for one. (36)

The applicant for a UPL licence must have completed the required ultralight flight syllabus provided by a certified flight training organisation. The applicant must submit proof of having completed the syllabus at the required level. His minimum flying experience must be at least 25 hours, at least 15 of which on instruction flights and no less than 5 of which solo. The required 25 hours must include at least 5 hours of cross-country flying, including at least one solo cross-country flight of no less than 150 km. During this solo flight the student pilot must land on at least one airfield other than the airfield of departure. In ultralight aviation flying times are normally calculated from takeoff to landing, without adding any time used for taxiing. (36)

Prior to taking a skill test for a UPL licence the applicant must successfully complete the entire ultralight curriculum and meet the flying experience requirements. The applicant must submit proof that during the skill test he passed the flight manoeuvres in normal and emergency procedures at the level required of an ultralight pilot, and proved his ability to comply with the instructions and procedures of air traffic services. (36)

A UPL licence holder is permitted to fly solo as an ultralight pilot-in-command without a fee. He is also permitted to carry passengers as an ultralight pilot-in-command. The requirement for carrying passengers is that he has the minimum flying experience of 35 hours, at least 15 of which solo. In addition, he must have passed a skill test for a passenger carrying rating. Furthermore, the flight examiner must confirm the passenger carrying rating in the licence holder’s flight time record logbook with his signature and submit a skill test report. (36)

A UPL licence holder may only act as pilot-in-command in an ultralight aircraft if he has flown at least two flights with an ultralight aircraft during the past 12 months, or flown a flight with an instructor. A UPL licence holder with a passenger carrying rating may only carry passengers if he has flown at least three takeoffs and landings as a Pilot Flying (PF) with an ultralight aircraft during the past 90 days, or flown a flight with an instructor. (36)

The period of validity of a UPL licence is five years maximum. The validity of the UPL depends on a valid medical certificate. In addition to general licence revalidation requirements, the requirement for UPL revalidation is that the licence holder has flown as an ultralight pilot on at least two separate flights during the 12 months prior to the expiration date of the licence. Alternatively, the applicant may submit proof of an instruction flight that has been flown during the 12 months prior to the expiration date of the licence, or submit a no less than three month old report of a successfully passed skill test or proficiency check on an ultralight aircraft. Separate provisions apply to the renewal of an expired UPL licence. (36)

An ultralight pilot must receive differences training for an ultralight aircraft which is fitted with retractable landing gear, tail skid, floats, skids or any other nonstandard equipment or characteristics. The differences training must include a sufficient number or practices which include all procedures with the equipment in normal and emergency situations. An ultralight instructor or a person sufficiently familiar with the type can provide the differences training. The person that provided the differences training must validate the training in the licence holder’s flight time record logbook with his signature. During familiarisation training one must acquaint oneself with the ultralight type’s flight manual. (36)

The aforementioned differences and familiarisation requirements were the same in the previous aviation regulation, dated 20 Dec 2007, that applied to ultralight flight crew licensing. In its predecessor, dated 12 Jan 2000, the requirements corresponding to the present differences and familiarisation requirements were given as type rating training requirements. As per the type training requirements the pilot had to receive training for each new ultralight aircraft type. Type training had to include familiarisation with the flight manual and a familiarisation flight that lasted no less than 30 minutes and which included at least five landings. A UPL licence holder who, as per aviation regulation, was permitted to act as pilot-in-command on an ultralight aircraft and who was well familiar with the type was allowed to provide this training. The person who provided the type training had to validate the training in the licence holder's flight time record logbook with his signature.

In order to obtain a floatplane rating the UPL licence holder had to receive training in accordance with the approved curriculum, possess enough theoretical knowledge on the topics determined by the aviation authority as well as have sufficient flying experience. The subjects in question were divided into three entities. The first entity comprised subjects related to legislation concerning waterborne traffic, seaplanes and their use as well as maritime distress signals, distress communications and search and rescue procedures. The second entity comprised subjects related to floatplane flight control techniques and handling in various meteorological conditions and when coming ashore as well as emergency procedures. Subjects in the third entity included the use, care and maintenance of a floatplane as well as its special characteristics such as aerodynamic features, pontoon drag and performance comparisons with corresponding landplanes as well as the special equipment and its use in floatplanes. (36)

Prior to commencing floatplane training the UPL licence holder has to have no less than 35 hours of flying experience, with a minimum of 15 solo hours on an ultralight aircraft. Floatplane training has to include no less than five flight hours with an instructor and at least 50 water landings on an ultralight aircraft. The UPL licence holder must successfully complete a proficiency check for a floatplane rating. Independent floatplane operations require that the flight training certificate holder's head of training or the chief flying instructor has validated the successfully completed training in the UPL licence holder's flight time record logbook with his signature, and that the flight examiner submitted his report. (36)

5.2 Ultralight Flight Instructor Rating requirements

The present prerequisites for issuing an ultralight flight instructor rating, the rights and limitations of an ultralight flight instructor rating, its period of validity as well as revalidation and renewal are defined in aviation regulation PEL M2-71, issued on 5 May 2009. This chapter only examines the case most important for the research material in this study: the applicant for, or the holder of, an ultralight flight instructor rating has a valid UPL licence but no balloon, glider, motor glider, autogiro or helicopter flight instructor rating. The following paragraphs examine the present ultralight flight instructor rating requirements. (37)

The applicant for an ultralight flight instructor rating must meet the aviation authority's requirements for theoretical knowledge instruction, flight training and flying experience as well as flying skills. In addition, the applicant must be at least 18 years of age. (37)

The applicant for an ultralight flight instructor rating must submit proof of having had completed the theoretical knowledge instruction provided by a certified flight training organisation on an ultralight flight instructor course. The applicant must show that he has successfully passed the theoretical knowledge examinations required of an ultralight flight instructor rating that are required for an UPL licence, i.e. didactics, theory of flight instruction as well as flight training and its arrangements. (37)

The applicant for an ultralight flight instructor rating must have completed the flight instructor training provided by a certified flight training organisation. The applicant must submit proof of having successfully reached the level required of an ultralight flight instructor. Prior to the commencement of the ultralight flight instructor course he must have had a valid UPL licence for no less than two years, the total flying experience of no less than 100 flight hours and a passenger carrying rating. He must have flown no less than 70 hours as pilot-in-command, at least 10 of which during the 12 months prior to submitting the application for the rating. As a student ultralight flight instructor he must have trained at least two student pilots up to the UPL licence; the student pilots were not allowed to be credited for any other type of licence. The instruction must have occurred under the control of an ultralight flight instructor who was assigned as his supervisor. Moreover, the supervising ultralight flight instructor must have submitted a written endorsement. (37)

The applicant for an ultralight flight instructor rating must submit proof of having passed a skill test and the associated theoretical knowledge examinations required of an ultralight flight instructor, including pre and post-flight instruction. (37)

The applicant for an ultralight flight instructor rating, if he does not have a valid unlimited ultralight flight instructor rating, will first be issued an ultralight student flight instructor rating until the time when he has trained the aforementioned two student pilots up to the UPL licence level. Under the supervision of a flight instructor approved by the head of training an ultralight student flight instructor rating holder is also permitted to provide theoretical knowledge instruction and flight instruction for an UPL licence for a fee, apart from the student pilot's skill test for the first solo flight.

The holder of an ultralight flight instructor rating is permitted to collect a fee for the provision of theoretical knowledge instruction and flight training for a UPL licence. He is allowed to provide theoretical instruction and flight training for a floatplane rating, provided that he is floatplane rated for ultralight aircraft and has no less than 15 hours of floatplane flying experience. He is also permitted to provide theoretical instruction and flight training for ultralight air towing, provided he has the corresponding rating and no less than 15 hours of air towing experience. (37)

The holder of an ultralight flight instruction rating or a student ultralight flight instructor rating may only act as an instructor on ultralight aircraft if he has acted as an ultralight instructor for two hours on five separate flights during the past 24 months, or if he has passed an instructor proficiency test on an ultralight aircraft. The flight examiner must have validated this in the ultralight flight instructor rating holder's flight time record logbook with his signature, and submitted a report on the successful completion of the proficiency test. (37)

The period of validity of the ultralight flight instructor rating is dependent on the period of validity of his UPL licence. In order to revalidate his ultralight flight instructor rating he has to fulfil two of the following three requirements: participate in ultralight flight instructor refresher training within 60 months prior to the expiration date; provide no less than two hours of flight instruction on five separate flights on an ultralight aircraft within 24 months prior to the time of expiration or; successfully complete a proficiency check or skill test on an ultralight aircraft within 12 months prior to the expiration of the rating. Separate provisions apply to the renewal of an expired ultralight flight instructor rating. (37)

5.3 Ultralight flight training organisations

In the autumn of 2009 there were 31 associations and one sole proprietorship that were certified by the aviation authority to provide flight training for a class B UPL licence. Appendix 1 lists all certified flight training organisations. Associated with the AIB's investigation B6/2009L, in the autumn of 2009 the AIB received a survey asking whether the aviation authority or its representative had conducted training inspections at their facility and if so, when. Altogether 20 (63 %) of the organisations responded to the survey. According to the answers a little over half of the respondents had been inspected by the aviation authority or its accredited representative. One association answered that it had not provided any training for a UPL licence. (38)

5.4 Ultralight Pilot Licence curriculum

The Finnish Aeronautical Association (FAA) has drawn up a curriculum for a Motor Glider Pilot Licence and a UPL licence. The aviation authority has approved the curriculum. The following examines the current version, which was published by the FAA on 1 Sept 2008 and approved by the aviation authority on 11 Nov 2008 for a powered glider licence as per aviation regulation PEL M2-46 and a UPL licence as per aviation regulation PEL M2-70. The study showed that virtually all organisations that provide training for a UPL licence use this curriculum. Still, the associations and the sole proprietorship are not required to use the curriculum when they provide said training. Alternatively, they could come up with their own curriculum that meets the requirements of aviation regulation PEL M2-70 as regards the UPL licence and then seek approval from the aviation authority. The FAA's curriculum includes both theoretical instruction and a flight training syllabus. The curricula have defined the minimum requirements for a UPL licence. (39)

5.4.1 Theoretical knowledge instruction

As per the curriculum, theoretical knowledge instruction includes at least 48 lessons on the subjects presented in table 1. The number of lessons presented in the table is only a suggestion, indicative of the significance of the subject. One lesson lasts 45 minutes. Whereas the grouping of subjects is carefully considered, the order in which they are taught is not binding. If the civil aviation authority has not approved another curriculum for the organisation or the sole proprietorship, the subjects and their content and the number of lessons have to be taught as given in the curriculum. Theoretical instruction must be taught as a single, continuous course. The instruction can be provided in the form of classroom education, practices or supervised distance learning. Powered glider and ultralight training are considered analogous and no further theoretical instruction is required when migrating from one class of licence to the other. Nevertheless, theoretical instruction must sufficiently point out the differences in the use of ultralight aircraft and powered gliders as well as in using the engine. (39)

Table 1. The subjects of theoretical knowledge instruction and the number of lessons required for a UPL licence (39)

Subject	Number of lessons
Aviation rules and regulations	6
Airframe structures and powerplant	3
Cockpit instruments	2
Aerodynamics	4
Principles of flight	4
Meteorology	6
Navigation	5
Flight operations, flight manual	5
Human factors	3
Flight procedures	4
Radio and electric equipment	2
Radiocommunications regulations	1
Aviation communications	3
Total	48

Table 1 shows that the focus of theoretical instruction is on aviation rules and regulations, meteorology, navigation and flight operations. The topics included in each subject are detailed in the curriculum and the required minimum levels of knowledge are determined. There are three competence levels: A, B and C – A being the highest and C the lowest. The requirement for level A is the ability to reliably and correctly apply essential information to practice. The competence for level A is verified by testing. As regards level B, the student must be able to explain the definitions of concepts and key terms. When it comes to level C, only general appreciation of the subject is required. The following explains the content of theoretical instruction in more detail with regard to airframe structures and powerplant, cockpit instruments, aerodynamics, principles of flight, meteorology, flight operations, human factors and flight procedures. The letter in the brackets after the subject indicates the required competence level when the student has no prior aviation licence. (39)

Topics that are taught in lessons concentrating on airframe structures and the powerplant include the structure of the aircraft, structural loads, the powerplant in general, engine cooling, engine lubrication, the ignition system, the carburettor, aviation fuels, the fuel system, propellers, engine use and the electric system. Airframe structure (B) classes include, among other things, the main part of the airframe and equipment, the fuselage, the wings, the horizontal stabiliser, the vertical stabiliser, the primary flight controls and main equipment, the trim system and wing flaps. The airframe's structural loads (B) includes instruction on structural classification, materials, fabrication methods and tensile strength. Powerplants instruction (B) includes, among other things, the principles of 4-stroke and 2-stroke engines as well as engine structures in general. Fuel systems (B) includes fuel tanks and fuel lines, breathers, mechanical and electric fuel pumps, gravity feed system, the selection of the fuel tank and the use of the fuel system. Engine use (B) includes, among other things, starting methods and precautions, fault identification, runup and system checks as well as the necessary measures to be taken as a result of propeller nick. (39)

Cockpit instruments include the pitot-static system, airspeed indicator, altimeter, vertical speed indicator, slip indicator (ball), magnetic compass, engine instruments and other instruments. The pitot-static system (B) includes the purpose of the system, its operating principle and structure, static pressure system and backup systems, position error, drainage, pitot heating, errors caused by blocks and leaks as well as protecting the pressure sources. As regards the airspeed indicator, instruction includes the principle and structure of a pitot tube airspeed indicator, a Venturi type airspeed indicator, pressure differences between dynamic and static pressure, the definitions of indicated airspeed, calibrated airspeed and true airspeed, errors, instrument readings and colour markings (A) as well as establishing the correct functioning of the airspeed indicator. The altimeter topic includes, among other things, instruction on the principles and structure of the altimeter, the purpose of the sub-scale setting (A), pressure altitude and true altitude. Engine instruments (B) include instruction on the principles, indications and use of the following instruments: oil temperature, cylinder head temperature, coolant temperature, exhaust gas temperature, manifold pressure, fuel volume and engine RPM. (39)

Topics taught in aerodynamics classes include the motion of air around a fixed object of varying shape, 3D-flow around an aerofoil, aerodynamic forces in flight, flight controls, trimming, wing flaps, airbrakes and slots, stalling, tailspin avoidance, aircraft stability as well as load factors and flight manoeuvres. Stalling includes instruction on the critical angle of attack (A), flow separation (A), reducing lift and increasing drag (A), centre-of-pressure travel (B), stalling characteristics (B), factors affecting the stall speed and stalling characteristics (A), stalling in different flight conditions (level flight, climb, glide and turn) (B), symptoms of an approaching stall and stall warning devices (B) as well as recovering from a stall (B). Tailspin avoidance (B) includes instruction on (wing) tip stall (B), increasing roll (B), identifying an approaching tailspin (A) as well as the immediate and appropriate recovery from a tailspin (A). Aircraft stability includes instruction, among other things, on the basic concepts of static and dynamic stability (B), longitudinal stability (B) as well as the effect of the centre of gravity on longitudinal stability and controllability (A). (39)

Principles of flight includes instruction on preparing (briefing) for the flight, loads on the ground, controlling the aircraft on the ground, controlling the aircraft in the air and the effect of flight controls, straight flight, straight and level flight, climbs and descents, flying at a low airspeed and stalling, turns and the smooth simultaneous use of flight controls, takeoffs and climbs, the traffic pattern and landing, sideslip and a slipping turn, forced landings, nonstandard flight conditions and upset recovery as well as controlling the aircraft in special conditions. Preparing for the flight includes instruction on, among other things, pre-flight inspections, the daily inspection and the takeoff checklist (B). Flying at a low airspeed and stalling (A) includes instruction on a gradually and rapidly developing stall, accelerated stall, load factors and stall speed in a turn as well as load factors and the stall speed in a wings-level recovery. Takeoffs and climbs include instruction on, among other things, a normal takeoff (A) as well as emergencies during takeoff and initial climb (A). (39)

The principles of flight-subject includes the topics of the landing pattern and landing, which includes instruction on, among other things, the use of wing flaps during the approach and landing (A), proper trimming during the approach (A), maintaining airspeed and power control during the final leg (A), an aborted approach and a go-around (B) as well as a nonstandard low-altitude approach due to a low ceiling (B). Sideslip and slipping turn (B) includes instruction on the principles and the purpose of a sideslip, the initiation of a sideslip, recovery and directional control as well as how to initiate and recover from a slipping turn. Forced landings includes instruction on a prepared emergency landing (A), a forced landing with no engine power (B) and a forced landing during takeoff (A). Nonstandard flight conditions and upset recovery (A) includes instruction on, among other things, recovery from a 90 degree bank angle and from an inverted position, normal tailspin and recovery as well as the most common mistakes in tailspin recovery. Controlling the aircraft in special conditions (B) includes instruction on, among other things, takeoff and landing on a short airfield, takeoff and landing over a high obstacle, operations from soft and uneven airfields as well as optical illusions caused by slanting terrain and inclines. (39)

Meteorology includes instruction on the atmosphere, pressure, density and temperature, humidity and rain, air pressure and wind, cloud formation, fog, mist, haze, air masses, weather fronts, icing, thunder, the Finnish climate, altitude measuring, aviation weather service, interpreting and forecasting weather data, weather information available at flight planning and aviation weather broadcasts. Air pressure and wind includes instruction on, among other things, high and low fronts (C) vertical and horizontal convection (C), surface wind and geostrophic wind (C), the effect of the wind gradient and strong winds at takeoffs and landings (B), the interrelationship of isobars and wind (B) as well as turbulence and gusting (B). Icing includes instruction on the conditions in which icing can occur (A) as well as avoiding icing conditions and precautionary measures (B). In addition, instruction includes the effects of hoar and hoarfrost as well as clear ice and the effect of icing on aircraft performance (B). Altitude measuring includes instruction on, among other things, the significance of altimeter pressure settings in flight operations (B), pressure altitude and density altitude (B), height from a reference plane, altitude above sea level and flight levels (QNH, QFE and QNE) (A) as well as the ICAO Standard Atmosphere (B). (39)

Flight operations include instruction on, among other things, mass and centre of gravity (CG), performance values at takeoff, landing and enroute, permitted manoeuvres and airspeeds, winter operations and airworthiness. Mass and centre of gravity (A) includes instruction on maximum mass limitations, the forward and aft limits of the CG as well as CG calculations using the aircraft’s flight manual and the weighing certificate. Performance at takeoff includes instruction on takeoff run and available distance (B), ground effect at takeoff and initial climb (B) as well as the use of wing flaps and airbrakes (A). In addition, instruction includes the effect of mass, wind and density altitude to takeoff performance (A) as well as the effect of the quality and slant of the runway surface to takeoff performance (B). Cross-country performance includes instruction on, among other things, range and endurance (A), glide ratio (A), how icing affects performance (A) as well as how the condition of the aircraft’s surface and wing flaps affect performance (B). Airworthiness includes instruction on, among other things, the maintenance and repair that the pilot is permitted to perform (A). (39)

Human factors include instruction on the basics of human physiology and psychology. Basics of psychology includes instruction on the causes and effects of stress (C), how alertness affects stress (B), how stress affects performance (B) as well as identifying and mitigating stress (B). In addition, instruction includes the basics of the pilot's decision-making (B), the effect of attitudes to situation assessment and decision-making (B) as well as risk assessment and situational awareness (B). (39)

Flight procedures include instruction on noise abatement, general flight safety as well as the aircraft and flight operations. The aircraft-topic includes instruction on, among other things, seat harnesses. Flight operations includes instruction on, among other things, rapid wind changes at takeoff, approach and landing (B). (39)

The FAA's previous curriculum for a Motor Glider Pilot Licence and a UPL licence was published on 12 Dec 2004 and approved on 4 Jan 2005. It was used from 2005–2008. The theoretical knowledge instruction curriculum was the same as presented in table 1 and the required competence levels were the same as in the current curriculum. The title of its predecessor was *The Training Manual for an Ultralight Pilot Licence*. It did not include the curriculum for a Motor Powered Glider Licence. The manual was published and approved in 1993 and used from 1993–2005. The contents, structure and appearance differed from its later versions. (39, 30, 41)

The subjects in the manual were principles of flight, aerodynamics, airframe structures and systems, ultralight aircraft engines, ultralight instruments, navigation, flying weather, aviation regulations, ultralight flight operations as well as human physiology. The subjects had four competence requirement levels: A, B, C and D. In contrast to the newer curricula, level A was the lowest and level D the highest. Level A topics included general and background information for the purpose of understanding concepts and terms. Level B topics included the basics. It was enough to be able to generally describe or grasp the topic. Level C topics had to be taught in such a manner that the student could grasp and apply the information to practice, as required. The goal of teaching level D topics was to get the student to understand the topic so well that he could later use the information in a safe manner as required in practical operations. The student's competence for level C and D was verified by tests. For example, the subject ultralight flight operations included the topic *Loading: takeoff mass, centre of gravity*, which was required at level D competence. (41)

5.4.2 Flight training

The ultralight flight training syllabus consists of practices as per table 2. The table lists the practices and their topics as per the flight syllabus. The syllabus itself explains the practices in more detail in the form of a list. In the chapter titled *General* in the syllabus it is said that the practices comprise of, for the most part, entities that need to be trained. The contents of said practices can be flown on separate flights and different contents of several practices can be amalgamated into a single flight. Practice number 15 is the first solo flight. Before this, the student must complete practices 1–14 and successfully pass a skill test flown with an instructor other than his own. The goal of the skill test is to ensure that the student is capable of safe flight operations and able to control the aircraft in basic manoeuvring and emergency situations. Moreover, prior to the first solo flight, the student must successfully pass written tests on aerodynamics, principles of flight, aviation regulations and flight operations as well as on the flight manual of the aircraft used in training. (39)

Table 2. Topics of the practices in the ultralight flight training syllabus.

Practice	Topic of the practice
1	Familiarisation with the a/c
1E	Emergency procedures
2	Pre-flight preparation and post-flight procedures
3	Familiarisation flight
4	The effect of flight controls
5	Taxiing
5E	Abnormal situations
6	Straight and level flight
7	Climb
8	Descent
9	Turn
10A	Flying at a low airspeed
10B	Stalling
11	Tailspin avoidance
12	Takeoff and climb to the downwind leg
13	Landing pattern, approach and landing
12/13E	Emergency situations
14	Steep turns and upset recovery
15	First solo flight
16	Forced landing practice with no engine power (idling)
17	Prepared emergency landing practice
18A	Instruction flights from an aerodrome when it is open
18B	Cross-country flight
18C	Navigation problems at low altitude and low visibility

The purpose of practice number 1 is to introduce the aircraft, cockpit layout, systems, checklists, procedures to be memorised and the flight controls to the student. The purpose of practice number 1E is to teach the proper procedures if there is a fire in the engine, cabin or electrical system on the ground or in flight, evacuation of the aircraft as well as the use and location of emergency equipment. The goal of practice number 2 is to teach the pre-flight inspection, both outside and inside, how to start the engine, runup, system checks and how to turn the engine off. The objective of practice number 5 is to teach, among other things, pre-taxi checks, brakes off, speed control on the ground and stopping. Practice number 5E focuses on abnormal situations that happen during taxiing, such as brake and flight control malfunctions. (39)

The objective of practice number 10A is to teach the student to identify a critically low airspeed, maintain control and recover to normal airspeed. The purpose of practice number 10B is to teach the student to identify a stall and the symptoms of an approaching stall. In addition, the practice comprises stalling and stall recoveries in different configurations, with or without engine power, as well as a recovery from a stall in which the aircraft is banking. The goal of practice number 11 is to teach the recovery from an incipient tailspin. The onset of an incipient tailspin is commenced by stalling the aircraft at a 45 degree bank angle. Practices 10B and 11 must absolutely comply with the recommendations and limitations in the aircraft's flight manual concerning manoeuvring, mass and centre of gravity. During the course the student must accrue at least one hour of instruction flights on which stall recovery and tailspin avoidance is practiced. (39)

The objective of practice number 12 is to teach, among other things, the takeoff checklist, procedures to be memorised during takeoff and after takeoff as well as the methods and techniques that are used in takeoffs from a short runway and a soft runway. The purpose of practice number 13 is to teach, among other things, the approach and landing with and without engine power (idling), the methods and techniques used in landing on a short runway and a soft runway as well as an aborted landing and a go-around. Emergency procedures are taught during practices 12/13E which include an aborted takeoff, engine failure following takeoff, missed landing and go-around as well as an aborted approach. The goal of practice number 14 is to teach steep turns (45 degree bank angle) in level flight and in a descent, aggravated stall and recovery as well as upset recovery. (39)

Before the first solo flight, i.e. practice number 15, the student must pass a skill test. The skill test comprises of the following topics: determining the aircraft's loading, checks before starting the engine, starting the engine, engine warmup and runup, taxiing, takeoff checklist, takeoff and climb, trimming in straight flight at different airspeeds, straight and level flight at a given airspeed and altitude, turning at a 30 degree bank angle, turning towards a given fixed point, stalling in level flight with the engine at idle, stalling in level flight in the landing configuration, stalling in a turn (bank angle 10–20 degrees), steep turns (bank angle 45 degrees) to the left and right, side-slipping to the left and right (if permitted on the aircraft type), homing in on given compass headings, landing pattern, touch-and-go, final approach and landing, monitoring the airspace and other traffic as well as radiocommunications. (39)

During the first solo flight the student shall practice all aforementioned manoeuvres except stalling, upset recovery, tailspins, emergency landings and aborted takeoffs. The instructor must draw up a detailed plan for each solo flight and require a post-flight debriefing as well as provide as much feedback to the student as possible from the observations the instructor can make from his position on the ground. (39)

Practice number 16 teaches an emergency landing without engine power (engine at idle). The practice must comprise no less than three landings with the engine at idle. Topics to be taught include, among other things, the emergency landing procedure, selection of the landing site, preparedness to change the site, glide distance, planning the emergency landing pattern, check points, checks at engine failure and post-landing action. The purpose of practice number 17 is to teach how to perform a prepared emergency landing.

5.5 Ultralight flight instructor training organisations

For a long time already Finnish Sport Aviation Institute Ltd (FSAI) has been the only ultralight flight instructor training organisation in Finland. In the spring of 2010 the aviation authority also issued an ultralight flight instructor training certificate to the Flying Club of Ii. Consequently, at present, there are two certified ultralight flight instructor training organisations in Finland. Nonetheless, the following only focuses on the FSAI because the Flying Club of Ii is so new as an ultralight flight instructor training organisation that it is less significant for the purposes of this study.

The FSAI is a training unit situated in Räyskälä, mostly owned by the Finnish Aeronautical Association. The purpose of the FSAI is to organise advanced training in sport aviation as well as instructor training for flying clubs. The FSAI closely cooperates with the FAA's air sport commissions and its head office. The FSAI organises annual ultralight flight instructor courses. In the spring of 2009 there were 13 students on the FSAI's ultralight flight instructor course. In association with investigation B6/2009L, in the autumn of 2009 the FSAI received the AIB's survey which asked whether the aviation authority or its representative had conducted any training inspections at the FSAI and if so, when. The FSAI replied that the most recent training inspection took place 3–4 years ago, counting back from the autumn of 2009. (20, 38)

5.6 Ultralight flight instructor rating curriculum

The FSAI has drawn up a curriculum for its ultralight flight instructor course and the civil aviation authority has approved the curriculum. The curriculum is based on aviation regulation PEL M2-71. The following examines the valid curriculum, published on 23 Sept 2008. The curriculum is listed in the aviation authority's training certificate. (42, 38)

The curriculum states that the minimum duration of the ultralight flight instructor course is 10 weeks. According to the course requirements a person who meets the requirements of aviation regulation PEL M2-71 at the time when the ultralight flight instructor rating is being applied for, at the latest, can be accepted to the course. The applicant must pass all theoretical knowledge subjects at the level required of a flight instructor, mentioned in the paragraph on aviation regulation PEL M2-71 regarding the entry exam for the ultralight flight instructor course. At least 80 % correct answers from the training material used for a UPL licence or at least 75 % correct answers from the material that is used as the ultralight flight instructor course's entry level exam are considered a passing level. The student must pass the test before commencing flight training. (42)

Training is divided into two phases. Phase one includes a written entry exam on theoretical subjects as well as theoretical instruction. This phase lasts 2 days. The second phase contains theoretical instruction, flight training, an evaluated lesson demonstration, written final tests and a flying proficiency test. The second phase lasts 8–10 days. Theoretical instruction is provided for 27–28 hours, which also include teamwork (1–2 hours in 2–4 member teams) as well as classroom instruction practice (1 h per student). Subjects included in the theoretical instruction are didactics (6 h), flight instruction techniques and principles of flight (6 h), how to organise flight training (1 h), how to arrange flight training (3 h), problems arising in flight training (2 h), flight safety (3 h), airspace classification (1 h), planning and flying a cross-country flight (2 h) as well as flight rules and pilot-specific weather minima (1 h). (42)

The purpose of flight training is to provide the student flight instructor with the practical competence for flight instruction and further hone his personal flying skills. For this purpose the syllabus includes instruction flights (IN), two kinds of instruction practice flights (IP) and (PA) as well as solo flights (S) to enable familiarisation with new equipment. In addition, a sufficient number of proficiency test flights are flown. Apart from solo flights and the flight that is flown to establish the student flight instructor's entry level flying skills, student flight instructors fly all flights from the instructor's seat. On instruction flights (IN) the flight instructor instructs the student flight instructor on the proper techniques and how topics are taught on instruction flights. On (IP) instruction practice flights the student flight instructor teaches the flight instructor. On (PA) instruction practice flights the student flight instructors are paired, flying the flights together. (42)

The flight syllabus includes 11 different flights. Table 3 lists the ultralight flight instructor course's flight syllabus. Table 3 shows that some flights are flown as single instruction flights but most are flown over three flights; first as instruction flights (IN), then as instruction practice flights with the flight instructor (IP) and, finally, as instruction practice flights paired with another student flight instructor (PA). The flights shown in brackets are not mandatory. The number of flights can be increased through refresher flights, which can complement certain flights whose didactic goals were possibly compromised by environmental factors. If appropriate, practices 7–10 can be flown at any time during the second phase of the syllabus. The syllabus consists of no less than 25 flights and 13 total flight hours. (42)

Table 3. The ultralight flight instructor course flight syllabus. The syllabus includes instruction flights (IN), two kinds of instruction practice flights (IP) and (PA) as well as solo flights (S). On instruction practice flight (IP) the student flight instructor teaches the flight instructor and on instruction practice flight (PA) the student flight instructor is paired with another student flight instructor.

	Topic and minimum flight time	IN	IP	PA	S
0	Familiarisation with the a/c. Moving on the ground. Establishing the entry level skills of the student flight instructor.	1	-	-	-
1	Positioning in the cockpit and equipment. Familiarisation flight. Start-up, taxi, runup. Effect of flight controls, aileron drag. 20 min	1	1	1	-
2	Level flight at different airspeeds. Trimming. Flight planning. Airspace monitoring. 20 min	1	1	1	-
3	Takeoff and climb. Turns (correct turns, mistakes, turns of different duration), touch-and-go, landing pattern (high, low, use of airbrakes/wing flaps) and landing. 2 touch-and-go landings. 35 min	1	1	1	-
4	Takeoff and climb to a predetermined altitude, engine and propeller control practices (if possible on the type), emergency procedures in flight. Landing pattern and the landing as a spot landing. 3 touch-and-go landings. 35 min	1	1	1	-
5	Steep turn, sideslip, low altitude landing pattern and landing. 3 touch-and-go landings. Takeoff and climb (repeat). 30 min	1	1	1	-
6	Flying at a low airspeed, partially developed stall, fully developed stall including one in the landing configuration, aggravated stall, tailspin if permitted. Landing pattern and landing (refresher). 30 min	1	1	1	-
7	Emergencies at takeoff and in flight. Landings with the engine at idle (simulated emergency landing), aborted approach and go-around. 30 min	1	1	-	-
8	Cross-country flight which includes landings at a controlled aerodrome and an uncontrolled airfield. Flight plan, trip and fuel calculations. 2 h	1	-	-	-
9	Familiarisation training 20 min	1	-	-	(1)
10	Manoeuvring: loop, hammerhead turn, lazy eight. When necessary, these can be done on a glider or powered glider. 15 min	1	-	-	(1)
11	Skill test. 30 min	1	-	-	-

6 ACCIDENT STATISTICS IN ULTRALIGHT AVIATION, GLIDING AND MOTOR POWERED GLIDING AS WELL AS GENERAL AVIATION

This chapter examines the development of safety in ultralight aviation using accident and damage statistics compiled from 1990–2009. Twenty years was selected for the period of review because it was considered to be statistically sufficiently representative so as to detect changes in safety. What's more, it was no longer possible to obtain reliable and comparable ultralight aviation data from the 1980s. The development of safety in ultralight aviation is compared to the safety of the two types of aviation closest to it: gliders and powered gliders as well as general aviation. To begin with, the development of safety in ultralight, glider and powered glider and general aviation is studied by means of the number of aircraft and flight hours. Thereafter, the development of accidents and minor accidents in ultralight, gilder and powered glider and general aviation is examined. The accident and minor accident ratio is obtained by proportioning the volume of accidents and damage to the number of flight hours. In addition, the trend of deaths and serious injuries in aviation accidents is assessed. When it comes to general aviation, only aeroplanes were included; helicopters used in general aviation were altogether excluded from the study.

6.1 Aircraft and flight hours

The aviation authority has registered and the FAA has catalogued ultralight aircraft since 1983. In the 1990s the FAA catalogued class A and class B ultralight aircraft until the end of 1992. In the beginning of 1993 the then aviation authority, the CAA's Flight Safety Authority, began to register class A and class B ultralight aircraft that were either new or returned to airworthiness as per aviation regulations (43). The ultralight aircraft that were found to be airworthy in aircraft annual inspections were moved from the FAA's catalogue to the CAA's aircraft register at the rate that owners submitted their registration applications. The CAA registered class A and class B ultralight aircraft until the end of 2005. When the new Aviation Act entered into force in the beginning of 2006 the situation changed with regard to ultralight aircraft: the Act no longer applied to class A ultralight registration and, therefore, it was decided to move them back to the FAA's catalogue. In the beginning of 2006 the aviation authority changed its name from the CAA's Flight Safety Administration to the Finnish Civil Aviation Authority. The FAA began to catalogue airworthy class A ultralights in the beginning of 2007. During 2008 the last airworthy class A ultralight that remained in the Civil Aviation Authority's aircraft register was moved to the FAA's catalogue. As of 2009 there were no class A ultralights in the Civil Aviation Authority's aircraft register. FAA cataloguing was also sought for those class A ultralights which had not been in the aviation authority's aircraft register. The aviation authority registered gliders and powered gliders as well as general aviation aeroplanes as early as the late 1950s.

The following table lists the number of Finnish ultralight aircraft from 1990–2009. The number of ultralights from 1990–1992 in this table comprises class A and class B ultralights catalogued by the FAA. The number of ultralights from 1993–2005 comprises class A and class B ultralights registered by Finavia. The number of ultralights from 2006–2008 comprises class B ultralights registered by the Finnish Civil Aviation Authority as well as the class A ultralights catalogued by the FAA. For the sake of comparison the table also lists the number of Finnish gliders and powered gliders as well as general aviation aeroplanes from 1990–2009, as per the aviation authority's aircraft register. The number of general aviation aeroplanes includes aeroplanes used for both private and commercial purposes. In table 4 the number of aircraft during some years indicates the number of aeroplanes in the aircraft register or the catalogue as of the beginning of the following year.

Table 4. The number of ultralight aircraft (U), gliders and powered gliders (G) and Finnish general aviation aeroplanes (GA) from 1990–2009. (33, 45, 46)

Year	Number of aircraft		
	U	G	GA
1990	283	377	666
1991	310	370	700
1992	279	376	693
1993	62	364	670
1994	118	365	647
1995	157	369	627
1996	172	369	618
1997	177	374	595
1998	177	373	577
1999	174	366	566
2000	174	372	570
2001	173	374	544
2002	173	374	532
2003	197	378	519
2004	215	381	510
2005	221	386	519
2006	217	390	522
2007	259	402	540
2008	298	404	555
2009	325	406	562

Table 4 shows that a strong statistical change occurred from 1992 to 1993 in the number of ultralight aircraft. On the one hand, this was partially caused by the fact that not all airworthy ultralights had been transferred to Finavia's aircraft register in 1993 and, on the other hand, it was in part because the FAA's catalogue also included a large number of non-airworthy ultralight aircraft. The number of registered ultralights remained fairly stable from 1996–2002, but their number rose significantly from 2003–2009, by more than one hundred aircraft. During the review period the number of class A ultralights notably decreased in relation to class B ultralights. For example, in 1990 the total number of 283 ultralight aircraft consisted of 108 class A and 175 class B aircraft (44). In 2009 the total number of 325 ultralight aircraft consisted of 33 class A and 292 class B aircraft (45, 46). No momentous change occurred with regard to registered gliders and powered gliders except for the fact that their number grew somewhat in the 2000s. The number of general aviation aeroplanes markedly decreased from 1991–2004, by approximately 190 aircraft. After this, their number has steadily risen, albeit at a much lower level than in the beginning of the 1990s.

Since 1973, under aviation regulations, the owner or operator of each registered aircraft has had the obligation to report the number of flight hours flown during the past year to the aviation authority (47, 48). On the basis of these reports the aviation authority has compiled statistics on annual flight hours per each aircraft category. The present aviation authority, Trafi Aviation, provided the ultralight flight hour statistics from 1991–2002. The study could not establish whether the CAA's Flight Safety Authority compiled them as early as 1991 since it only began to register ultralight aircraft in 1993. Trafi Aviation also made glider and powered glider as well as general aviation aeroplane flight hours from 1990–2009 available to the study. The aviation authority has divided flight hours in general aviation into private and commercial activities. Both private and commercial flight hours were included in the accident and damage statistics because the AIB's archives had not segregated accidents and minor accidents in general aviation into private and commercial operations. Commercial operations are not permitted in ultralight aviation or in glider and powered glider flying.

The aviation authority calculated the reporting percentage from all of the reports submitted from 1990–2002, which conveys the annual percentage of reports received of all airworthy aircraft. The reporting percentage was calculated from all airworthy aircraft without itemising different aircraft categories. As regards the period of 1990–2002, the aviation authority estimated the number of unreported flight hours on the basis of the reported percentage and added the unreported flight hour estimate to reported flight hours. Since 2002 the aviation authority changed the flight hour calculation method by no longer calculating the reported percentage or estimating the number of unreported flight hours. As a result, the number provided by the aviation authority from 2003–2009 only includes the reported flight hours. Nevertheless, for the purpose of this study the aviation authority retroactively calculated the reported percentage from 2003–2009. This enabled the researcher to estimate the unreported flight hours from that period and add the number to the reported flight hours. By doing so, the number of flight hours from 2003–2009 became comparable with the corresponding figures from 1990–2002.

The FAA has not calculated the number of flight hours of the ultralight aircraft in its catalogue in a manner comparable to the aviation authority. The FAA estimates that the number of flight hours in 1990 was 10 % lower compared to 1991. Judging from this, the number of ultralight aircraft flight hours in 1990 was estimated in the research. The flight hours of class A ultralights in the FAA's catalogue from 2007–2009 was not estimated because their flight hours pale in comparison with those of class B ultralights. This being the case, their elimination from the study does not significantly affect the results.

Table 5 presents the flight hours and reporting percentages obtained from the aviation authority as well as the author's corrected flight hours from 1990–2009. The flight hours received from 1990–2002 consist of the reported flight hours and an estimate of the unreported flight hours. It was not necessary to correct the numbers from 1990–2002. That being the case, the corrected flight hours are the same as the obtained flight hours. The flight hours from 2003–2009 in table 5 only include the reported flight hours. They were corrected by adding an estimate of the unreported flight hours which was calculated through the reported percentage. Subsequently, the corrected flight hours from 2003–2009 include the reported flight hours as well as the estimates of the unreported flight hours.

The flight hours in table 5 are given at the level of accuracy that was obtained from the aviation authority. Hence, they have not been rounded up. Most flight hours are given at the nearest hour, however, some of them were given at the nearest ten hours, or even hundred hours. The corrected flight hours from 2003–2009 are rounded up to the nearest hour. Table 5 shows that the reported percentage has remained extremely high: 92–100 % during the entire period of review. Still, the percentage from 1990–1992 probably does not include flight hours in ultralight aviation because the aviation authority began to register ultralight aircraft as late as 1993. Nonetheless, in this study the corrected flight hours from 1990–1992 are estimated to be the same as the flight hours obtained. Table 5 only includes the flight hours of Finnish aircraft.

Table 5. Ultralight (U), glider and powered glider (G) as well as general aviation aeroplane (GA) flight hours in Finland from 1990–2009. (49–53)

Year	Flight hours provided by the aviation authority			Reported percentage	Corrected flight hours		
	U	G	GA		U	G	GA
1990	5044	36850	115460	95	5044	36850	115460
1991	5604	34815	97670	97	5604	34815	97670
1992	5706	36750	89640	97	5706	36750	89640
1993	4720	33800	88420	95	4720	33800	88420
1994	3440	32700	79230	95	3440	32700	79230
1995	3190	31700	74990	97	3190	31700	74990
1996	3121	31300	75270	98	3121	31300	75270
1997	2392	34000	76750	98	2392	34000	76750
1998	2286	24700	70500	95	2286	24700	70500
1999	2179	29577	63252	100	2179	29577	63252
2000	3124	23754	61765	100	3124	23754	61765
2001	4308	26078	51705	100	4308	26078	51705
2002	5747	31654	57611	100	5747	31654	57611
2003	6923	26557	54441	96	7211	27664	56709
2004	11083	23279	53929	96	11545	24249	56176
2005	12128	26021	52662	96	12633	27105	54856
2006	12841	26038	59230	98	13103	26569	60439
2007	12686	20798	57676	97	13078	21441	59460
2008	12586	20439	55215	94	13389	21744	58739
2009	13357	23662	51218	92	14518	25720	55672

Figure 1 presents the corrected flight hours in ultralight aviation as per table 5 and the number of ultralight aircraft from 1990–2009 as per table 1. As regards the period of 1990–1992 the graph depicting the number of ultralight aircraft in the figure is shown in light grey and the flight hours of ultralight aviation as a dotted line. This signifies the fact that the numbers are not directly comparable with the ones of later years. The FAA catalogued ultralight aircraft from 1990–1992 and the aviation authority began to register them from the beginning of 1993, as explained earlier. Figure 1 shows that in the 1990s ultralight aviation flight hours reached their nadir at the end of the decade. Thereafter, flight hours have soundly risen. The strongest growth was experienced in the early years of the 2000s. During the past decade ultralight flight hours have increased approximately sixfold. During recent years this growth has significantly slowed down. Figure 1 also shows that the number of ultralight aircraft has not risen in step with the increase in flight hours.

Figure 2 presents the corrected flight hours in ultralight aviation in comparison to glider and powered glider and general aviation aeroplane flight hours, as per table 5 from 1990–2009. Figure 2 shows that flight hours with general aviation aeroplanes markedly decreased in the 1990s and the beginning of the 2000s. Thereafter, they have remained more or less stable, or have slightly increased. Whereas glider and powered glider flight hours also decreased on average during the review period, they decreased less than those of general aviation aeroplanes. The study revealed that pilots record flight hours differently into their flight time logbooks in different types of aviation. In ultralight aviation the flight time is normally recorded from takeoff to landing, without adding the time to taxi. In general aviation the flight time normally also includes taxiing time. While this issue was not researched any deeper in this study, it was estimated as being relatively insignificant to the comparability of flight hours obtained from the civil aviation authority.

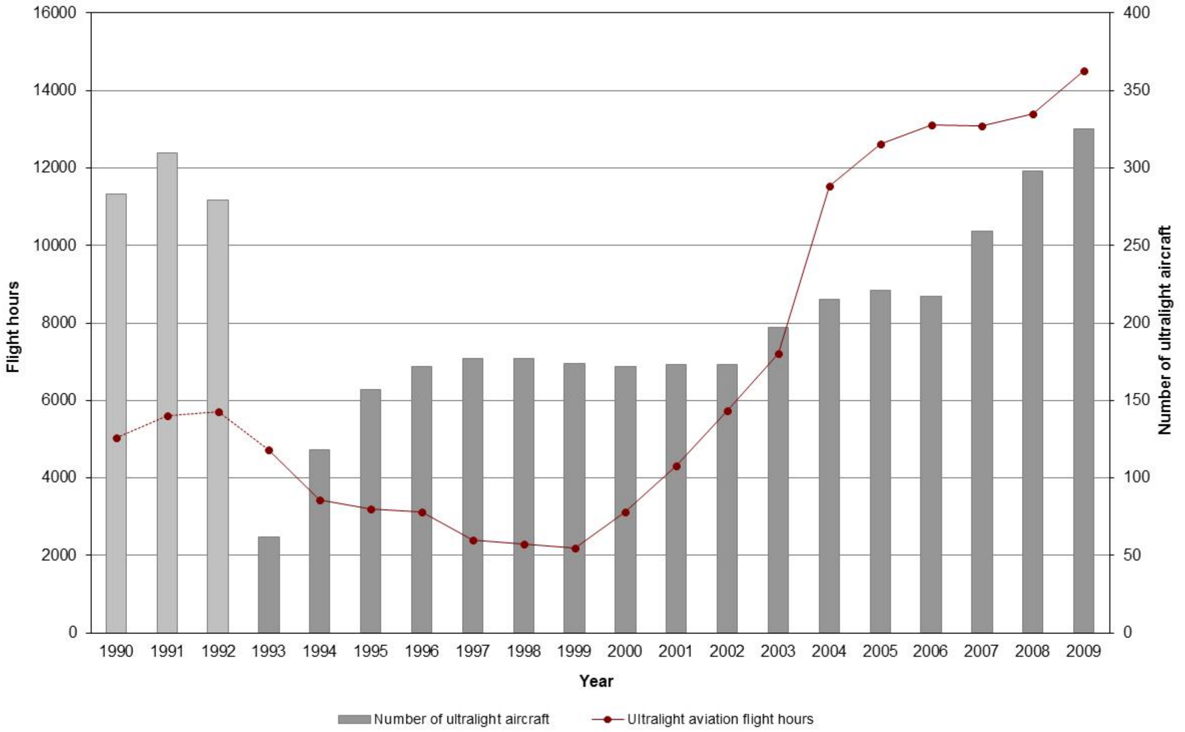


Figure 1. Ultralight aviation flight hours and the number of ultralight aircraft in Finland from 1990–2009.

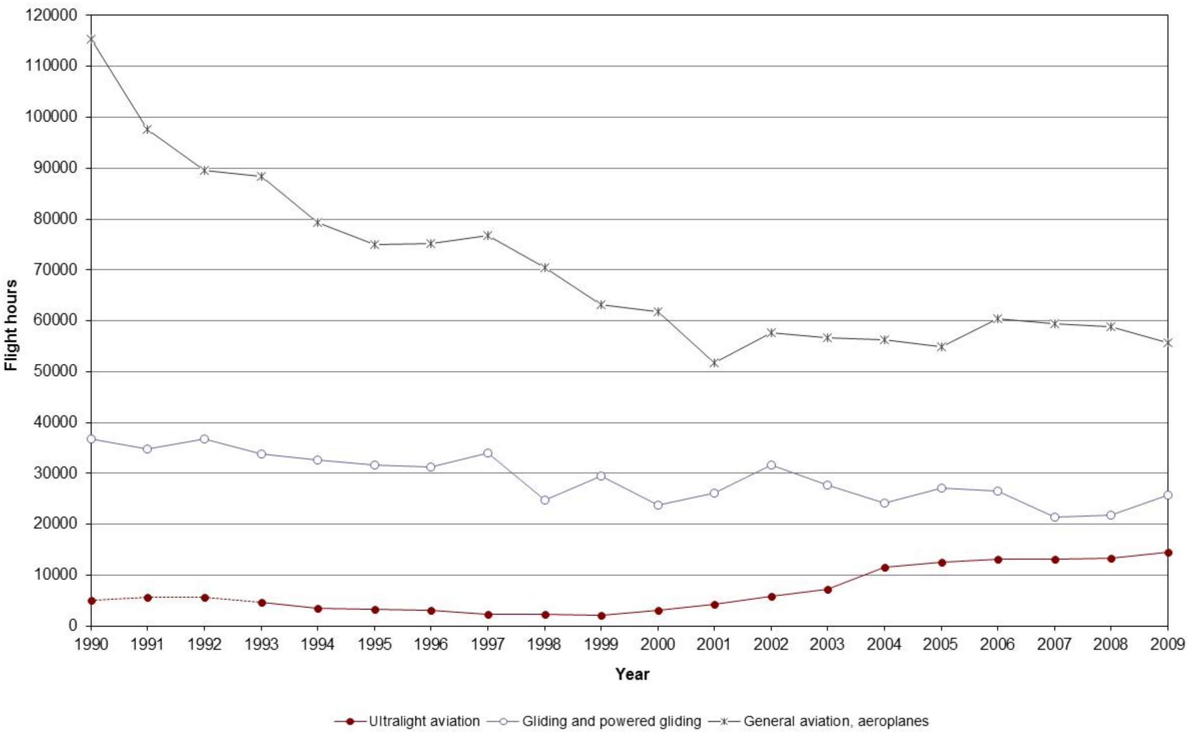


Figure 2. Ultralight aviation, glider and powered glider as well as general aviation aeroplane flight hours in Finland from 1990–2009.

As regards the years 1993–2009, the study's statistics reflect the number of registered ultralight aircraft and their flight hours. In addition to registered ultralights during that period there were probably some non-registered ultralights in Finland that were flown. Since they were not included in the aircraft register, their possible flight hours were not included in this study for the period in question. The same also applies to non-registered gliders, powered gliders and general aviation aeroplanes during that same period. It would be difficult to estimate the number of non-registered aircraft or their flight hours and, therefore, they are not analysed any further in this study.

6.2 Accidents and minor accidents

With regard to aviation accidents, Finland has applied the definition of Annex 13 to the Convention on International Civil Aviation. Pursuant to the definition an accident is an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which:

a) a person is fatally or seriously injured as a result of:
   - being in the aircraft, or
   - direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or
   - direct exposure to jet blast,

   except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; or

b) the aircraft sustains damage or structural failure which:
   - adversely affects the structural strength, performance or flight characteristics of the aircraft, and
   - would normally require major repair or replacement of the affected component,

   except for engine failure or damage, when the damage is limited to the engine, its cowlings or accessories; or for damage limited to propellers, wing tips, antennas, tires, brakes, fairings, small dents or puncture holes in the aircraft skin; or

c) the aircraft is missing or is completely inaccessible. (54)

Annex 13 to the Convention on International Civil Aviation does not define the concept of a minor accident. In Finland this concept has been used for such aviation accidents that meet the definition of an accident as described in Annex 13, which do not result in injuries to persons and in which the damage to the aircraft is either minor or major (54). The study revealed that when it comes to borderline cases in practice the difference between an aviation accident and a minor accident is nothing but elusive. No precise definition exists and each occurrence is considered on a case-by-case basis. Therefore, different persons may categorise the same borderline case as an aviation accident or a minor accident. Research aimed at standardisation so as to make the results of each year's investigation comparable. Therefore, the same classification principles regarding aviation accidents and minor accidents were retained throughout the period of review. Research showed that the typical minor accident in all studied aircraft classes involved damage to the landing gear following a rough or bounced landing.

Pursuant to Annex 13 an injury resulting in death within thirty days of the date of the accident is classified as a fatal injury by ICAO. (54)

Pursuant to Annex 13 a serious injury is an injury which is sustained by a person in an accident and which:

- requires hospitalization for more than 48 hours, commencing within seven days from the date the injury was received; or
- results in a fracture of any bone (except simple fractures of fingers, toes or nose); or
- involves lacerations which cause severe haemorrhage,
- nerve, muscle or tendon damage; or
- involves injury to any internal organ; or
- involves second or third degree burns, or any burns affecting more than 5 per cent of the body surface; or
- involves verified exposure to infectious substances or injurious radiation. (54)

Table 6 shows the itemised and total numbers of all reported accidents and minor accidents to ultralights, gliders and powered gliders and general aviation aeroplanes from 1990–2009. Table 6 includes the aviation accidents and minor accidents to aircraft registered or catalogued in Finland. The numbers were added up from the AIB's annual aviation accident and incident statistics from 1996–2009. Prior to the founding of the AIB, CAA's Flight Safety Authority compiled corresponding annual statistics and its old publications were used in calculating the numbers for aviation accidents and minor accidents from 1990–1995. Table 6 does not include any accidents or minor accidents that occurred to foreign aircraft in the territory of Finland. Nonetheless, pursuant to Annex 13, the AIB must institute an investigation into the circumstances of accidents and minor accidents that happen in the territory of Finland, be they Finnish-registered or foreign-registered aircraft.

Table 6. Aviation accidents and minor accidents to ultralights (U), gliders and powered gliders (G) and general aviation aeroplanes (GA) in Finland from 1990–2009. (55–61)

Year	Aviation accidents			Minor accidents			Total		
	U	G	GA	U	G	GA	U	G	GA
1990	2	1	2	39	19	20	41	20	22
1991	1	3	2	25	19	16	26	22	18
1992	4	3	4	16	8	17	20	11	21
1993	1	0	2	8	16	17	9	16	19
1994	1	2	3	13	11	6	14	13	9
1995	0	0	3	5	8	12	5	8	15
1996	1	2	1	6	6	8	7	8	9
1997	0	0	1	6	6	4	6	6	5
1998	1	2	2	10	7	7	11	9	9
1999	0	0	2	9	9	10	9	9	12
2000	2	4	1	5	5	5	7	9	6
2001	0	2	1	6	6	9	6	8	10
2002	1	0	3	7	10	12	8	10	15
2003	1	0	2	9	6	7	10	6	9
2004	2	0	2	10	10	7	12	10	9
2005	1	0	3	11	7	6	12	7	9
2006	2	0	1	13	8	4	15	8	5
2007	0	1	1	9	4	7	9	5	8
2008	0	1	3	13	7	5	13	8	8
2009	3	1	3	10	7	8	13	8	11

Table 6 shows that, on average, one accident occurs each year in ultralight aviation as well as in glider and powered glider aviation. The accident rate in general aviation is twice as high. Minor accidents clearly outnumber accidents in all types of aviation. In the beginning of the 1990s minor accidents were the most prevalent in all types of aviation during the review period. Table 6 only includes officially reported accidents and minor accidents. The reporting culture has notably changed during the period of review. In the beginning of the 1990s only a part of minor accidents was reported (18). Whereas the threshold of reporting incidents is now significantly lower, some incident may remain unreported even today. It is estimated that the volume of minor accidents was two- or threefold compared to the ones reported to the aviation authority (18). The number of accidents is much more reliable during the entire period of review than the volume of minor accidents.

Table 7 presents the ratio of accidents and minor accidents for ultralights, gliders and powered gliders and general aviation aeroplanes per 10 000 flight hours in Finland. The calculation included the number of accidents and minor accidents presented in table 6 as well as the corrected flight hours presented in table 5. Figures 3 and 4 show the data in table 7 as graphs. Figure 3 shows the ratio of accidents and minor accidents per 10 000 flight hours in all reviewed types of aviation from 1990–2009, and table 4 the information from 2000–2009, respectively.

Table 7. Accidents and minor accidents for ultralights (U), gliders and powered gliders (G) and general aviation aeroplanes (GA) per 10 000 flight hours in Finland from 1990–2009.

Year	Accidents per 10 000 flight hours			Minor accidents per 10 000 flight hours			Total		
	U	G	GA	U	G	GA	U	G	GA
1990	3.97	0.27	0.17	77.33	5.16	1.73	81.29	5.43	1.91
1991	1.78	0.86	0.20	44.61	5.46	1.64	46.40	6.32	1.84
1992	7.01	0.82	0.45	28.04	2.18	1.90	35.05	2.99	2.34
1993	2.12	0.00	0.23	16.95	4.73	1.92	19.07	4.73	2.15
1994	2.91	0.61	0.38	37.79	3.36	0.76	40.70	3.98	1.14
1995	0.00	0.00	0.40	15.67	2.52	1.60	15.67	2.52	2.00
1996	3.20	0.64	0.13	19.22	1.92	1.06	22.43	2.56	1.20
1997	0.00	0.00	0.13	25.08	1.76	0.52	25.08	1.76	0.65
1998	4.37	0.81	0.28	43.74	2.83	0.99	48.12	3.64	1.28
1999	0.00	0.00	0.32	41.30	3.04	1.58	41.30	3.04	1.90
2000	6.40	1.68	0.16	16.01	2.10	0.81	22.41	3.79	0.97
2001	0.00	0.77	0.19	13.93	2.30	1.74	13.93	3.07	1.93
2002	1.74	0.00	0.52	12.18	3.16	2.08	13.92	3.16	2.60
2003	1.39	0.00	0.35	12.48	2.17	1.23	13.87	2.17	1.59
2004	1.73	0.00	0.36	8.66	4.12	1.25	10.39	4.12	1.60
2005	0.79	0.00	0.55	8.71	2.58	1.09	9.50	2.58	1.64
2006	1.53	0.00	0.17	9.92	3.01	0.66	11.45	3.01	0.83
2007	0.00	0.47	0.17	6.88	1.87	1.18	6.88	2.33	1.35
2008	0.00	0.46	0.51	9.71	3.22	0.85	9.71	3.68	1.36
2009	2.07	0.39	0.54	6.89	2.72	1.44	8.95	3.11	1.98

Table 7 and figures 3 and 4 show that, on average, the accident and incident ratio in ultralight aviation per flight hour has been on the decline during the review period. In the 1990s the accident and incident ratio was higher than in the 2000s. Moreover, the ratio also exhibited stronger annual fluctuation compared to the 2000s. The accident and incident numbers, particularly, for 1994, 1998 and 1999 can be clearly distinguished in figure 3. In 1994 the total number of ultralight aviation accidents and minor accidents was much higher than in 1993 or 1995. In 1998 and 1999 the total number of ultralight aviation accidents and minor accidents exceeded that of 1997 and 2000. During the period of review ultralight flight hours reached their nadir in 1998 and 1999; this raises the accident and incident ratio for those years.

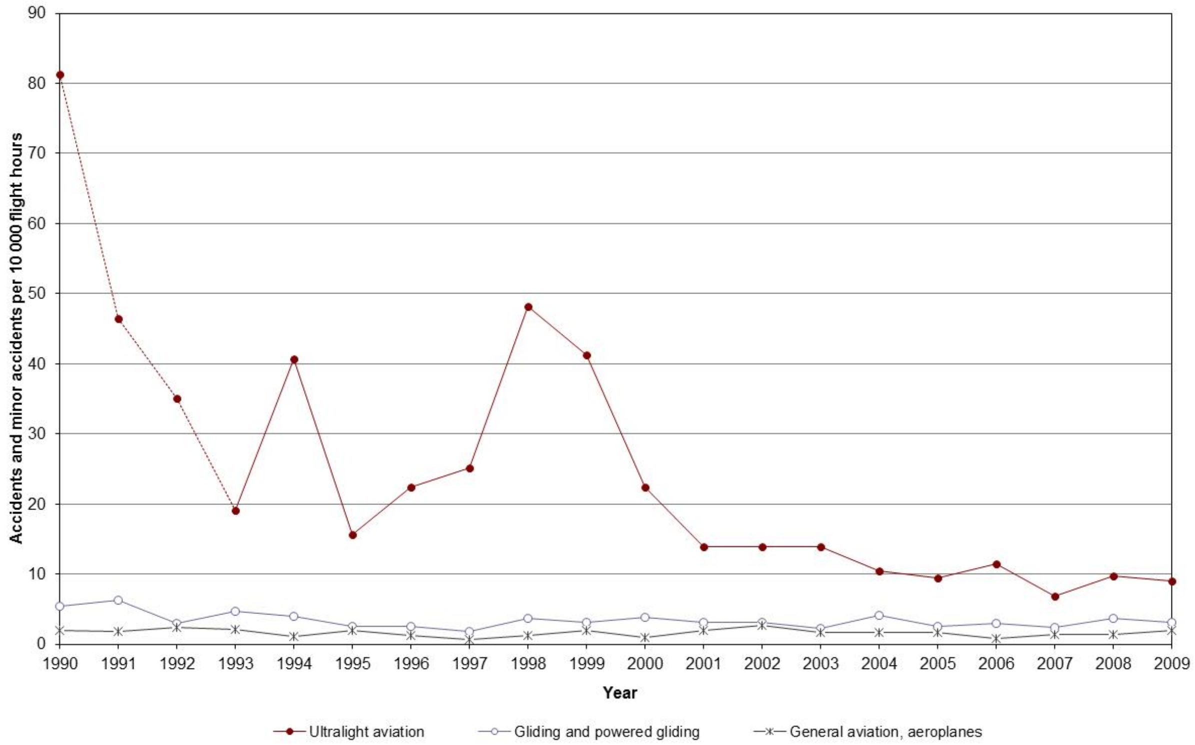


Figure 3. The ratio of accidents and minor accidents for ultralights, gliders and powered gliders and general aviation aeroplanes per 10 000 flight hours in Finland from 1990–2009.

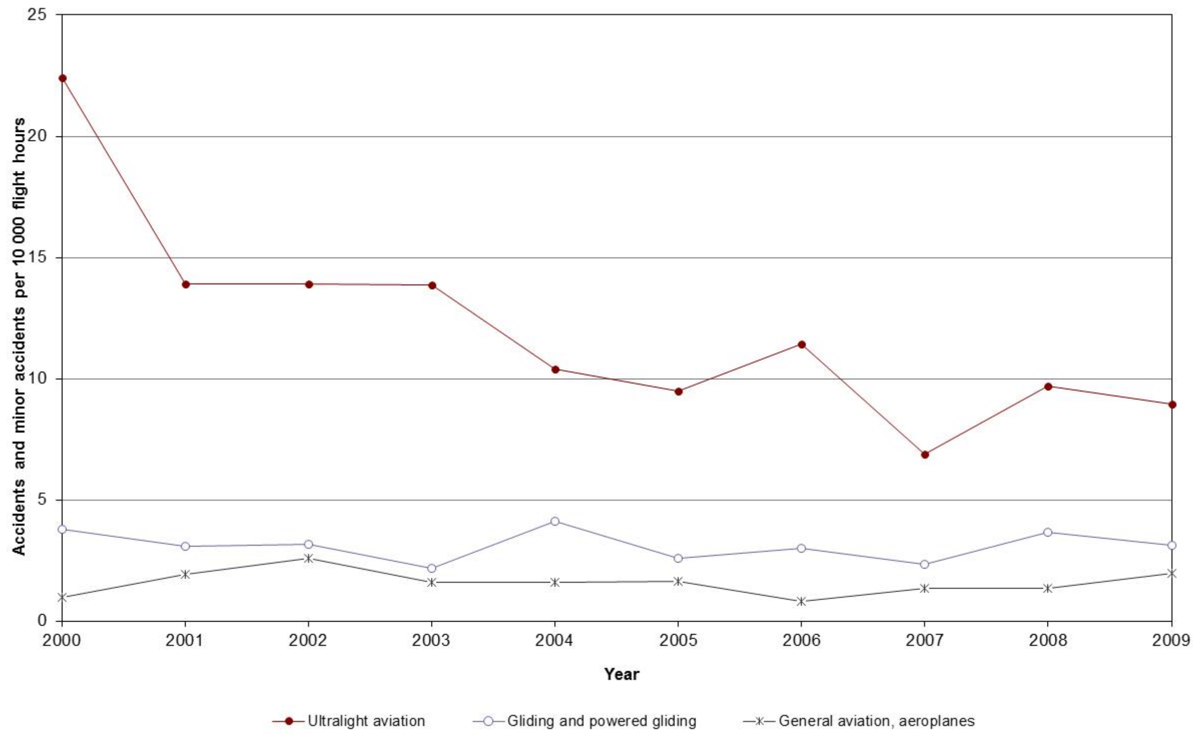


Figure 4. The ratio of accidents and minor accidents for ultralights, gliders and powered gliders and general aviation aeroplanes per 10 000 flight hours in Finland from 2000–2009.

From 1990–1994 Finnish ultralight aircraft had an accident or minor accident, on average, every 223 flight hours. From 1995–1999 one occurred every 347 flight hours, from 2000–2004 every 743 flight hours and from 2005–2009 every 1076 flight hours, respectively. When proportioned to the number of flight hours the ratio of accidents and minor accidents in ultralight flying has been much higher compared to glider and powered glider flying or in general aviation throughout the entire review period. While in the 2000s this ratio came significantly closer to that of glider and powered glider flying or general aviation, it is still clearly distinguishable. The accident and minor accident ratio for gliders and powered gliders as well as general aviation aeroplanes has remained more or less stable throughout the entire review period. From 2000–2009 Finnish gliders and powered gliders had an accident or a minor accident every 3240 flight hours, on average, and the corresponding ratio for general aviation aeroplanes was 6368 flight hours. The ratio in general aviation may be somewhat better due to the fact that the statistics also include commercial operations in addition to private activities.

In 2006 Finavia's sport aviation section prepared a report on the different types of sport aviation's safety levels from 2003–2005. One purpose of the report was to establish the link between type certification and safety levels. In the report the ratio of accidents and minor accidents for non-type certified ultralight aircraft was compared to the one for type-certified Touring Motor Gliders (TMG). A TMG is a powered glider that has a fixed powerplant and propeller and which, in accordance to its flight manual, can self-launch and climb on its own engine power (62). The fixed engine and propeller are non-retractable.

According to the report ultralight aircraft had accidents or minor accidents every 898 flight hours from 2003–2005. Correspondingly, TMGs had accidents or minor accidents every 969 flight hours in the same period of time. When proportioned to the number of landings, ultralight aircraft had an accident or minor accident in every 3687 landings. Respectively, TMGs had an accident or minor accident in every 3025 landings in the same period of time, on average. Judging by the report, type certification did not significantly affect the safety level because the accident and incident ratio for ultralight aircraft was about the same as for TMGs. (63)

Whereas the period of review of the report was relatively short, its results can be considered to be indicative. Using the information in table 7 Finnish ultralight aircraft had an accident or minor accident, on average, every 923 flight hours from 2003–2005. Consequently, the results in Finavia's report regarding the safety level in ultralight aviation closely mirrors the results of this study. According to the report TMGs had accidents or minor accidents much more often than gliders and powered gliders as per this study. The reason for this is that in this safety study the accident and incident ratio was jointly calculated for gliders and powered gliders. Finnish gliders clearly outnumber Finnish powered gliders and the accident and incident ratio for gliders in proportion to flight hours is much lower than the one for powered gliders. The probable reason for this is that, on average, glider operations differ from powered glider operations by the number of landings per each flight hour.

6.3 Fatalities and serious injuries

Table 8 indicates the number of fatalities and serious injuries that resulted from accidents to Finnish ultralight aircraft, gliders and powered gliders and general aviation aeroplanes from 1990–2009. The table shows that altogether 10 persons perished in ultralight accidents during the period of review. In the 2000s six persons died in ultralight accidents. On average, 0–2 persons died in ultralight accidents each year during the period of review. There are several years in the period of review when no-one died in ultralight accidents. In the early 1990s only three persons perished in ultralight accidents even though many forced landings and minor accidents occurred then. The probable reason for this is that the accident safety, i.e. the pilot's survival index, in an ultralight aircraft is high (18). The most important factors that contribute to this are the low mass of the aircraft and a low stall speed (18). During the review period a total of three persons perished in glider and powered glider accidents and 24 persons in general aviation aeroplane accidents, respectively.

Table 8. The number of fatalities and serious injuries in accidents that happened to ultralight aircraft (U), gliders and powered gliders (G) and general aviation aeroplanes (GA) in Finland from 1990–2009.

Year	Fatalities			Seriously injured			Total			Total per 10 000 flight hours		
	U	G	GA	U	G	GA	U	G	GA	U	G	GA
1990	1	0	2	1	1	1	2	1	3	3.97	0.27	0.26
1991	0	1	2	1	2	0	1	3	2	1.78	0.86	0.20
1992	2	0	1	4	4	3	6	4	4	10.52	1.09	0.45
1993	0	0	2	1	0	1	1	0	3	2.12	0.00	0.34
1994	0	0	0	1	1	0	1	1	0	2.91	0.31	0.00
1995	0	0	1	0	0	3	0	0	4	0.00	0.00	0.53
1996	0	0	0	2	1	1	2	1	1	6.41	0.32	0.13
1997	0	0	0	0	0	2	0	0	2	0.00	0.00	0.26
1998	1	0	0	1	2	0	2	2	0	8.75	0.81	0.00
1999	0	0	1	0	0	0	0	0	1	0.00	0.00	0.16
2000	0	0	2	0	1	0	0	1	2	0.00	0.42	0.32
2001	0	0	1	0	1	0	0	1	1	0.00	0.38	0.19
2002	0	0	0	1	0	1	1	0	1	1.74	0.00	0.17
2003	0	0	4	2	0	0	2	0	4	2.77	0.00	0.71
2004	2	0	2	1	0	1	3	0	3	2.60	0.00	0.53
2005	0	0	0	1	0	1	1	0	1	0.79	0.00	0.18
2006	2	0	2	0	0	0	2	0	2	1.53	0.00	0.33
2007	0	1	0	0	0	0	0	1	0	0.00	0.47	0.00
2008	0	0	3	0	1	1	0	1	4	0.00	0.46	0.68
2009	2	1	1	1	0	1	3	1	2	2.07	0.39	0.36

The number of persons in table 8 that were fatally or seriously injured is based on the same source as the number of accidents and minor accidents in table 6. In addition, table 8 indicates the number of fatalities and serious injuries per 10 000 flight hours. This number was calculated by using the number of fatalities and serious injuries in table 8 and the corrected flight hours in table 5. The number of fatalities and serious injuries per 10 000 flight hours is shown as a graph in figure 5. This figure shows that ultralight aviation has caused many more fatalities or serious injuries proportioned to flight hours than gliders or powered gliders or general aviation aeroplanes. General aviation numbers include both private and commercial operations.

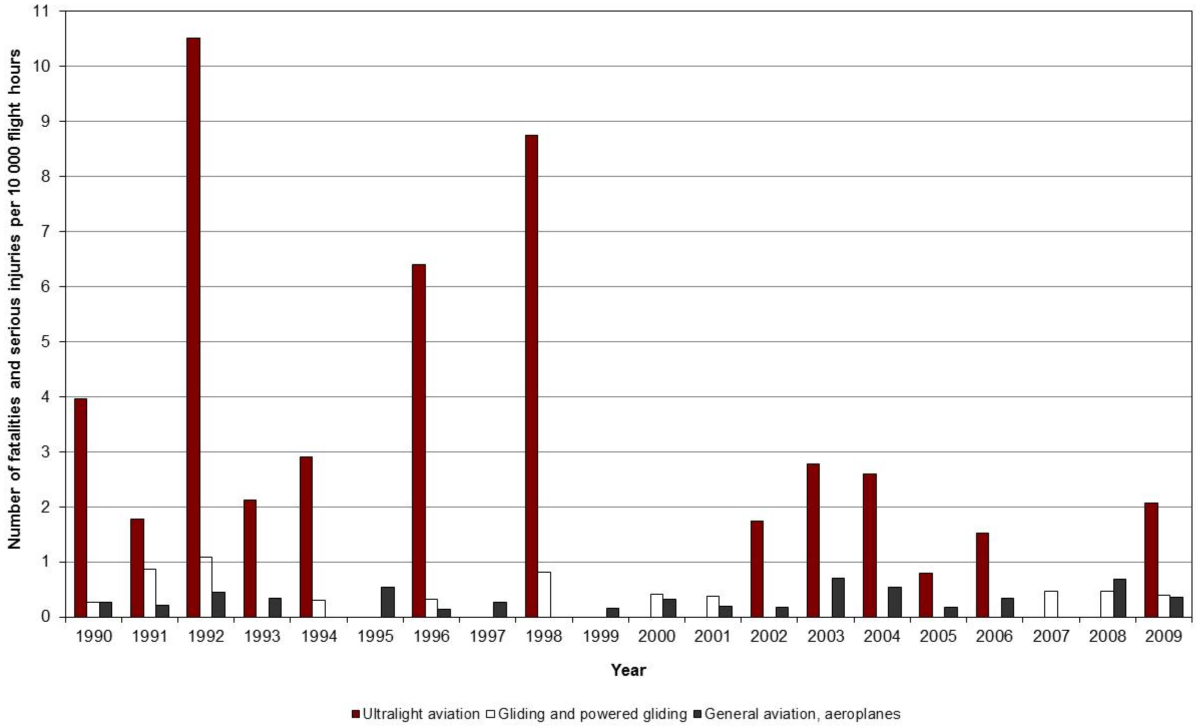


Figure 5. The number of fatalities and serious injuries from accidents in ultralight aviation, glider and powered glider operations and general aviation aeroplanes per 10 000 flight hours from in Finland 1990–2009.

7 ACCIDENTS, MINOR ACCIDENTS AND SERIOUS INCIDENTS IN ULTRA-LIGHT AVIATION INVESTIGATED BY THE ACCIDENT INVESTIGATION BOARD

7.1 Research material and methodology

In all, the AIB investigated 29 ultralight aviation accidents, minor accidents or serious incidents during the period 1996–2009. Each case is listed in appendix 2. The appendix also details each investigation by the report number, title, date and the class of the ultralight (U class) aircraft in question, which is either A or B. Most AIB ultralight aviation investigations have concerned class B ultralights.

This study was limited to ultralight accidents, minor accidents and serious incidents investigated by the AIB between the period of 2000–2009. While the number of reports to be analysed was not excessive, the material was still extensive enough for the purpose of finding common human factors. The study wanted to focus on the present most important human factors so it would have been purposeless to deliberate older cases. When it comes to human factors that play the most important role these days, the occurrences of the 2000s are the most important because ultralight aircraft evolved in reliability and performance at the turn of the previous decade. The causes of occurrences in the 1990s were probably more technical. In addition, there was a desire to focus on the occurrences that involved surface-controlled ultralights because they are, at present, more important in sport aviation than weight-shift controlled ultralights. This being the case, the study analyses altogether 20 class B ultralight accidents, minor accidents and serious incidents investigated by the AIB between the period of 2000–2009. Subsequently, the research material includes 20 AIB investigation reports. Table 9 lists each ultralight accident, minor accident and serious incident included in the research material, as well as the report numbers, their titles and dates of occurrence.

Each AIB investigation is designated by an identifier that consists of four parts, such as C1/200L. The first part (A, B, C or D) indicates the category of the investigation. This is determined by the severity of the occurrence, the extent of its consequences, the probability of recurrence and its significance to public safety. In borderline cases the selection of the category may vary. Category A investigations compose the most serious major accidents, which may not involve ultralight aviation. All ultralight accidents, minor accidents and serious incidents have been investigated as category B, C or D occurrences. Ultralight accidents resulting in fatalities have always been category B investigations. Category D investigations are done on the least serious occurrences and are briefer than category B or C investigations. Safety studies, i.e. category S investigations, can be conducted if several similar occurrences take place and there is a desire to assess whether they contain any common safety issues. Safety studies can also be done if analogous causal factors have been discovered in accident investigations and if it is deemed necessary to determine the chances of eliminating them. This study is the AIB’s first aviation safety study. The second part of the investigation identifier is a sequence number referring to the order of the accident within its accident category in the year in question. The third part refers to the calendar year of the occurrence. The fourth part indicates the accident category, which in ultralight aviation investigations is always L (aviation). The AIB’s other accident categories include M (maritime), R (railways) and Y (other). For example, investigation C1/200L is the first category C aviation investigation that was started in 2000. (25, 64)

In this study the title of the investigation indicates whether the occurrence involves an accident, a minor accident or a serious incident. In addition, it specifies the location of the occurrence. The terms aviation accident and minor accident, used in the titles of investigations, are analogous with the statistics presented in chapter 6. All AIB investigations included in the research material are listed at the end of the references. The list includes the titles of investigations which, in many cases, vary a little from those listed in this study. Pursuant to Annex 13 to the Convention on International Civil Aviation a serious incident is an incident involving circumstances indicating that an accident nearly occurred (54). Examples of serious incidents as per Annex 13 are listed in appendix 3.

Table 9. Ultralight accidents, minor accidents and serious incidents included in the research material.

Occurrence	Identifier	Title of investigation	Date of occurrence
1	C1/2000L	Accident in Mäntsälä	5.1.2000
2	C11/2000L	Accident at Parainen	19.8.2000
3	C11/2002L	Accident at Viitasaari	16.11.2002
4	C7/2003L	Accident at Kirkkonummi	11.6.2003
5	B1/2004L	Accident at Hollola	16.2.2004
6	B3/2004L	Accident at Mäntsälä	24.8.2004
7	D1/2005L	Minor accident at Viitasaari	15.1.2005
8	D6/2006L	Serious incident at sea off Turku	22.4.2006
9	B2/2006L	Accident at Sodankylä	10.7.2006
10	D9/2006L	Minor accident at Haapavesi	11.7.2006
11	D11/2006L	Minor accident at Oulunsalo	1.8.2006
12	B3/2006L	Accident at Lake Hirsijärvi	8.8.2006
13	D4/2007L	Minor accident at Pudasjärvi	3.2.2007
14	C5/2007L	Serious incident at Helsinki	12.8.2007
15	D2/2008L	Minor accident at Vampula	22.6.2008
16	D5/2008L	Minor accident in Hanko	24.7.2008
17	D2/2009L	Accident at Lahti-Vesivehmaa	16.1.2009
18	D3/2009L	Accident at Helsinki	21.4.2009
19	D4/2009L	Accident at Inkoo	28.4.2009
20	B6/2009L	Accident at Kauhava	4.8.2009

Appendix 4 contains the summaries of all investigations included in the research material. The summaries were compiled on the basis of the investigation reports. Information in the investigation reports was supplemented on the basis of discussions with the investigators. These talks concerned, among other things, such things as potential contributing factors which, after reading the investigation reports, spawned questions or which remained ambiguous on the basis of information in the reports. In addition, some of the AIB's archives were used to augment the information included in investigation reports. The research material was analysed by using the SHELL model; the SHELL analyses of all of the investigation reports included in the research material are also listed in appendix 4. Appendix 5 includes photographs taken of all ultralight accidents, minor accidents and serious incidents included in the research material which the AIB investigated. The photographs come from the AIB's archives. No suitable photographic evidence of occurrence number 2 could be found. The following chapter presents the SHELL model and the justifications why it was selected as the model for analysis.

7.2 The SHELL model

The human factors that contributed to the onset of accidents, minor accidents and serious incidents in a given environment can be analysed by the SHELL model. The International Civil Aviation Organization (ICAO), among others, recommends the use of the SHELL model in the analysis of human factors in aviation accidents. Since ICAO recommends its use and the AIB has previously used it in human factor analyses in a similar study, the SHELL model was selected as the analysis model for the research material. By using the SHELL model it was possible to systematically analyse the research material, 20 AIB investigation reports. The SHELL model also made it possible to clearly categorise the human factors that contributed to the onset of accidents, minor accidents and serious incidents. The SHELL model was originally proposed by Edwards in 1972; it was further developed by Hawkins in 1975 to its present form. (65)

The abbreviation SHELL is derived from the first letters of its English language components: Software, Hardware, Environment, Liveware and Liveware. Figure 6 presents the SHELL model and its parts. The elemental feature in the model is the interrelationship between its components as well as their mutual compatibility. The model only focuses on human interrelationships, i.e. those that contain the Liveware-segment. Other interrelationships, such as the Hardware-Hardware, Hardware-Software and Hardware-Environment are excluded from the analysis. (65)

Figure 6. The SHELL-model: Software (S), Hardware (H), Environment (E), Liveware (L) and Liveware (L). (65)

Liveware, the central element of the model, means the human activity, or part of it, which is analysed within its environment (65). In this study Liveware represents the pilot or the person who was most likely controlling the ultralight aircraft. In one AIB ultralight aviation investigation (B6/2009L) there were two pilots in an aviation accident; the second pilot was probably the pilot flying at the time of the accident. The other occurrences included in the research material only involved single pilots. In this study Liveware can also mean the owner, operator, builder or manufacturer of an ultralight aircraft who, prior to the occurrence, either performed or commissioned some technical work on the aircraft which contributed to the onset of the occurrence. This work could have involved, for example, construction, repair or modification prior to the occurrence flight.

The human being, i.e. Liveware, is the most critical component of the model. His performance varies and he also has many well-known limitations. Human performance is limited by, among other things, physical shape and size, physiological needs with regard to nourishment, water and oxygen, capacity to receive and process information, responses to stimuli, memory capacity, stress handling capabilities and tolerance of environmental conditions. Furthermore, people differ in their characteristics. These differences can be controlled to a degree by, among other things, flight instructor and student pilot selection, and flight training and standardised procedures. However, it is often the case that the system must be built to tolerate human dissimilarity. Hence, Liveware is a complicated component which is aptly depicted by the intricate shape of its borders in table 6. In order for the different components of the model to perform well as an entity, the other components must conform well to the Liveware component. The following chapters present the other components of the SHELL model, as well as their interrelationships with the Liveware component in the centre. (65)

Software denotes the training, experience, skills, knowledge, legislation, regulations, instructions, procedures and supervision under which a human being functions. In this study the Liveware-Software interrelationship is mainly used to analyse how the pilot's flight training, flying experience, flying skills and supervision as well as aviation regulations, flight manuals, checklists and procedures affect occurrences.

Hardware stands for structures, systems and equipment used by the human being or to which he focuses his actions (65). In this study the Liveware-Hardware interdependency is used to analyse the human ability to operate, repair, construct and manufacture an aircraft as well as its systems and components. This may pertain to the skill of the pilot, owner, operator or manufacturer to design and fabricate as well as repair or use the aircraft and its systems and equipment. The interrelationship also examines human performance in loading an ultralight aircraft with regard to the mass and centre of gravity. Moreover, the Liveware-Hardware interrelationship includes the compatibility of the interface between the cockpit layout and the pilot. For example, instrumentation design should take into account the human being's limited information processing capability as well as his in-flight memory and stress handling capacities. All cockpit layout design should take into account the physical size, shape and mobility of the human body. For example, instruments should be positioned at the appropriate height and distance from the person in the cockpit.

Environment represents the surroundings in which the human operates (65). The environment includes, among other things, meteorological conditions, aerodrome conditions such as terrain and obstacles, the season and the time of day as well as sounds in the cockpit. Seasonal environmental factors can include, for example, snowy and icy terrain. Factors regarding the time of day may include, for example, the sunset. Haste, which is entirely caused by environmental factors, can also be counted as environment. For example, if the sun is about to set during the flight, the pilot may be in a hurry to make it to his destination before nightfall. Haste during the flight, in turn, may be detrimental to human performance. Nevertheless, in this study the Liveware-Environment interrelationship is used, first and foremost, to analyse the effect of meteorological conditions, such as strong winds, on human performance.

The second Liveware stands for the other people with whom, or within the sphere of influence of, the human in the focus of the analysis, i.e. the core Liveware, operates. In this study the other people usually mean persons, passengers or the second pilot, with whom the pilot communicates during the flight. In addition, the second Liveware can mean any person with whom the pilot communicated before the flight in such a manner that it immediately affected the onset of the accident, minor accident or serious incident. Typical Liveware-Liveware interrelationships include various failures in communication, such as misunderstandings.

7.3 Common human factors

7.3.1 The Liveware-Software interrelationship

The factors belonging to the Liveware-Software interrelationship which the study found relevant were divided into six categories. These are the pilot's insufficient training, limited flying experience, poor flying skills and unsound course of action, also an inadequate flight manual and insufficient supervision. The following paragraphs examine each category separately.

Insufficient training

As per table 10, insufficient pilot training was found to have contributed to four occurrences. Three of these involved limited or inadequate type rating training and two occurrences involved insufficient basic training. In addition, in one case the ultralight flight instructor's training was also insufficient.

Table 10. Insufficient pilot training in various occurrences.

Insufficient training	**Occur-rence**
Limited type rating training	1 5 14
Insufficient basic training	5 20
Insufficient ultralight flight instructor training	20

In occurrence number 1 the pilot's type training on the accident type consisted of approximately 16 hours of instruction flights, including 76 landings. The accident type was more developed than the type of aircraft he had previously flown. Its characteristics resembled those of a conventional aeroplane. According to the investigation report the accident aircraft type was so challenging that the pilot's type training did not provide him with sufficient enough experience with its characteristics or, particularly, to its approach technique on a short runway.

In occurrence number 5 the pilot had flown a 40 minute-long type training flight, including five landings. The investigation report states that sometimes pilots transfer to more demanding aircraft types with regard to their performance or control characteristics with too little flying experience and insufficient type training. Hence, it can be interpreted that the investigation commission believed that the pilot had transferred to a more demanding aircraft type with too little flying experience and that his type training had been insufficient regarding the demands of the aircraft type.

In occurrence number 14 prior to the serious incident the pilot received theoretical instruction on the aircraft type in question and flew one type rating flight with an instructor on the type's amphibian version. The type rating training flight lasted 50 minutes and included five landing. The flight met the type training requirements as per the aviation regulation pertaining to ultralight pilot licensing. The investigation commission considered the training, which met the requirements of the aviation regulation, to be insufficient because the aircraft in question was an amphibian and the cockpit controls markedly differed from the aircraft types the pilot had previously flown. Hence, based on this and discussions with the researcher, the investigation commission regarded the pilot's type training as limited.

In occurrences 1, 5 and 14 the pilot had a valid UPL licence before receiving type rating training. In occurrence number 1 the pilot had received much more type training compared to occurrences 5 and 14. Still, each investigation commission held that the type training was insufficient or inadequate with regard to the demands of the aircraft type in question. At the time when occurrences 1, 5 and 14 took place, the valid ultralight licence aviation regulation laid down that pilots had to receive type training for each new ultralight type. This training had to concentrate on the flight manual and include a type training flight which was to last no less than 30 minutes and include at least five landings. In occurrences 5 and 14 the flights were just a little longer than the minimum required and the number of landings just met the minimum requirement.

The ultralight pilot licensing aviation regulation issued at the end of 2007 replaced type rating training with differences and familiarisation training. According to the present aviation regulation pertaining to ultralight pilot licences the pilot must receive familiarisation training for each new aircraft type and he must become familiar with the aircraft's flight manual during training. Differences training must be provided for ultralight amphibians and the training must include a sufficient number of practices. These practices must encompass all of the systems' normal and emergency procedures. Differences training can be provided by a flight instructor or a person who is well familiar with the type. The aviation regulation does not determine any specific minimum number for flight hours, practices or landings included in differences and familiarisation training. Nor is the content of said practices determined in any more detail than the abovementioned. This being the case, the volume and, largely, the contents of differences and familiarisation training is left to the judgement of the instructor and the trainee. The study revealed that there are no clear, uniform guidelines for differences and familiarisation training.

The investigators in occurrence number 5 believed that the training had shortcomings, particularly, with regard to aircraft loading and the centre of gravity. On the basis of the investigation report it can be taken that training, in this case, referred to basic and type training. When occurrence number 5 took place the requirement for a UPL licence included at least five hours of cross-country flights, no less than three of which were to be flown as instruction flights. The commission considered this to be insufficient. According to the investigation commission ultralight aviation should pay more attention to aircraft loading limits as well as highlight the importance of mass and balance calculations, at least in the basic and type training phases.

Occurrence number 20 was affected by the prevailing culture in ultralight flight training, in which some flight training organisations or individual flight instructors had taught their students to turn back towards the airfield from very low altitudes during simulated engine failures following takeoff. In occurrence number 20 a turn-back from a low altitude had been shown or instructed to the pilot, both in basic ultralight flight training and ultralight flight instructor training.

Investigation reports normally assess pilot training from a general perspective and in an concise manner. Some level B and C investigations, as well as most level D investigations, limit the analysis of pilot training to only stating which licences were valid at the time of the occurrence and when they would expire. Other investigations also state when the pilot began the ultralight flight training, on what aircraft type the training was flown, when the licence was issued, when the familiarisations training on the accident type was provided and how many flight hours and landings the training included. It seems that many investigations did not delve any deeper into pilot training and, therefore, it is difficult to consider the linkage between occurrences and shortcomings in training, if any. Potential shortcomings could also be found in the content of training, the safety culture of the training organisation as well as instructors' attitudes towards safety.

Limited flying experience

The pilot's limited flying experience contributed to 13 occurrences. In eight of them the pilot's limited flying experience on the type was a contributing factor and in one incident it may have contributed to the occurrence. In five occurrences the pilot's limited total flying experience was a factor and three incidents were affected by the pilot's limited recent flying experience. In two occurrences factors other than the abovementioned contributed to the incidents. Table 11 presents the pilot's limited flying experience with regard to different occurrences.

Table 11. The pilot's limited flying experience with regard to different occurrences. Occurrences marked with an asterisk (*) are those in which flying experience may have been a contributing factor.

Limited flying experience	**Occur-rence**
Limited flying experience with the aircraft type.	1 3* 5 14 15 16 17 18 19
Limited total flying experience.	15 16 17 18 19
Limited recent flying experience.	1 6 9
Considerable flying experience with airliners.	4*
Limited flying experience with regard to a turn-back.	20

In occurrence 1 the pilot's flying experience on the type was 21.1 hours which included 107 landings. While the investigation report does not directly state that the pilot's limited flying experience with the aircraft type played a role, later conversations with the investigator indicated that this was the case. The investigation report claimed that the aircraft type was so challenging that the pilot's practice flights did not provide him with sufficient skills with regard to the aircraft's characteristics or landing technique on a short airfield.

In occurrence number 3 the pilot had only flown 0.5 hours and two landings on the type. While the investigation report does not directly state that the pilot's limited flying experience with the aircraft type contributed to the onset of the occurrence, later conversations with the investigator indicated that this may have contributed to the pilot selecting the wrong wing flap setting at takeoff. Hence, the pilot's limited flying experience with the type may have been a contributing factor.

In occurrence number 5 the pilot had only flown 1.5 hours and 10 landings on the type. The investigation report states that the pilot's limited flying experience with the aircraft was a causal factor. Moreover, the report also states that in some cases pilots transfer to more demanding aircraft types with too little flying experience. Therefore, it can be inferred that the pilot's flying experience on the aircraft type was insufficient regarding its demands.

In occurrence number 14 the pilot had only flown 1.4 hours and six landings on the type. The experience was accrued on two flights. The investigation commission believed that the pilot's experience on the type was limited and that the pilot's flying experience of altogether two flights and six landings was a causal factor.

In occurrence number 15 the pilot had flown 3.3 hours on the aircraft type. The investigation report states that the pilot's limited flying experience with the aircraft type was a contributing factor.

In occurrence number 16 the pilot had flown 3.5 hours on the aircraft type. The investigation report states that the pilot's limited flying experience with the type can be regarded as a contributing factor.

In occurrence 17 the pilot had flown 6.8 hours and 33 landings on the type. The investigation report states that the pilot's limited flying experience with the type was a contributing factor.

In occurrence number 18 the pilot had flown approximately 33 hours on the type, which was also the student pilot's total flying experience. While the investigation report does not directly state that the pilot's limited flying experience contributed to the occurrence, later conversations with the investigator indicated that this was the case. The pilot was a student pilot whose flying experience, by definition, is limited.

In occurrence number 19 the pilot had flown approximately 10 hours on the type. The investigation report states that the pilot's limited flying experience was a contributing factor. This can also be interpreted to mean the flying experience on the type in question.

As a conclusion it can be said that when the pilot's limited flying experience either contributed to or may have contributed to the occurrence, the pilot had flown approximately 0.5–10 hours on the type. This excludes the two highest flight hour numbers in the range. The second highest number of flight hours, 21.1. hours in occurrence number 1, was probably considered to be insufficient with regard to the demands of the flight. In occurrence number 18 the pilot had the most flying experience, approximately 33 hours. The pilot was a student pilot whose flying experience, as a rule, is limited. Occurrence number 18 differs from the other cases in the sense that the pilots in other occurrences already had UPL licences.

In occurrence number 15 the pilot's total experience on ultralight aircraft was 33.8 hours, accrued over eight years. The investigation report states that the pilot's total flying experience was both limited as well as a causal factor.

In occurrence number 16 the pilot received the UPL licence in the autumn of 2007. His total flying experience on ultralights was approximately 53 hours. According to the investigation report, contributing factors included the pilot's limited total experience as well as his limited experience on operating from narrow runways.

In occurrence number 17 the pilot started his ultralight flight training in July 2008 and received the UPL licence in December 2008. His total flying experience was 48.2. hours, including 298 landings. According to the investigation report the pilot's total flying experience was both limited as well as a contributing factor.

In occurrence number 18 the pilot had a UPL student pilot licence with the total experience of approximately 33 hours on ultralights. Later conversations with the investigator indicate that the pilot's limited flying experience was a contributing factor.

In occurrence number 19 the pilot's total flying experience on ultralights was approximately 53 hours. The investigation report states that the pilot's flying experience was both limited as well as a contributing factor. It can be inferred that the pilot's limited total flying experience was a contributing factor.

In occurrence number 1 the pilot's total experience on ultralights was approximately 361 hours. This had been accrued over 14 years through varying annual flight hours. During the past 12 months he had flown approximately 30 hours which means that his recent flying experience can be considered to be relatively good. The previous flight before the accident flight was flown 3.5

months earlier. The investigation report infers that the pilot's recent flying experience to safely control the aircraft was degraded due to the 3.5 month hiatus in flying. This, as well as conversations with the investigator, make it justifiable to say that the pilot's limited recent flying experience contributed to the occurrence to a degree.

As regards occurrence number 6 the pilot had flown altogether 100 hours on aeroplanes and gliders between the period of 1983–1986. He quit flying in 1986 following an incident that resulted in damage. After this he had a 15 year hiatus in flying. His second flying phase began in 2003 at which time he started ultralight training from the very beginning. After this he had accrued 22.9 hours of total flying experience. The investigation report states that the pilot's limited recent flying experience contributed to the accident.

In occurrence 9 the pilot's total flying experience on all aircraft types amounted to approximately 190 hours, including 996 landings. In 2004 the pilot received approximately 10 hours worth of floatplane training on the accident aircraft. After this, during two years of flying on the accident aircraft he amassed approximately 20 flight hours on 19 flights, including 88 landings. Only five of the nineteen flights were either solo flights or flights with a person who held no licence. While these five flights encompassed altogether 53 landings, 49 of them were made on a single flight that lasted 1.1 hours. The investigation commission believes that takeoffs and landings performed in this manner do not provide adequate flying experience for floatplane landings at an unfamiliar location. The investigation report states that the pilot's limited recent flying experience contributed to the accident.

In occurrence number 4 the pilot's total flying experience on all aircraft types was approximately 17 000 hours, including approximately 77 hours on the type in question. The pilot was a professional airline pilot; in this type of aviation the onboard flight computer prevents the pilot from exceeding the aircraft's flight envelope, such as stalling the aircraft. There was no stall warning system on the ultralight accident aircraft. The pilot's considerable flying experience as an airline pilot may have contributed to the fact that he instinctively continued to pull on the control stick in a sudden abnormal situation, waiting for a stall warning. This means that the pilot's significant flying experience on jetliners may have contributed to the occurrence. One can also reason that the pilot's flying experience on ultralight aircraft was relatively limited in comparison to his extensive experience on jetliners.

In occurrence 20 the pilot who probably was the pilot flying began his ultralight flight training in 2006, and glider and PPL training in 2007. He started his ultralight flight instructor training in 2009. His total flying experience on all aircraft types was approximately 287 hours and 1063 landings, including approximately 149 hours and 713 landings on the type in question. While his recent flying experience was good, he had not flown that much from the flight instructor's seat. In 2006, during ultralight flight training, the pilots had flown turn-backs towards the runway from simulated engine failures following takeoff. It is not known whether he was controlling the aircraft himself at the time. Neither could the investigation establish whether he had possibly practiced turn-backs on solo flights before the flight instructor course. Nevertheless, the investigation commission believes that he had little experience with turn-backs before the course. On the flight instructor course's instruction practice flights the pilot flew turn-backs following takeoff. Since turn-backs were not taught at all on instruction flights or instruction practice flights, the experience accrued on an instruction practice flight cannot be considered sufficient. The pilot had very limited flying experience of simultaneous flying and instructing a turn-back; this contributed to the occurrence.

Poor flying skills

The pilot's poor flying skills were established as a contributing factor in nine occurrences, as shown in table 12. In five occurrences the pilot did not recognise the symptoms of an approaching stall. Two occurrences involved insufficient airspeed monitoring. In addition, in two occurrences, the pilot lost control of the aircraft at landing. In an additional two occurrences the contributing factors were other than the abovementioned.

Table 12. The pilot's poor flying skills in different occurrences.

Poor flying skills	**Occur-rence**
The pilot did not recognise the symptoms of an approaching stall.	1 4 9 17 20
The pilot insufficiently monitored the airspeed.	10 20
The pilot lost control of the aircraft at landing.	16 18
The pilot did not completely master the approach technique on a short runway.	1
The pilot had a rough flying style.	6

In five occurrences the contributing factor was that the pilot did not recognise the symptoms of an approaching stall. In all occurrences the airspeed became too low during the approach or in a climb. In occurrence number 1 the approach was stable and the pilot did not notice any slack in flight controls which could have been taken as a symptom of an approaching stall. In occurrence number 4 the pilot's extensive experience on jetliners may have contributed to the fact that, in a sudden abnormal situation while in climb, he intuitively waited for a stall warning and continued to pull on the control stick. In occurrence number 9 the aircraft stalled during the approach in a strong longitudinal wind. The investigation commission estimated that the pilot found it difficult to maintain proper airspeed because the ground speed is easily felt to be high in a strong tailwind. As regards occurrence number 17 the investigators believe that the stall developed so rapidly in a climb that the inexperienced pilot did not have the time to recognise the symptoms of an approaching stall. In occurrence number 20 the aircraft stalled in a turn-back towards the runway during the practice of simulated engine failure following takeoff. The pilot was probably incapable of paying sufficient attention to maintaining the airspeed. As the glide angle decreased, airspeed bled off and reached stall speed.

In all five occurrences the aircraft stalled at low altitude, probably no higher than 50 m. Due to the low altitude it was either difficult or impossible to recover from the stall. In at least two occurrences the pilot's course of action during the stall only made the situation worse. In occurrence 1 the aircraft was flying so low that the pilot had no chance to react to the rapid stall. He instinctively applied full opposite aileron, which probably only exacerbated the situation by increasing the angle of attack of the stalling wing. The only way to recover from the stall would have been to push on the stick but the low altitude did not permit this. In occurrence number 17 the pilot's corrective action was unsound. The aircraft went into a left sideslip, while simultaneously quickly losing altitude. When the aircraft was strongly banked to the left, the full elevator provided the turning momentum.

In occurrences 4 and 9 the stalled ultralight aircraft was an Ikarus C42. In occurrence 1 it was a Cora 200 Arius, an ATEC Zephyr 2000 in occurrence 17 and an EV-97 Eurostar in occurrence 20y.

In ultralight pilot theoretical instruction the stall is included under the subject of aerodynamics. The following topics, among other things, are taught: the aircraft's characteristics in a stall, factors that affect stall speed and the aircraft's behaviour in a stall, stalling in different configurations, symptoms of an approaching stall and stall warning systems as well as recovering from a stall. The topic of tailspin avoidance includes, among other things, the immediate and correct stall recovery technique. Some of the competence requirements for stall-related topics and tailspin avoidance are at level A, the highest level, and some at level B. For instance, the trainee should be able to safely and precisely apply in practice the factors that relate to stall speed and aircraft behaviour in a stall. The trainee should also be able to safely and precisely apply in practice the immediate and correct stall recovery technique. The trainee's competence is verified through knowledge examinations. With regard to aircraft characteristics in a stall, stalling in different configurations, the symptoms of an approaching stall and stall warning systems as well as stall recovery, only mastering the definitions of concepts and key terms at explanatory levels is required. This competence is not verified through examinations.

During classroom training on the principles of flight, the following topics related to flying at a low airspeed and stalling are taught: a gradually and rapidly developing stall, an accelerated stall, load factors and stall speed in a turn as well as load factors and stall speed in a wings-level recovery. Flying at a low airspeed and stalling is included, in its entirety, at the highest competence requirement level. This means that the trainee should be able to safely and precisely apply essential low airspeed and stalling-related information to practice. Competence is verified through examinations.

In ultralight flight training stalling is instructed during at least one flight. The purpose is to teach the student to recognise the stall and the symptoms of an approaching stall. The practice includes several stalls and stall recoveries, with or without engine power, as well as recovery from a stall when the aircraft is banked.

According to the airworthiness requirements of aviation regulations an ultralight aircraft must exhibit a clear and distinctive stall warning in straight flight and in a turn in any normal configuration. Stall warning can be provided through the aircraft's normal aerodynamic characteristics or with a device that provides a clearly distinguishable stall warning.

In two occurrences it was established that the pilot did not sufficiently monitor the airspeed. In occurrence number 10 the aircraft became difficult to control due to a low climb rate. Airspeed monitoring during the climb was either disregarded or careless. The pilot's attention focused on the tachometer reading and the poor controllability of the aircraft. In occurrence 20 the pilot flew a demanding right-hand turn-back from the right seat. This required constant airspeed and sideslip monitoring. Since the airspeed indicator and the turn indicator were on the left instrument panel, it made it difficult to read them in this situation. In both cases the aircraft was an EV-97 Eurostar.

In two occurrences the pilot lost control of the aircraft during landing, with the aircraft veering off the runway. In occurrence number 16 the aircraft rapidly dropped from approximately 4 m height from the surface of the airfield. The pilot tried to counter this by increasing power. Since the wind strength and direction varied before landing, the pilot lost control of the aircraft. This resulted in a hard landing, with the aircraft bouncing twice and veering off the runway. In occurrence 18, as the aircraft was approaching the ground, the pilot flared the glide angle. The aircraft came very close to the ground, whereafter it went into a climb. In order to avoid stalling the pilot increased power a little. Soon thereafter the pilot applied full power, resulting in loss of control of the aircraft. The aircraft turned and rolled to the left. The left landing gear and the nosewheel collided with the ground. The left wingtip, too, hit the ground. After the ground roll the nosewheel broke off at which time the propeller hit the ground and the engine died.

In occurrence number 1 the pilot's less-than perfect approach technique to a short runway was a contributing factor. He did not fully master throttle control in adjusting the rate of descent, or the use of the control stick in adjusting the angle of attack and airspeed.

In occurrence number 6, as per the investigation report, the pilot's rough flying style contributed to the occurrence.

Unsound course of action

As presented in table 13 the pilot's unsound course of action was established as a contributing factor in nine occurrences.

Table 13. The pilot's unsound course of action in different occurrences.

Unsound course of action	Occurrence
The pilot failed to perform a pre-flight inspection or checks in accordance with the checklist or the best practices in aviation before starting the engine or prior to takeoff.	2 6 10 14 19
The pilot did not check the landing area by first flying over it at a safe altitude before descending to a low altitude.	7 12
The pilot selected an unsuitable forced landing site.	11 19
The pilot failed to perform the mass and balance calculations prior to the flight.	5
The pilot did not land due to safety constraints.	11
Following the takeoff, the pilot commenced a climbing turn from a low altitude and at a low airspeed.	19

In five occurrences the pilot failed to complete a pre-flight inspection or checks as per the checklist or the best practices in aviation before starting the engine or prior to takeoff. In occurrence 2 the pilot did not check the float attachments during pre-flight checks during stopover landings, as per best aviation practices. The fact that the float attachments were coming loose would probably have been noticed at that time. In occurrence number 6 the pilot probably failed to check that the canopy lever was in the locked position before takeoff, as should have been done as per the best practices in aviation. The check would probably have caught the unlocked lever and, thus, prevented it from opening in mid-air. In occurrence 10 the pilot did not complete the takeoff checklist in accordance with the flight manual. This resulted in erroneous trimming. In occurrence 14 the pilot did not go through the engine start checklist, which resulted in leaving the throttle fully open at full power during engine start. As regards occurrence number 19, it is likely that not all of the procedures detailed in the checklist were completed. This resulted in the fact that both fuel cocks remained closed at takeoff.

In occurrences 7 and 12 the pilots intended to land on a lake; one landing was to be made on lake ice and the other on the water. In neither case did the pilot first check the landing site by flying over it at a safe altitude prior to descending to a low altitude. In both cases the aircraft hit power lines that crossed the lake. The pilots detected them too late to avoid them. The pilots would have been in a much better position to detect the power lines from a fly-over at a safe altitude.

In occurrences number 11 and 19 the pilots selected unsuitable emergency landing sites. In both of these instances the engines failed in flight. In occurrence 11 this happened at the edge of the control zone of the destination aerodrome and in occurrence number 19 this happened in a climb following takeoff. In occurrence 19 the pilot selected a field close to the destination aerodrome as his forced landing site. The field was more than 10 km straight ahead, beyond a body of water. This translated into a high likelihood of not making it all the way to the site following a glide. In occurrence number 19 the pilot did not select his forced landing site from the front sector. Instead, he turned towards a field that was next to the takeoff airfield. In both instances the pilots homed towards airfields even though they had several alternative forced landing sites which were closer to them, where they would have made it more reliably and in a safer manner.

Inadequate flight manual or AOM

An inadequate flight manual or AOM contributed to three occurrences, as presented in table 14.

Table 14. Inadequate flight manual or AOM in different occurrences

Inadequate flight manual or AOM	Occurrence
The manual did not mention the airspeed indicator error.	1 4
The manual did not mention that the aircraft was only designed to operate from licensed aerodromes.	4
The manual's centre of gravity range-figures did not correspond to the weighing certificate.	5

In occurrences number 1 and 4 the flight manual did not mention the airspeed indicator error. In occurrence 1 the airspeed indicator displayed an airspeed which was approximately 8–10 km/h too high at the approach speed. In occurrence 4 the airspeed indicator displayed an airspeed which was 5 km/h too high. In neither occurrence was the pilot aware of the magnitude of the error and believed that he was maintaining a safe airspeed margin to the stall speed. In reality, however, the airspeed was so low that it resulted in a stall.

In occurrence number 4 the flight and operation manual also failed to mention that the aircraft was only designed to operate from licensed aerodromes. In the flight manual's original English language version this was mentioned because in Germany, the aircraft's state of manufacture, ultralight operations are only permitted from licensed aerodromes. It is possible that the landing gear design did not sufficiently consider the fact that outside Germany the aircraft would also be operated from uneven fields. When pilots flew from uneven fields, as was the case in occurrence number 4, the pilot should have been made aware that the aircraft design criteria did not necessarily include operations from fields.

In occurrence number 5 the permissible range of the centre of gravity reported in the Finnish language flight manual did not correspond to the weighing certificate. The figures included in the weighing certificate were based on the aircraft manufacturer's weighing. These figures were not retroactively changed to correspond to Finland's tighter restrictions regarding centre of gravity limits.

Insufficient oversight

In occurrence number 3 the failure to supervise an engine modification was a contributing factor. In reality, nobody supervised the modification. This was partly caused by human error due to the responsibilities of Finavia's Civil Aviation Authority and the Finnish Aeronautical Association and partly because the pilot had completed the modification before obtaining the permission to do so. Neither was the modification inspected before the pilot received a permit to fly. Due to a structural flaw in the engine modification the engine died on the accident flight.

7.3.2 The Liveware-Hardware interrelationship

The factors under the Liveware-Hardware interrelationship that the study established as contributing factors were categorised into four entities. These were poor manufacture as well as poor construction or repair skills. The former suggests a defect which was already on the aircraft, its component or equipment as the aircraft left the manufacturer's premises. On the other hand, poor construction or repair skills refer to the pilot's, owner's, operator's or fabricator's construction and repair skills. The other entities were incorrect loading and the pilot's poor skills in using cockpit equipment.

Poor manufacture

As per table 15 poor manufacture was a contributing factor in five occurrences.

Table 15. Poor manufacture in different occurrences.

Poor manufacture	Occurrence
The airspeed indicator displayed an airspeed that was too high or was otherwise unreliable.	1 4 15
Seat harness attachments were too weak.	4
Combustible material in the heating system.	8
The wheel brakes could not keep the aircraft at a standstill at full power.	14

In occurrences number 1 and 4 the airspeed indicator displayed an airspeed that was too high and in occurrence number 15 the indication was unreliable. In occurrence 1 the airspeed indicator display had an error which varied in magnitude and direction, depending on static pressure in the cockpit. In the approach speed range the indication was approximately 8 km/h too high; the error grew as airspeed increased. In occurrence 4, as per the aircraft's type-certification inspection, the airspeed indicator error was +5 km/h. In occurrence number 15 the pilot said that the airspeed indicator on the instrument panel was unreliable. The airspeed range on the indicator was 0–140 km/h. The contributing factor involved the difficulty to determine airspeed due to the unreliable airspeed indicator. In all of the occurrences the airspeed indicators were already installed by the manufacturer.

Another contributing factor in occurrence number 4 was the fact that the seat harness attachments failed at a load lighter than that of airworthiness requirements. The manufacturer had installed the seat harnesses. As a result of this failure the pilot and the passenger hit their faces on the sharp top edge of the instrument panel, which caused some of their serious injuries.

In occurrence number 8 the heating duct that led warm air from the heat exchanger to the cockpit as well as its control valve on the firewall were made of flammable material. When a fire broke out in the heating system in flight, they were destroyed. Materials used in these locations should not be easily combustible. The aircraft manufacturer chose to use flammable materials in these heating system components.

In occurrence number 14 the wheel brakes could not keep the aircraft at a standstill at full power after engine start. The wheel brakes were already on the aircraft when it was delivered from the manufacturer.

Poor manufacture does not always infer mediocre manufacturing skills. There is a desire to make ultralight aircraft light and in a cost-effective manner. This being the case, parts and components that are not considered to be crucial for safety are not necessarily constructed with top quality in mind.

Poor construction or repair skills

The poor construction or repair skills of the pilot, owner, operator or constructor either contributed or may have contributed to seven occurrences, as presented in table 16.

Table 16. Poor construction or repair skills in different occurrences. In the occurrence marked with an asterisk (*) poor construction or repair skills may have contributed to the occurrence.

Poor construction or repair skills	Occurrence
Fuel system	3 11
Airspeed indicator	9* 15
Float attachment	2
Canopy locking structure	6
Nose landing gear skid	13
Left aileron	15

A structural fault in the aircraft's engine fuel system was a contributing factor in occurrences 3 and 11. In both instances the engine was starved of fuel as a result of a construction or maintenance error; the engine died in flight. In occurrence number 3 the pilot incorrectly installed the engine fuel pump return line. This resulted in fuel vapours collecting in the fuel pump and the aspirator line, causing a vapour lock on the accident flight. The vapour lock blocked fuel flow to the engine and the engine died on the accident flight. In occurrence 11 an overly long hose had been installed on the fuel system during maintenance. While in flight the overly long hose, as a result of bending, flattened at a turn in the fuel line junction, located between the airframe and the wing. This blocked fuel flow from the right tank and the engine died.

In occurrences 9 and 15 the airspeed indications were unreliable. In occurrence number 9 the airspeed indication was probably unreliable, which may have been a contributing factor. The aircraft had been washed a few days before the accident. The airspeed indicator was noticed to stick on flights that followed the washing, which is a typical symptom of water in the pitot-static system. While no water was found in the pitot-static system after the accident, this does not rule out the possibility that there may have been water in the system on the accident flight. In occurrence number 15 the pilot believed the airspeed indicator on the instrument panel to be unreliable and, therefore, he had installed a tube anemometer outside the cockpit for the purpose of airspeed indication. The investigators thought that anemometers are unsuitable for use in aircraft because the installation location is prone to disturbance and the scale's range did not reach 100 mph, the highest permissible airspeed. The range of the scale was 10–80 mph. Anemometers are commonly used as airspeed indicators, for example, in weight-shift controlled ultralights, which normally fly at considerably lower airspeeds than surface-controlled ultralights.

In occurrence number 2 unsuitable structural solutions were used in the float attachment. Material which was too soft had been used at crucial points of the attachment. Moreover, different types of material were layered, which caused sliding surfaces and wear on the attachment. The cross braces between the pontoons had been bought from boating supplies. What is more, locknuts were not used in the attachment.

In occurrence number 6 the structure of the amateur-built canopy locking system made it possible for the canopy to open in flight. From the safety standpoint the locking system was defective because it did not have a safety latch which could have prevented an inadvertent opening.

In occurrence number 13 the nose landing gear skid, a modified snowboard, was too weak. It broke off at takeoff. The owner of the aircraft had fabricated the skids from snowboards.

In occurrence number 15 the pilot incorrectly repaired the aircraft's damaged left aileron. Additionally, the soft fabric used on the aileron decreased the aileron effect. Both factors contributed to insufficient aileron effect.

Incorrect loading

Incorrect loading contributed to four occurrences, as shown in table 17. Incorrect loading means that the loading exceeded the maximum takeoff mass (MTOM) or that the loading moved the centre of gravity (CG) outside the permissible range. The MTOM and the permissible range for the CG are given in the flight manual. In each occurrence presented in table 17 the case involved two-seater landplanes with the MTOM of 450 kg.

Table 17. Incorrect loading in different occurrences.

Incorrect loading	Occurrence
The mass of the aircraft exceeded its MTOM	4 5 20
The centre of gravity was outside the permissible range	3 5

Excess weight contributed to occurrences 4, 5 and 20. In occurrence 4 the takeoff weight exceeded the MTOM by 17.5 kg. This degraded acceleration, lengthened the takeoff distance and increased the stall speed. In occurrence 5 there was approximately 85 kg extra weight on the accident flight and 32 kg in occurrence 20, respectively, which increased the stall speed. In each case the excess weight was reported in relation to 450 kg, the MTOM.

In occurrences 3 and 5 the CG was clearly outside the permissible range. In occurrence 3 the CG was forward of the permissible range and in occurrence 5 it was aft of the permissible range. In both occurrences the location of the CG significantly degraded longitudinal control.

Performance values given in the flight manual are normally based on the MTOM. Excessive weight degrades aircraft performance. Among other things, takeoff distances become longer, climb and turn rates decrease, stall speeds increase and the flight manual's cross-country and landing performance figures no longer apply. Excessive weight affects the manoeuvrability of an aircraft and it may affect its controllability as well. Changes vary by type and they cannot be accurately predicted. Excessive weight may also strain aircraft structures.

The minimum useful load of a two-seater ultralight must be at least 175 kg. In conjunction with occurrence number 20 the investigation commission calculated the minimum useful loads of ten randomly selected Finnish-registered ultralights; the average minimum useful load was approximately 180 kg. The calculation relied on the manufacturers' mass and balance information. This mass should include the weight of the fuel that is required for the flight as well as the weight of people and baggage. It is often challenging to load a two-seater ultralight aircraft in a way that does not exceed the MTOM when two people go on a flight. The minimum useful load of many ultralight types does not permit the loading along with two people and fuel without exceeding the MTOM. Equipment may often be added to the aircraft after its original weighing, which only further reduces the minimum useful load. In occurrences 4, 5 and 20 there were two people in the aircraft. When one person flies in a two-seater ultralight, loading is rarely a problem.

In ultralight theoretical instruction the subject of mass and centre of gravity includes instruction on maximum mass limitations, CG forward and aft limits and CG calculations made by using the aircraft's flight manual and weighing certificate. The required competence level is the highest in which case the student should be able to safely and correctly apply the essential information to practice. As regards occurrence number 20 the investigation commission came to believe that ultralight flight training does not pay sufficient attention to excess weight because instruction flights are flown with excess weight that require mass and balance calculations are typically only cross-country flights.

Poor skills in using cockpit equipment

The pilot's poor skills in using cockpit equipment contributed to three occurrences, as shown in table 18.

Table 18. The pilot's poor skills in using cockpit equipment in different occurrences. In the occurrence marked with an asterisk (*) the poor skills may have contributed to the occurrence.

Poor skills in using cockpit equipment	Occurrence
Wing flap lever	3*
Throttle lever	14
Ignition switch	14
Fuel cock selector knob	19

In occurrence number 3 the pilot inadvertently selected full wing flap at takeoff, which may have been the result of the pilot's poor skill in using the wing flap lever. When the pilot used the lever the aircraft was in a takeoff run on the runway. The pilot probably focused most of his attention on controlling the aircraft at the time. The investigation report does not mention any details of the wing flap lever, or where in the cockpit it is positioned. On the basis of this information one cannot exclude the possibility that the wing flap lever would have been incompatible with the pilot. In this case the construction of the wing flap lever would be unsatisfactory.

In occurrence number 14 the engine went straight into full power when it was started and the aircraft began to roll. Although the pilot tried to stop the aircraft by braking, in an unexpected situation he did not find the throttle to set the engine to idle. Neither was he able to kill the engine from the ignition switch; he was too occupied with trying to steer the aircraft, remain on the runway and avoid colliding with anything.

In occurrence number 19 the aircraft had two fuel selector knobs. One of them was open and the other one was closed before the accident flight. Even though the intention was to open the fuel cock that was closed, the selector knob that was open was probably inadvertently closed just prior to takeoff or during takeoff. As a result, both fuel cocks were closed at takeoff and the engine died soon after takeoff.

7.3.3 The Liveware-Environment interrelationship

The factors under the Liveware-Environment interrelationship that the study established as contributing factors were categorised into two entities: meteorological conditions and other environmental factors. The meteorological conditions that either contributed or may have contributed to occurrences are shown in table 19. The other environmental factors are shown in table 20.

Table 19. Meteorological conditions in different occurrences. In the occurrence marked with an asterisk (*) the meteorological conditions may have contributed to the occurrence

Meteorological conditions	Occurrence
Strong and/or gusty wind	9 15 16
Tailwind	4 9
Lighting conditions	7 12
Conditions favourable to hoarfrost	17*

In occurrence number 9 the wind was strong and gusty but otherwise the flying weather was good. The investigation report stated that the strong and gusty wind contributed to the occurrence. The investigation report of occurrence number 15 states that, according to the pilot, it was windier during the accident flight compared to his earlier flight the same day. According to the investigation report the wind hit the aircraft and the aircraft went into a tailspin. Although the investigation report does not claim that the wind would have contributed to the occurrence, both the abovementioned information and conversations with the investigator leads to the belief that the gusty wind contributed to this occurrence to a degree. In occurrence number 16 the wind was variable, both in direction and strength, which, according to the investigation report contributed to the pilot losing control at landing. In each case the wind made it more difficult to control the aircraft.

In occurrences 4 and 9 it was particularly a tailwind that contributed to the occurrences. In occurrence number 4 the tailwind lengthened the takeoff distance, causing the aircraft to take off close to aerodrome obstacles. This forced the pilot to turn at a low altitude and at a low airspeed, which resulted in a stall. Also, in occurrence number 9, the tailwind probably contributed to the pilot's action with the result that the aircraft stalled. The tailwind was strong. An inexperienced pilot may find it difficult to maintain proper airspeed because the ground speed easily feels high in a strong tailwind. In both occurrences the aircraft was an Ikarus 42C.

In occurrences 7 and 12 the lighting conditions were contributing factors. In occurrence number 7 the low sun angle straight ahead made the early detection of a power line difficult. In occurrence number 12 the grey lighting conditions made it difficult to detect the grey power line against the backdrop of the grey lake surface. Moreover, the sun was possibly shining from straight ahead, dazzling the pilot.

In occurrence 17 the conditions favourable to hoarfrost may have contributed to the occurrence. It is possible that hoarfrost formed on the wings prior to the accident when the aircraft was brought outside from the hangar or during taxiing. The aircraft stalled in a climb. Hoarfrost and other contamination on the wing increase the stall speed of an aircraft. Approximately 30 minutes after the accident a thin layer of hoarfrost and a few frozen droplets of water were detected on the wings. The investigation could not establish whether there was any hoarfrost on the wings at the time of the accident.

Table 20. Other environmental factors in different occurrences.

Other environmental factors	Occurrence
Unfavourable takeoff site conditions	4
Haste	13

In occurrence number 4 the unfavourable conditions at the takeoff site contributed to the occurrence. The conditions included an uneven field and an incline, which lengthened the takeoff distance.

The onset of occurrence 13 was affected by haste which was caused by environmental factors. The accident happened 8 minutes before sunset and twilight lasted only 52 minutes after sunset. The pilot and the passenger were in a hurry to get to the destination before nightfall.

7.3.4 The Liveware-Liveware interrelationship

The factors under the Liveware-Liveware interrelationship that the study established as contributing factors are presented in table 21.

Table 21. Poor communication in different occurrences.

Poor communication	Occurrence
Misunderstanding	2
Other failure in communication	19

In occurrence number 2 the owner of the aircraft at the time of the accident flight partly misunderstood the previous owner's instructions on how to install the floats. The instructions were given over the telephone. As a result, the owner installed the floats in a somewhat incorrect manner, which contributed to the occurrence.

In occurrence number 19 a factor that belongs under the Liveware-Liveware interrelationship can be considered to have existed between the pilot and the passenger, possibly a failure to communicate before takeoff or in flight. It is probable that the pilot or the passenger inadvertently closed the open fuel cock selector knob before takeoff or at takeoff.

7.3.5 Précis

Five of the 20 investigated occurrences led to fatalities; in all, six persons perished. Four occurrences resulted in serious injuries to five persons. In most occurrences the aircraft was either badly damaged or destroyed.

Whereas the pilot flew alone in 13 occurrences, on the remaining flights the pilot was accompanied by a passenger or another licensed pilot. Only in occurrence number 20 were there two pilots on the accident flight, the second one probably the pilot flying at the time of the accident. The average age of the pilots in all occurrences was 50.3, ranging from 31 to 78. In almost all occurrences the pilot had an UPL licence. Occurrence number 18 was the exception, in which the pilot had an ultralight flight student licence. In nearly all instances the pilots' UPL licences were valid at the time of the occurrence. There was one exception in which the pilot's UPL licence had expired about a month before the accident flight. This, however, did not contribute to the occurrence. In a couple of cases the pilot or the probable pilot flying had yet other licences in addition to the UPL licence. The pilot in occurrence 2 held an ultralight flight instructor-rating and in occurrence 20 the pilot had completed an ultralight flight instructor course. While he was not yet instructor-rated, he held an ultralight student flight instructor rating.

In five occurrences, i.e. approximately 25 % of all occurrences, the accident, minor accident or serious incident happened to an Ikarus C42, C42B or C42S, i.e. an ultralight aircraft type manufactured by the German Comco Ikarus GmbH. In two cases the aircraft was a Slovak-made Dynamic WT-9 and in two instances the occurrence involved a Czech-made EV-97 Eurostar. With regard to the other occurrences, the aircraft involved different types each time. During the period of review the clearly most popular class B ultralight aircraft types in Finland were the Ikarus C42 and Ikarus C42B. Hence, it only makes sense that they were also represented the most in this study. One cannot say the same about the Dynamic WT-9; during the review period there were only three of them registered in Finland. The first Dynamic WT-9 that was imported to Finland was the aircraft which was destroyed in occurrence number 5. Since then two of them have been imported to Finland, one of which was destroyed in occurrence number 19. The EV-97 Eurostar has been a popular ultralight aircraft type in Finland during the period of review.

When the occurrences were categorised per the phase of flight, eight of them happened during the approach or landing. Six happened during the takeoff or climb and five on cross-country flights. Eleven of all occurrences happened during the summer months, i.e. in June, July and August. Five of them occurred in the winter, in January and February. Three of them occurred in the spring, in April. Only one occurrence took place in the autumn, in November. One half of the occurrences happened between 12:00–18:00 hours, seven occurrences between 18:00–24:00 and three occurrences between 09:00–12:00. In 13 occurrences the aircraft had wheels as landing gear. In three occurrences the ultralight was fitted with floats and two occurrences involved aircraft that had skids as landing gear at the time of the occurrence. One occurrence involved an ultralight amphibian which had floats as well as retractable wheels. Amphibians can operate, i.e. take off and land, from land or water. In one occurrence the ultralight was fitted with wheels and skids.

As the contributing human factors were analysed with the SHELL model, factors could be attributed to each SHELL interrelationship, albeit many more to some than others. The largest part of the factors could be found under the Liveware-Software interrelationship, followed by Liveware-Hardware. Fewer were found in Liveware-Environment and the least amount in Liveware-Liveware. Judging by the research material the factors that contributed the most to the occurrences were the pilot's limited flying experience, poor flying skills and unsound course of action. In recently investigated occurrences the pilot's poor flying skills contributed to every occurrence. The contributing factors that played a role in the occurrence were the only factors that were included in this study. During the reading of the investigation reports many other factors were also found which, in different conditions or chains of events, could have contributed to the occurrence in question. Still, they were not considered to be contributing factors.

Table 22 graphically illustrates the division of human factors analysed in chapter 7.3, i.e. the entities between and behind different SHELL-interrelationships. The occurrences are presented in chronological and numerical order, so as to demonstrate the development of said factors during the period of review. The pilot's inadequate training contributed or may have contributed to 13 occurrences. Nine occurrences were affected by the pilot's poor flying skills and unsound course of action. Shortcomings in the flight manual contributed to three occurrences. In only one occurrence the failure to supervise the pilot was established as a contributing factor. In five occurrences shortcomings in manufacturing were contributing factors. The poor construction or repair skills of the pilot, owner, operator or constructor either contributed or may have contributed to seven occurrences. Incorrect loading was a factor in four occurrences. The pilot's poor skills in using cockpit equipment contributed or may have contributed to three occurrences. When it comes to environmental factors, meteorological conditions contributed or may have contributed to seven occurrences, and other environmental factors to two occurrences. Failure in human communication was only found to be factor in two occurrences.

Judging by the investigated occurrences it seems that the very same factors show evidence of shortcomings during the entire period of review. While there is some annual variation, this is only normal and happenstance. Looking at table 22 it would seem that shortcomings in flight manuals only contributed to occurrences in the early 2000s. However, on the basis of the study it is impossible to categorically state that shortcomings in flight manuals would have ceased to exist. After all, occurrences investigated at the end of the review period found such shortcomings in flight manuals which, in other conditions, could have been contributing factors. Judging by the study and table 22 it is impossible to establish any clear changes in human factors that contributed to the occurrences during the period of review.

Table 22. Summation of SHELL analyses.

Occurrence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Σ
Liveware-Software																					
Training	X				X									X						X	4
Flying experience	X		X	X	X	X			X					X	X	X	X	X	X	X	13
Flying skills	X			X		X			X	X						X	X	X		X	9
Course of action		X			X	X	X			X	X	X		X					X		9
Flight manual	X			X	X																3
Oversight			X																		1
Liveware-Hardware																					
Manufacture	X			X				X						X	X						5
Construction/repair		X	X			X			X		X		X		X						7
Loading			X	X	X															X	4
Use of equipment			X											X					X		3
Liveware-Environment																					
Weather				X			X		X			X			X	X	X				7
Other factor				X															X		2
Liveware-Liveware																					
Communication		X																	X		2

The analysis of human factors relied, for the most part, on final investigation reports. The reports contained a certain degree of variation which made it more difficult to analyse the human factors that contributed to the occurrences in a standardised manner. This variation was mainly caused by the fact that occurrences were investigated at different levels and by several investigators. Chapter 8.3 analyses the different levels chosen for the investigations in more detail.

8 IMPROVEMENT OF ULTRALIGHT AVIATION SAFETY THROUGH ACCIDENT INVESTIGATION

8.1 The impact of accident investigation in general

The goal of accident investigation is to improve safety and prevent accidents. Accident investigation indirectly contributes to safety by means of its investigation reports by presenting the history and factual information of occurrences, analysing it, drawing conclusions and issuing safety recommendations. Safety recommendations crystallise the accident investigators' opinion of what should be done to improve safety. Key principles in the formulation of safety recommendations include targeting, practicality and unambiguous, measurable goals. Consequently, a safety recommendation must be directed at an organisation which is able to function in the manner prescribed. Since recommendations are not binding requirements, they may be directed at anyone or thing. It is up to the recipient of the recommendation to decide which measures are to be carried out. In some instances other sections in the investigation report provide such background information that makes it possible for the recipient(s) to draw their own conclusions and consider further action. Accident investigation does not lay down rules and regulations, nor does it decide what is to be done to improve safety. If this were the case, then the Accident Investigation Board of Finland (AIB) would be partly responsible for safety and could also have to explain its possible accountability in the next accident investigation. (66)

The AIB follows the implementation of safety recommendations, and at times the media, too, probes into it. This monitoring, for its part, acts as a reminder of the safety recommendations that have been issued and it may even promote their implementation. Monitoring and coverage of noncompliance in the media are means of advancing the implementation of safety recommendations and by so doing promote public safety. Monitoring ascertains attitudes towards safety recommendations, determines which types of safety recommendations best advance safety as well as what kind of recommendations are only likely to remain as proposals. This being the case, the issuance of safety recommendations has been improved by assigning accountability to recommendations as well as such concrete goals that make it possible to later determine the status of their implementation. This tends to weed out the most wide-ranging safety recommendations. Nonetheless, general ideas can be brought up elsewhere in the investigation report. (66)

The first prerequisite for the accident investigation report having an impact is that the focus groups receive the report and also read it. Even just reading the report can often have a positive effect on safety. There are normally things in the report that contain informative value. When it comes to aviation, it is also often useful to read reports that concern types of aviation close to one's own. For example, an ultralight pilot can benefit from reading glider and powered glider or general aviation accident investigation reports in addition to reports concerning ultralight aviation. Investigation reports are promulgated free of charge as hardcopies as well as on the Internet. The share of the latter has lately been on the rise. In addition to publishing safety recommendations and investigation reports the AIB aims to influence and promulgate safety-related information to many focus groups by informing the media of the results of investigations. Furthermore, accident investigators present the investigation process and completed investigations at several events on an annual basis. The audience is often in the position to make a difference in safety-related issues. Time and again, safety improvements involve available financial resources and how they are allocated. Accident investigation may be able to influence this. (66)

In the autumn of 2002 the AIB commissioned a study in which the AIB's focus groups, such as different safety authorities, operators, the rescue service and certain trade unions, were interviewed. On the aviation side the groups included, among others, Finavia and the Finnish Aeronautical Association. The AIB received positive feedback for a job well done and accident investigation, in general, was considered to be a good investment of public resources. According to the study, there was a desire to see more occurrences investigated. The focus groups would also like to provide expertise to the investigations and for the improvement of the investigation process. Criticism from the focus groups brought out that sometimes too many safety recommendations were issued and that these recommendations were not always well thought through. Too many recommendations cause an inflationary effect, Therefore, it behoves one to speak less often and with more gravitas. Other issues that were brought up included improving consultation with associated organisations, the importance of independence and high ethical standards as well as active and methodical communications. As regards the Internet, the study stated that when information increasingly migrates online, it does not automatically translate into information reaching the operators. The focus groups also hoped that the AIB would actively promulgate international accident investigation information because the international exchange of information for the purpose of benefiting from the results of accident investigation has been scant. The focus groups also proposed that the safety authorities and operators in aviation, navigation and railroads would do more to learn from each other's experiences and take advantage of the other sectors' best practices. (67)

The focus group study also separately analysed the different investigation branches. The AIB received the hardest, although constructive, criticism on aviation investigation. Most attention was given to the recommendations: better relevance, clarity and consistency were desired. Attention was also paid to the independence of accident investigation and the lack of follow-up regarding the recommendations. According to the study the actors in aviation, such as the civil aviation authority, implement all possible safety improvements with or without AIB recommendation. Nevertheless, the AIB's accident investigations were considered to be beneficial. (67)

Between December 2004 and January 2005 the AIB conducted an accident investigation report reader survey in order to gather information to support better investigations and reports. For the most part the survey polled information related to the manner in which reports were being read. Questions included, among other things, which parts of the reports the readers found most interesting. Additionally, readers were polled on whether the reports were perhaps too long and why the respondents chose to read them in the first place. The survey provided the general impression that accident investigation was considered to be beneficial. While critical and even negative comments were also received, nobody questioned the significance of investigation to safety. Criticism may have been mitigated by the fact that the respondents were probably interested in accident investigation, they had read reports and had a positive opinion regarding investigation in general. Most respondents said that they read the reports on professional grounds or to learn more, or to obtain more information. The survey did not directly ask the respondents to detail how the investigations have possibly improved safety. (68)

A report pertaining to measuring the input of accident investigation was completed in January 2010. According to the report the AIB had hitherto attempted to assess the impact of its activity through monitoring the implementation of safety recommendations, focus group studies and reader surveys. The report also states that the monitoring of the implementation of safety recommendations does not suffice in assessing the impact of accident investigation. In addition to the AIB issuing some safety recommendation, several other issues are also at play with regard to its implementation. A major accident alone can spawn a debate which can result in the same conclusions as accident investigation. It can also happen that an accident may speed up the implementation of a long drawn-out proposal with regard to safety. A promptly published investigation report may also have a similar effect. (66)

According to the report completed in January 2010 it is impossible to directly measure how much accident investigation improves safety or how many accidents it can help prevent. Accident investigation's direct effect on safety, such as a decrease in accident rates as a result of the investigations, cannot be demonstrated. One of the problems is that it is impossible to precisely isolate the

AIB's effect on safety from a myriad other safety-related factors. Nevertheless, as per the report, it is possible to gauge the input of accident investigation in many ways through indirect means. It is possible to set indirect and sector-specific goals for accident investigation whose realisation can be measured. Each specific sector should be measured in its most appropriate manner. According to the report the means of assessment include different-sized surveys which are directed at different target groups, questionnaires, media monitoring and self assessment. In addition, information should be gathered from safety levels, the dissemination of information resulting from accident investigation as well as changes in the recipients' course of action. Background information for the assessment of effect regarding some sectors can be obtained by gathering information on related operating costs, the economic consequences of accidents and, possibly, on the costs of various actions that affect safety. (66)

Sector-specific basic statistics lay the foundation for measuring the input of accident investigation. According to the report these include, at the very least, the number of accidents, the costs resulting from accidents, the number of investigations, the circulation of investigation reports, the number of web hits, audience numbers at various events, investigation times, investigation costs, the extent of international cooperation and following up the implementation of safety recommendations. Sector-specific impact assessments create the best possible overall picture regarding the role of accident investigation. Since quantitative results are probably scarce, the result constitutes, for the most part, a qualitative and somewhat comparative assessment. (66)

It is also very difficult to directly assess how accident investigation improves the safety of ultralight aviation. According to the report, however, this can be indirectly gauged by analysing the input of the different sectors. The ultralight accident and damage statistics presented in chapter 6 lay the foundation for assessing the development of ultralight aviation safety. Judging by these the safety of ultralight aviation gradually improved in the 2000s. The human factors analysed in chapter 7 that contribute to ultralight accidents, minor accidents and serious incidents, in turn, provide an underpinning for an analysis of their evolution during the period of review. As stated in chapter 7 it is difficult to establish any clear changes in human factors that contributed to the occurrences in the 2000s. Therefore, this chapter mainly focuses on safety recommendations that were issued and their implementation as well as the effect of accident investigation on their implementation. In addition, this chapter examines the volume and categories of accidents, minor accidents and serious incidents in ultralight aviation as well as investigation times and costs.

8.2 The implementation of safety recommendations

The AIB issued altogether 14 ultralight-related safety recommendations in the class B investigations it started in the 2000s and which were completed by the end of May 2010. Ten of them, i.e. approximately 71 %, were implemented by the end of May 2010. One recommendation was still pending and three will not be implemented. A safety recommendation is counted as implemented so long as it is at least partly implemented. Ten of the safety recommendations were directed at the aviation authority, three at the FAA and one at an ultralight aircraft manufacturer. The following paragraphs list all safety recommendations, grouped by each investigation. The list presents the content of each recommendation, the recipient and the status of its implementation, which is indicated in brackets following the recommendation. The status of implementation regarding safety recommendations directed at the aviation authority and the FAA is based on interviews with them, and the status of the other recommendations is based on the AIB's safety recommendation follow-up. Investigations D2/2009L and B6/2009L are the AIB's last class B ultralight investigations started in the 2000s that involve safety recommendations. The investigations were completed in June 2010 – at the same juncture as this study. The safety recommendations presented therein, altogether seven, are also detailed in the chapter.

Investigation C11/2002L issued four safety recommendations:

1. The investigation commission recommended that the CAA's Flight Safety Authority supplement its regulation with regard to the supervision of amateur-built aircraft fabrication. (not to be implemented)
2. The investigation commission recommended that the CAA's Flight Safety Authority require appropriate planning in powerplant modification and expert inspection of said modification as well as comments whenever powerplants other than aviation engines were modified for use in aviation. (not to be implemented)
3. The investigation commission recommended that the CAA's Flight Safety Authority expand the opportunities for the initial inspections of amateur-built aircraft with regard to the monitoring of the airworthiness of the aircraft and their equipment. (not to be implemented)
4. The investigation commission recommended that the FAA pay special attention to the assessment of fabricators' skills during the construction permit application process. (implemented)

Investigation C7/2003L issued two safety recommendations:

1. The investigation commission recommended that the CAA's Flight Safety Authority pay attention to the installation of seat harnesses on the Ikarus C42 ultralight aircraft. (implemented)
2. The investigation commission recommended that the CAA's Flight Safety Authority require the inclusion of airspeed indicator calibration charts in all ultralight aircraft flight manuals. The information in said charts shall rely on import inspections or flight tests. (implemented)

Investigation B1/2004L issued three safety recommendations:

1. The investigation commission recommended that the FAA ensure that, during basic and advanced instructor training, instructors make certain that students fully understand the D-marked topics and that their competence is ascertained through practical examples and competence testing. (implemented)
2. The investigation commission recommended that the CAA's Flight Safety Authority pay attention to different ultralight aircraft types' control characteristics and performance values and, when necessary, specify the requirements set for type rating training. (implemented)
3. The investigation commission recommended that the CAA's Flight Safety Authority consider raising the requirements for an Ultralight Pilot Licence to correspond to the quality and function of present ultralight aircraft types. (implemented)

Investigation D6/2006L issued one safety recommendation:

1. The investigation commission recommended that the aircraft manufacturer replace the duct and valve materials with incombustible materials. In addition, it was recommended that the fireproofing of all ultralight aircraft firewall structures and feed-through conduits be checked during importation and inspections. (implemented)

Investigation D9/2006L issued one safety recommendation:

1. The investigation commission recommended that the Finnish Civil Aviation Authority together with the FAA and AIB, design a warning marker that would forewarn of a ballistic parachute system, and indicate the location of the rocket motor. (implemented)

Investigation C5/2007L issued two safety recommendations:

1. The investigation commission recommended that the FAA draw up general instructions and a generic checklist for taxiing and engine runups with ultralight aircraft. In addition, it was rec-

ommended that ultralight flight instructors' basic and refresher training emphasise the correct use of checklists. (implemented)

2. The investigation commission recommended that the Finnish Civil Aviation Authority amend the content of the type rating training segment in PEL M2-70 so as to better take into account the effect of different ultralight aircraft cockpit layouts and technical characteristics in training. (implemented)

Investigation D2/2008L issued one safety recommendation:

1. The investigation commission recommended that the Finnish Civil Aviation Authority clarify the test pilot's flying experience requirements and provide the required regulations to the FAA. (pending)

Investigation D2/2009L issued one safety recommendation:

1. The investigation commission recommended that the aircraft manufacturer add a clear mention to the Flight and Operations Manual that the pilot must make certain before each flight that the wings, stabilisers and control surfaces are free of snow, ice, hoarfrost or other contaminants.

Investigation B6/2009L issued six safety recommendations:

1. The investigation commission recommended that Trafi Aviation clarify the content of aviation regulation PEL M2-71, making it unambiguous with regard to the ultralight student flight instructor rating.
2. The investigation commission recommended that the Finnish Aeronautical Association prepare written guidelines for the instructors referred to in aviation regulation PEL M2-71 that supervise student flight instructors in sport aviation.
3. The investigation commission recommended that the Finnish Aeronautical Association lead a process in which the syllabi of ultralight pilots and flight instructors be made more detailed, and that instructions on how to fly manoeuvres as well as vital safety limits and goals for learning be included in the curricula.
4. The investigation commission recommended that Trafi Aviation lead the preparation of written proficiency standards for the instructors of sport aviation flight instructor courses, and that opportunity for training which provides such proficiency be arranged.
5. The investigation commission recommended that Finavia and the Emergency Response Centre Administration update their mutual measures and instructions related to air accidents.
6. The investigation commission recommended that Trafi Aviation take action against flying with aircraft exceeding the maximum takeoff weight.

The following assesses how the implemented or at least partly implemented safety recommendations issued to the aviation authority and the FAA were put into practice. Additionally, the effect of accident investigation on their implementation is estimated. Accident investigation has the greatest effect on the implementation of a safety recommendation when the justification for the recommendation was established, specifically, in accident investigation and the measure to be implemented is put into practice, specifically, as a result of the AIB's safety recommendation. A safety recommendation can also speed up corrective action with regard to an already known shortcoming. In this case the safety action that was implemented in order to put a safety recommendation into practice cannot exclusively be attributed to accident investigation. Still, the investigation, for its part, has prodded the measure along. In addition, the following provides a short description of those safety recommendations that were directed at the aviation authority and the FAA which are pending or which will not be implemented.

Investigation C7/2003L established that the seat harness attachments failed at a load which was lighter than that of airworthiness requirements. As a result of this failure the pilot and the passenger hit their faces on the sharp top edge of the instrument panel, which caused some of their serious injuries. The commission in investigation C7/2003L recommended that the CAA's Flight Safety Authority pay attention to the installation of seat harnesses in Ikarus C42 ultralight aircraft. Investigation revealed that the seat harnesses in newer Ikarus C42 B aircraft already had sturdier attachments. As a result of the safety recommendation the aviation authority published the airworthiness directive M 3095/05 which applied to the attachment of the seat harnesses on all ultralight aircraft. The directive entered into force on 15 July 2005. (69, 70)

Airworthiness directive M 3095/05 mandated a check prior to the next flight as to the attachments of an Ikarus C42 seat harness. Whether the seat harnesses were fastened to the frame tubes by plate bracket or wire had to be checked. If they were fastened by wire, the shoulder harness attachments had to be replaced with similar attachments to those in an Ikarus C42 B type ultralight no later than 1 Jan 2006. The directive instructed that the manufacturer's spare parts for an Ikarus C42 B be given preference. If those were not available, the parts could be fabricated from comparable material and made the same size as the spare parts. The design plans for all parts other than the manufacturer's own parts had to be submitted to the aviation authority. The Ikarus C42 is made in Germany. Soon after this airworthiness directive was published in Finland the German aviation authority issued a corresponding directive. This only proves how significant the issue was. The aviation authority estimates that the first safety recommendation in investigation number C7/2003L is a good example of a concrete recommendation that has been implemented. Furthermore, the aviation authority also estimates that the safety action was implemented, expressly, as a result of accident investigation. (69, 70)

Investigation number D9/2006L paid attention to an inactivated ballistic parachute recovery system. It was determined that this could pose a great danger to persons that were assisting the people in the aircraft following an accident. The investigation commission recommended that the Finnish civil aviation authority, together with the FAA and the AIB, design a warning marker that would forewarn of the existence of a ballistic parachute recovery system and indicate the location of the rocket motor. As a result, the aviation authority published the airworthiness directive M 3102/06 which applied to all aircraft that were fitted with a ballistic parachute system which could lower the entire aircraft to the ground. The directive entered into force on 1 Jan 2007. (69, 71)

Airworthiness directive M 3102/06 mandated three measures to be carried out during the next scheduled maintenance, however, no later than 31 March 2007. First, whether the detonator trigger in the cockpit was clearly marked with a warning colour, such as red was to be checked, and that the trigger or its vicinity had the following clearly distinguishable text: *BALLISTIC PARACHUTE*, or something similar. If this was not the case, it was to be rectified. Second, a yellow and red triangle warning of explosive material was to be fastened to the rocket motor cover. The text *VAARA-FARA-DANGER* was to be next to it, as shown in the appendix of chapter 6. Third, warning triangles were to be fasten or painted on both sides of the fuselage, approximately 0.5 metres from the rocket motor cover, to indicate the location of the rocket motor. The warning was to be visible to rescue personnel approaching the aircraft from the side. The warning triangles are to be yellow and red and carry the following text: *RAKETTIPELASTUSVARJO-BALLISTIC FALLSKÄRM-BALLISTIC PARACHUTE*, as shown in the appendix of chapter 6. The aviation authority estimates that the safety action was implemented, expressly, as a result of accident investigation D9/2006L.

Investigation C7/2003L found that the airspeed displayed was 5 km/h too high. This caused an approximately 8 % airspeed indicator display error at the stall speed, which contributed to the accident. The investigation commission recommended that the CAA's Flight Safety Authority require the inclusion of airspeed indicator calibration charts in all ultralight aircraft flight manuals. The information in said charts was to rely on import inspections or flight tests. The aviation authority implemented this recommendation by publishing the airworthiness directive M 3091/05 on 14 June 2005. The directive applied to all class B ultralights. The directive entered into force on 15 July 2005. As per the directive, the flight manual of each class B ultralight must have a calibration chart for the calibration of the pitot-static system's error. If the error exceeds ± 8 km/h or ± 5 %, the chart must also be installed on the instrument panel. The chart was to be installed no later than 1 Jan 2006. The aviation authority estimates that safety recommendation number 2 in accident investigation C7/2003L contributed to the implementation of the safety action. (69, 72)

Investigation B1/2004L concluded that there was the possibility that basic flight training did not sufficiently pay attention to related ultralight aircraft loading as the fact that the loading and CG limits were exceeded was a contributing factor. The FAA's ultralight pilot training guide, approved by the aviation authority on 15 April 1993 and valid at the time of the accident, lists the training and competence requirements for each topic. Topics related to the loading of ultralights had the highest competence requirement, level D. This meant complete command of the topic, including proficiency tests. The investigation commission recommended that the FAA ensure that, during basic and advanced instructor training, instructors make certain that students fully understand the D-marked topics and that their competence is ascertained through practical examples and competence testing. The aviation authority and the FAA believe that this safety recommendation is at least partially implemented. Aviation regulation PEL M2-71, issued on 20 Dec 2007, was amended by adding the requirement to participate in aviation authority-certified ultralight flight instructor refresher training within the preceding 60 months so as to revalidate the ultralight flight instructor rating. This requirement is one of three requirements, two of which must be completed to revalidate said rating. In other words, if the ultralight flight instructor rating holder meets the two other requirements, he does not have to participate in refresher training to revalidate his rating. The aviation authority estimates that safety recommendation number 1 in accident investigation B1/2004L contributed to the implementation of the safety action. (69, 73, 77)

In investigation B1/2004L the investigation commission recommended that the CAA's Flight Safety Authority pay attention to different ultralight aircraft types' control characteristics and performance values and, when necessary, specify the requirements set for type training. In investigation C5/2007L the investigation commission recommended that the Finnish Civil Aviation Authority amend the content of the type training segment in PEL M2-70 so as to better take into account the effect of different ultralight aircraft cockpit layouts and technical characteristics in training. The parallel recommendations issued in both investigations were implemented by replacing the type rating training paragraph in the aviation regulation, issued on 12 Jan 2000, with differences and familiarisation training in the new aviation regulation, issued on 20 Dec 2007. The aviation authority estimates that safety recommendation number 2 in accident investigation B1/2004L and safety recommendation number 2 in accident investigation C5/2007L contributed to the implementation of the safety action. (69, 74, 75)

In investigation B1/2004L the investigation commission recommended that the CAA's Flight Safety Authority consider raising the requirements for an Ultralight Pilot Licence to correspond to the level and function of present ultralight aircraft types. Pursuant to aviation regulation PEL M2-70, issued on 12 Jan 2000 and valid at the time of the accident, an applicant for a UPL licence had to have no less than 20 flight hours of experience on an ultralight aircraft, of which no less than 5 hours being solo flights. As regards cross-country flights, the applicant was required to have flown at least five hours on cross-country flights, of which no less than three hours with an instructor. The safety recommendation was implemented by raising the minimum flight hour requirement and by specifying the cross-country flying requirements in PEL M2-70, issued on 20 Dec 2007, the following aviation regulation. While that PEL M2-70 is no longer valid, its content with regard to the abovementioned is the same as the currently valid aviation regulation PEL M2-70, issued on 5 May 2009. According to it, the applicant for a UPL licence must have at least 25 flight hours on an ultralight aircraft, of which no less than 15 with an instructor and no less than 5 hours solo. The required 25 hours must include at least 5 hours of cross-country flying, including at least one solo cross-country flight of no less than 150 km. During this solo flight the student pilot must land on at least one aerodrome other than the aerodrome of departure. The aviation authority estimates that safety recommendation number 3 in accident investigation B1/2004L contributed to the implementation of the safety action. The more specific requirements for cross-country flying were not implemented as a result of the safety recommendation alone; pilot deviation reports filed by air traffic controllers regarding cross-country flying also played a role in this. (69, 74, 75)

In investigation C5/2007L the investigation commission recommended that the FAA draw up general instructions and a generic checklist for taxiing and engine runups with ultralight aircraft. In addition, it was recommended that ultralight flight instructors' basic and refresher training emphasise the correct use of checklists. The FAA implemented the safety recommendation by drawing up an Ultra Check List which includes the following sections: checks before engine start, checks after engine start, pre-taxi check, taxi check, takeoff check. The FAA estimates that safety recommendation number 1 in accident investigation C5/2007L contributed to the implementation of the safety action. (77)

Investigation D2/2008L called attention to test pilot proficiency requirements. As per aviation regulation AIR M5-2, issued on 25 Nov 1996, already valid at the time of the minor accident, the requirements for a person participating in flight test activities included a valid licence and required ratings for the aircraft type in question as well as sufficient experience for the test flight in question. The investigators believe that the definition of sufficient experience is too vague. The investigation commission recommended that the Finnish Civil Aviation Authority clarify the test pilot's flying experience requirements and provide the required regulations to the FAA. The aviation authority intends to consider this recommendation in the next amendment to aviation regulation AIR M5-2. (33, 69)

Investigation C11/2002L concentrated on amateur-built aircraft construction. The commission issued four safety recommendations which have not been implemented. In safety recommendation 1 the investigation commission recommended that the CAA's Flight Safety Authority supplement its regulation AIR M5-2 with regard to the supervision of amateur-built aircraft construction. In safety recommendation 2 the investigation commission recommended that the CAA's Flight Safety Authority require appropriate planning in powerplant modification and expert inspection of said modification as well as comments whenever powerplants other than aviation engines were modified to be used in aviation. The aviation authority intends to consider the topics included in the abovementioned two recommendations in the next amendment of the AIR M5-2, albeit in a different manner. The aviation authority does not intend to consider safety recommendations 3 and 4. The FAA believes that safety recommendation 4 has already been partly implemented because, after the recommendation was issued, the FAA has paid increasing attention the fabricators' skills when it includes comments during the application process. The FAA estimates that safety recommendation number 4 in accident investigation C11/2002L contributed to the implementation of the safety action. (69, 76)

In conclusion it can be said that the civil aviation authority believes that safety actions which were completed in order to implement two safety recommendations were specifically done as a result of accident investigation. This means that the aviation authority would hardly have implemented said actions within the same period of time, had the shortcomings that spawned the safety recommendations not been detected in accident investigation. The aviation authority and the FAA believe that most of the safety recommendations that were directed at them and which were implemented have contributed to completed safety actions. Nevertheless, other factors have also been in play.

8.3 The volume and categories of accident investigations as well as time and costs allocated to them

In the 2000s the AIB began to investigate a total of 20 class B ultralight aircraft accidents, minor accidents or serious incidents. The investigations were conducted in categories B, C or D, as presented in table 23. The table shows that half of the investigations, i.e. ten of them, were done as a category D and the other half as a category C. The table also shows that, on average, there have recently been more investigations as regards ultralight aircraft accidents, minor accidents or serious incidents than in the beginning of the 2000s. This corresponds well to the fact that the number of flight hours in recent years in ultralight aviation rose considerably in comparison to the early 2000s. The number of annual investigations varies, depending on the number of ultralight aircraft accidents, minor accidents or serious incidents. In addition, when the decision is made whether to start an accident investigation, consideration includes the seriousness of the occurrence as well as the probability of its recurrence. Even those occurrences and incidents that bear minor consequences can be investigated if they pose danger to many persons or if the investigation is deemed to have the potential to generate significant information with regard to public safety and accident prevention.

Table 23. The volume and categories (B, C or D) of investigations started by AIB between the period of 2000–2009 on class B ultralight aircraft accidents, minor accidents and serious incidents.

Year	B	C	D	Total
2000	-	2	-	2
2001	-	-	-	-
2002	-	1	-	1
2003	-	1	-	1
2004	2	-	-	2
2005	-	-	1	1
2006	2	-	3	5
2007	-	1	1	2
2008	-	-	2	2
2009	1	-	3	4
Total	5	5	10	20

Table 23 also shows that there were no category D investigations in the early 2000s. The reason for this is that AIB began to conduct category D investigations as late as in 2004. Whereas in the early 2000s there were more category C investigations, comparable occurrences were investigated as category D in the late 2000s. Category D investigations are briefer than category B or C investigations, resulting in reports that are only few pages in length. The format of category D investigations has varied, ranging from an approximately 3 page long preliminary report/ category D form to those that resemble category B or C reports. The format of category D investigation reports diverge from that defined in Annex 13 to the Convention on International Civil Aviation. In category B and C investigations the AIB follows the format described in Annex 13. The extent of category B investigation is comparable to that of category C.

The category of the investigation does not define whether it relates to an aviation accident, minor accident or serious incident. Occurrences categorised as accidents can be investigated as categories B, C or D. The most serious ultralight accidents that resulted in fatalities have always been investigated as category B. All occurrences that this study categorised as minor accidents were investigated as category D. They could also be investigated as category C. Serious incidents in ultralight aviation were investigated as categories C or D.

Pursuant to the EU's accident investigation directive the investigative bodies shall make every effort to make the report available to the public within 12 months of the date of the casualty.

Whereas in Finland the directive's 12 month goal applies to categories B and C investigation, it does not apply to category D investigations. The AIB's own goal is to publish category B reports within 12 months with regard to domestic investigations. The corresponding AIB deadline as regards domestic category C investigations is six months. The deadline goals have not changed in the 2000s. Table 24 presents the time spent in category B investigations in the 2000s regarding ultralight accidents, minor accidents and serious incidents. (24, 27, 63)

Table 24. The time that the AIB spent in class B investigations regarding ultralight accidents, minor accidents and serious incidents in the 2000s.

Occurrence number	Identifier	Date of occurrence	Investigation completed	Time spent (months)
1	C1/2000L	5.1.2000	6.3.2000	2.0
2	C11/2000L	19.8.2000	5.4.2001	7.5
3	C11/2002L	16.11.2002	17.9.2003	10.0
4	C7/2003L	11.6.2003	15.3.2004	9.1
5	B1/2004L	16.2.2004	5.10.2004	7.6
6	B3/2004L	24.8.2004	9.12.2004	3.5
7	D1/2005L	15.1.2005	23.1.2005	0.3
8	D6/2006L	22.4.2006	15.6.2006	1.8
9	B2/2006L	10.7.2006	18.7.2007	12.3
10	D9/2006L	11.7.2006	7.9.2006	1.9
11	D11/2006L	1.8.2006	8.12.2006	4.2
12	B3/2006L	8.8.2006	5.2.2007	5.9
13	D4/2007L	3.2.2007	3.5.2007	3.0
14	C5/2007L	12.8.2007	11.1.2008	5.0
15	D2/2008L	22.6.2008	12.12.2008	5.7
16	D5/2008L	24.7.2008	27.4.2010	21.1
17	D2/2009L	16.1.2009	9.6.2010	16.8
18	D3/2009L	21.4.2009	21.7.2009	3.0
19	D4/2009L	28.4.2009	1.3.2010	10.1
20	B6/2009L	4.8.2009	16.6.2010	10.4

Table 24 shows that the AIB reached its 12 month deadline target in almost every category B investigation that was started in the 2000s. Only in investigation number 9 was the deadline missed by about a week. While category C investigations were not completed within the deadline as often as category B investigations, all of them were completed within the 12 months prescribed by the EU's directive. According to the AIB's Operations Manual 2010 category C investigations are more concise than category D investigations. Nevertheless, in practice they are largely equivalent in extent. The severity of the occurrence, *per se*, does not determine how laborious the investigation will ultimately be. Therefore, six months can prove to be too short a time for a category C investigation. (63)

Apart from occurrence number 2 the costs of category B and C investigations that were completed by the end of May 2010, presented in table 24, average at EUR 13 000. The costs varied from approximately EUR 7 300 to EUR 24 700. These costs do not take into account the expenses of the AIB's regular staff; they only reflect the expenditure allotted to the investigation. In occurrence number 2 the investigator was AIB staff. While statistics for the costs of category D investigations have not been compiled on a case-by-case basis they are, on average, less expensive than category B or C investigations. (77)

9 ULTRALIGHT AVIATION ACCIDENT INVESTIGATION IN OTHER COUNTRIES

This chapter takes a look at ultralight aviation accident investigation in other countries. The survey was limited to ECAC member states and Canada. A questionnaire made for the purpose of this study was sent to the accident investigation authorities of 39 ECAC member states. The countries in question were: Albania, Armenia, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, France, Georgia, Germany, Greece, Hungary, Iceland, Italy, Ireland, Latvia, Lithuania, Luxemburg, Macedonia, Malta, Moldova, Monaco, the Netherlands, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom. In addition to the abovementioned the questionnaire was sent to the Canadian accident investigation authority. Of the ECAC member states the questionnaire was not sent to Azerbaijan, Montenegro, Turkey or Ukraine.

The questionnaire included the following questions:

- Do you investigate any ultralight aviation accidents and/or incidents and if you investigate ultralight aviation accidents and/or incidents, what type of accidents and/or incidents do you investigate?
- If you do not investigate every ultralight aviation accident and/or incident or if you do not investigate them at all, does some other investigating body investigate them in your country?
- How many ultralight aviation accidents and/or incidents are investigated officially on a yearly basis in your country and how many safety recommendations are given on a yearly basis in your country concerning officially investigated ultralight aviation accidents and/or incidents?
- If you investigate ultralight aviation accidents and/or incidents now, how are you going to investigate them in the future?

Countries define ultralight aircraft in different manner and, therefore, it was necessary to include the definition of an ultralight aircraft. In the questionnaire ultralight aircraft was defined as it is in the Finnish aviation regulation AIR M5-10, excluding weight-shift controlled aircraft. The definition as per AIR M5-10 is included in the beginning of chapter 4. The entire English language questionnaire is included in appendix 7.

Responses were received from 14 ECAC member states and Canada. The response percentage was 38. The ECAC member states that responded to the questionnaire were Croatia, Cyprus, Denmark, Georgia, Germany, Hungary, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom. The following paragraphs explain how the respondents described their ultralight accident and incident investigation processes.

9.1 Nordic countries

Denmark

According to the Danish Air Navigation Act, Accident Investigation Board Denmark (AIB DK) has to investigate all aviation accidents and incidents. This includes ultralight accidents and incidents. However it is up to the AIB DK to decide the scope of an investigation. This decision is by considering the expected flight safety outcome versus the resources that are needed for an investigation and what other investigations or tasks the AIB DK has at the time. The AIB DK always conducts a preliminary investigation into ultralight occurrences to determine if the immediate contributing factors are of a general flight safety character or if they could be determined unique to the occurrence and cannot be considered to constitute a general danger for ultralight aviation. If the flight safety outcome is determined to be low as a result of the preliminary investigation, further investigation will be minimal and the report will not follow the layout of a ICAO Annex 13 report; instead, it will be called a statement. The Danish Ultralight Flying Association investigates occurrences which the AIB DK will not investigate beyond the preliminary phase. AIB DK said that 7.8 ultralight accidents and 3.4 ultralight incidents, on average, were investigated during the past five years. In addition, 0.8 safety recommendations have been issued for ultralight aviation, on average. AIB DK intends to continue investigating ultralight accidents and incidents the same way as it does now without any changes.

Iceland

Icelandic Aircraft Accident Investigation Board (AAIB) replied that they do investigate ultralight aircraft accidents that resulted in fatalities. Their present legislation does not mandate the investigation of ultralight aviation accidents or incidents. Investigations are conducted for the purpose of improving flight safety in general. When existing legislation was written there were few ultralight aircraft operating within the country, maybe less than five. Since then ultralight aviation has become more popular; as of now the number of aircraft has increased up to approximately 50. AAIB replied that they began to investigate fatal ultralight accidents in 2009. The Icelandic Ultralight Club investigates all serious incidents in ultralight aviation and the police, too, investigate some accidents. Each year three ultralight accidents or incidents, on average, are investigated in Iceland. The AAIB could not say how many safety recommendations had been issued as a result of investigations. They intend to continue investigating ultralight accidents in the same manner as other aviation accidents.

Norway

Accident Investigation Board Norway (AIBN) replied that they do not investigate ultralight accidents and incidents; they only investigate related accidents/incidents involving conflicts between ultralight aircraft and other air traffic. The Norwegian Air Sports Federation (NLF) investigates all ultralight accidents and incidents in Norway. Their Safety Management System is approved by the Civil Aviation Authority – Norway. NLF accident investigation teams investigate serious incidents and accidents and issue their own reports. When requested they also assist the police in their investigations. In addition the police may investigate any accident and/or incident at their discretion. The NLF Air Safety Committee investigates ultralight aviation incidents. The AIBN replied that the NLF investigates approximately 1–2 serious incidents/accidents, on average, each year. The number of recommendations for ultralight aviation from the NLF's reports average 1–2 each year.

The NLF started doing their internal investigations as early as in 1986. The AIBN stopped investigating ultralight accidents and/or incidents in 1995 when the decision was made to consider the NLF's internal investigations sufficient for ultralight accident investigation. There was a short transition phase, where the AIBN and the NLF accident investigation team investigated cases together. According to the AIBN the ICAO did not issue a finding against this practice when they audited the AIBN in 2006. In addition, the AIBN says that all parties seem to agree that the current arrangement has worked well so far and, therefore, they do not plan to investigate ultralight aviation accidents and/or incidents in the foreseeable future. According to a report of the Norwegian Civil Aviation Authority there was an increase in the number of fatal accidents with Norwegian ultralight aircraft during the early and mid-nineties. The report also suggested an acceptable level of safety for this activity. Finally, the AIBN states that ultralight aviation safety in Norway appears to have improved significantly during the last decade.

Sweden

Statens haverikommission (SHK), the Swedish accident investigation authority, replied that legislation in Sweden gives them the opportunity to investigate ultralight accidents and incidents, but it does not force them to do so. SHK says that they will investigate any type of accident or incident if they find something that can mean there's something seriously wrong in general – a construction weakness or some such thing. Then the investigation will be conducted for the benefit of flight safety in general. If someone else investigates accidents or incidents it is probably the Royal Swedish Aero Club, the Hangglider or the Paraglider Association. SHK also said that if they decide to investigate ultralight accidents or incidents, they would investigate any type of occurrence. According to SHK's estimate 0–2 ultralight accidents or incidents are investigated in Sweden on an annual basis. In the future SHK will probably conduct investigations in very limited numbers. A new Act on Accident Investigation came into force 2004, pursuant to which ultralight accident investigation was no longer required.

9.2 Other ECAC member states and Canada

Canada

Transportation Safety Board of Canada (TSB) investigates occurrences in accordance with their Classification Policy which was established in 1996. Each occurrence is classified under one of the following: class 1 (public inquiry), class 2 (individual occurrence investigation), class 3 (individual occurrence investigation), class 4 (safety issue investigation) and class 5 (data collection). Whereas occurrences in classes 2 and 3 are fully investigated, brief reports are written from class 4 and class 5 investigations.

During the last 10 years (2 Dec 1999 – 2 Dec 2009) at least 246 ultralight occurrences were entered into the TSB's database. None of them was fully investigated. Brief reports were written of some investigations, as per class 5 rules. In some occurrences TSB investigators have assisted the coroner of the Provinces or Territories by writing brief reports pertaining to the factual information and history of the flight concerning the accident. In the last 10 years, there have been no recommendations issued by the TSB addressing ultralight safety problems. The TSB anticipates no changes to the present investigation practices. Although no full investigations have been carried out in the last 10 years, such investigations may take place in accordance with their Classification Policy.

Croatia

The Croatian Agency for Aircraft Accident and Serious Incident Investigation (AAASII) replied that they investigate ultralight accidents and incidents the same way as any other types of aviation accidents and incidents under their national legislation. There are no other organisations in Croatia that conduct ultralight accident investigations. The AAASII reported that they investigate 1–5 ultralight accidents or incidents each year. They also said that each final report includes a safety recommendation. The AAASII will continue to investigate ultralight accidents and incidents.

Cyprus

Cyprus Aircraft Accident and Incident Investigation Board (CAAIIB) replied that they investigate all ultralight aviation accidents and/or incidents under their legislation and pursuant to ICAO Annex 13. There are no other organisations in Cyprus that conduct ultralight accident investigations. The CAAIIB replied that, on average, they investigate one ultralight accident or incident each year and issue approximately 3 or 4 safety recommendations as a result. The CAAIIB intends to continue investigating ultralight accidents and incidents as they do now.

Georgia

The Civil Aviation Department of the United Transport Administration (UTA CAD), Georgia's accident investigation authority, reported that they investigate all types of accidents and/or incidents in accordance with their national legislation. Georgia has no other organisations that conduct ultralight accident investigation. The UTA CAD replied that they investigated on ultralight accident in 2005, two accidents in 2006, one accident in 2007 and none in 2008–2009. The UTA CAD said that they regularly issue safety recommendations. The UTA CAD will continue to investigate ultralight accidents and incidents under their state legislation requirements.

Germany

Bundesstelle für Flugunfalluntersuchung (BFU), the German accident investigation authority, replied that, under their national legislation, they investigate ultralight accidents which result in fatalities or serious injuries or that are caused by midair collisions and in-flight breakups. The BFU did not mention whether there are other bodies in Germany that conduct ultralight accident investigation. According to the BFU, in 2008 they investigated 17 ultralight accidents that resulted in 22 fatalities and three accidents that resulted in serious injuries to four persons. In 2009 they investigated 10 ultralight accidents in which 14 persons perished as well as six accidents that caused serious injuries to eight persons. The abovementioned figures include accidents that occurred to German ultralight aircraft within German territory and abroad. The BFU reported having issued 26 safety recommendations for ultralight aviation from 1998–2009. They did not say how they intend to conduct ultralight accident investigation in the future.

Hungary

The Hungarian Transportation Safety Bureau (TSB) reported that they investigate all types of ultralight accidents under their national legislation. Whereas the TSB will always investigate each ultralight accident and serious incident, the decision to investigate incidents is based on the nature and severity of the incident. If there are lessons to be learned, incidents are always investigated. The TSB's reply did not clearly state whether there are other organisations in Hungary that conduct ultralight accident investigations. The TSB says that they investigated nine ultralight accidents or incidents in 2007 and 13 in 2008. They issued one safety recommendation for ultralight aviation in 2007 and four in 2008, respectively. The TSB intends to continue investigating ultralight accidents and incidents under their national legislation.

Ireland

Ireland's Air Accident Investigation Unit (AAIU) replied that they are obliged under legislation to investigate any aviation accident where there is loss of life, serious injury or damage to aircraft. There are no other bodies that conduct ultralight accident investigations. The AAIU said that they investigate approximately 10 ultralight accidents each year and that they will continue the investigations as is. According to the AAIU, it is important that users are aware of the risks associated with operating such aircraft without the appropriate training, as ultralight flying is becoming more accessible to the general public.

The Netherlands

The Dutch Safety Board (DSB) replied that they investigate all accidents and serious incidents, due to the requirements of their national legislation. Most investigations are limited. Normally the police conduct a separate investigation with regard to almost all serious ultralight accidents in the Netherlands. DSB said that they have investigated 25 ultralight accidents from the year 2000 up until today. During this period they did not investigate any ultralight serious incidents. From the year 2000 onwards the DSB issued safety recommendations following an investigation regarding a mid-air collision between an ultralight aircraft and a foreign military aircraft. However, the recommendations were directed at military aviation and airspace structure. In 1999 the DSB issued one recommendation for ultralight aviation. In addition, more safety recommendations will be issued to ultralight aviation as a result of an investigation which will soon be completed. This investigation concerns an in-flight structural failure of an ultralight aircraft in 2008. In the future the DSB intends to investigate ultralight accidents and incidents in accordance with the requirements of their national legislation.

Portugal

Gabinete de Prevenção e Investigação de Acidentes com Aeronaves (GPIAA), the Portuguese safety AIB authority, replied that they investigate all types of accidents and serious incidents pursuant to ICAO Annex 13 as well as some incidents under their national domestic legislation. There are no other organisations in Portugal that conduct ultralight accident investigations. According to the GPIAA's separate statistics altogether 28 ultralight accidents and 18 incidents occurred in Portugal from 2003–2008. The GPIAA stated that they investigated each of them, resulting in 22 safety recommendations for ultralight aviation within the referred time period. The GPIAA intends to continue investigating ultralight accidents and incidents as presently.

According to the GPIAA's estimate there are approximately 420 registered ultralight aircraft and approximately 500 ultralight pilots in Portugal. For example, in 2007 ultralight aircraft amassed more than 30 000 flight hours. According to the GPIAA's phase of flight-categorised statistics 14 accidents and nine incidents occurred during the approach or landing from 2003–2008. Correspondingly, eight accidents and five incidents occurred during the takeoff or climb. Five accidents and three incidents occurred in level flight. One accident and one incident occurred during taxiing or on the apron. In other words 50 % of all ultralight accidents and incidents from 2003–2008 occurred during the approach or landing. The second highest accident or incident rate involves the takeoff or climb. According to the Portuguese statistics ultralight accidents resulted in 15 fatalities and 13 serious injuries from 2003–2008. All of the abovementioned figures are based on officially registered occurrences in Portugal, involving Portuguese as well as foreign ultralight aircraft. Furthermore, the statistics showed that the number of accidents and fatal accidents has been on the decline from 2003–2008. However, in the statistics the number of accidents was not proportioned to ultralight flight hours. Nevertheless, the GPIAA says that ultralight safety is improving and they also believe that they have contributed to the trend.

Spain

Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (CIAIAC), the Spanish accident investigation authority, does not investigate ultralight accidents or incidents. Instead, it cooperates with Real Federación Aeronáutica Española (RFAE), the Spanish Aeronautical Sport Association. For those accidents and incidents that result in fatalities or serious injuries and/or serious damage to aircraft, and also for those particularly interesting for the purpose of improving flight safety, the CIAIAC delegates the investigation to the RFAE. Usually the CIAIAC issues an annual report on ultralight accident rates, including statistical data compiled on the basis of the RFAE's reports. According to this information, altogether 97 ultralight accidents or incidents occurred in Spain from 2003–2008, 12 of which in 2003, 13 in 2004, 17 in 2005, 18 in 2006, 20 in 2007 and 17 in 2008, respectively. The CIAIAC said that they issued one safety recommendation in 2007 for ultralight aviation. In the future the CIAIAC will continue ultralight accident investigation by collaborating with RFAE.

United Kingdom

The Air Accidents Investigation Branch (AAIB) in the United Kingdom replied that they investigate all ultralight accidents deemed to be “reportable” under UK legislation. Moreover, the Chief Inspector may order an investigation for the benefit of flight safety if he believes this is warranted. The AAIB replied that they essentially investigate ultralight accidents and incidents in the same way they investigate any other general aviation accident or incident. The AAIB did not state whether there are other organisations in the UK that conduct ultralight accident investigations. In 2008 the AAIB carried out 47 investigations involving ultralights and issued three safety recommendations for ultralight aviation. There are no plans to change the way the AAIB investigates ultralight accidents and incidents.

9.3 Précis

Replies were received from 38 % of the accident investigation authorities to whom the questionnaire was sent. The percentage is considered to be reasonable and sufficient for the purposes of this study. All Nordic accident investigation authorities replied to the survey. There was some variance in the verbiage of replies; some answers were brief but other respondents elaborated their processes in more detail. In some replies certain questions were left unanswered. The common factor in almost all replies was that the respective accident investigation authorities do conduct ultralight accident investigations within their territory. Most respondents also stated that they intend to continue investigating ultralight accidents and/or incidents in the same way in the future.

According to the replies of the Nordic countries, Iceland, Norway and Denmark investigate ultralight accidents and incidents. Sweden investigates some of them. Iceland investigates at least the fatal accidents and serious incidents. Norway investigates accidents and serious incidents. Denmark investigates ultralight accidents and incidents in the same manner as any other aviation accidents and incidents. Of the Nordic countries, the national legislation of Iceland and Sweden does not require the investigation of ultralight accidents and/or incidents. This being the case, the purpose of accident investigation is to improve flight safety in general. In Denmark the arrangements of ultralight accident investigations most resemble those of Finland. In Finland and in Denmark national legislation demands that all ultralight accidents and serious incidents be investigated and that the national accident investigation authority conduct the investigations. In the other Nordic countries some investigative body other than the national accident investigation authority investigates all or some of the ultralight accidents and/or serious incidents.

All other ECAC member states’ accident investigation authorities that replied to the questionnaire reported that ultralight accidents are investigated within their territory. A couple of respondents mentioned that they investigate ultralight accidents pursuant to ICAO Annex 13. Approximately one half of the respondents replied that they investigate all types of ultralight accidents or each ultralight accident. Some replied that they investigate fatal accidents or those that resulted in serious injuries or serious damage to the aircraft. This description corresponds well to the ICAO Annex 13 definition of an aviation accident, presented in chapter 6.2. Most respondents also replied that they investigate ultralight incidents. Nearly all replied that they investigate ultralight accidents and/or incidents under their national legislation. Only one respondent stated that they do not conduct the investigations but, rather, cooperate with another organisation. Transportation Safety Board of Canada reported writing brief reports of ultralight accident investigations.

10 CONCLUSIONS

The primary aim of this study was to research and analyse the human factors that contribute to accidents, minor accidents and serious incidents in ultralight aviation. The most important research method involved the systematic analysis of AIB investigation reports on ultralight accidents, minor accidents and serious incidents using the SHELL-model. The research material included a total of 20 investigation reports written on class B ultralight accidents, minor accidents and serious incidents that occurred in Finland from 2000–2009. Another aim of the study was to analyse and assess how much accident investigation could improve the safety of ultralight aviation. The study achieved its goals. The following presents some of the findings related to common human factors in occurrences investigated by the AIB and how the safety of ultralight aviation can be improved through accident investigation. The common human factors are presented in the order of the SHELL-model interrelationships. No safety recommendations are issued as a result of this study.

10.1 Common human factors contributing to accidents, minor accidents and serious incidents in ultralight aviation

The pilot's limited flying experience either contributed to or may have contributed to 13 occurrences. Of these, in most cases it was the pilot's limited experience on the type contributed to the occurrence. The pilot's limited total flying experience was the second most important factor. While these were contributing factors throughout the period of review, pilot's limited type experience as well as limited total experience contributed to almost all occurrences that have been investigated in recent years. In occurrences where the pilot's limited total flying experience contributed or may have contributed, the pilot had approximately 0.5–1.0 flight hour of experience on the type, if the two highest total numbers in the group are excluding. With regard to occurrences where the pilot's limited total flying experience on the type was a contributing factor, the pilot had amassed approximately 33–53 total flight hours. Furthermore, limited recent flying experience also contributed to a few occurrences. Even though limited flying experience contributed to each of the 13 occurrences, it alone was not the cause of the occurrences. The minimum required flying experience for a UPL licence is 25 hours. No minimum requirements exist for differences and familiarisation training.

The pilot's poor flying skills contributed to almost one half of the occurrences. In most of these cases the pilot did not recognise the symptoms of an approaching stall, which resulted in a stall. A common factor in these occurrences was that the aircraft stalled at a low altitude, in a climb or during the approach, in which case it was either difficult or impossible to recover the aircraft. Ultralight aircraft are typically not fitted with stall warning systems – nor are they even required. Still, according to the airworthiness requirements, an airworthy ultralight aircraft must exhibit a clear and distinctive stall warning, provided through the aircraft's normal aerodynamic characteristics, in straight flight and in any normal configuration turn. This being the case, the pilot should be able to recognise the symptoms of an approaching stall which typically include buffeting, slack controls and nose down pitching. The best way to achieve this ability is through training. Ultralight flight instructors should, additionally, ensure in basic training as well as in differences and familiarisation training that the student pilots recognise the general symptoms of an approaching stall. On the other hand, a reliable stall warning system would probably help in many cases. It might be a good idea to study whether it would be possible to fit ultralight aircraft with reliable stall warning systems, and what this would entail. Other factors related to poor flying skills included insufficient airspeed monitoring and in a few cases the loss of control during landings.

The pilot's unsound course of action also contributed to almost one half of the occurrences. The pilot failed to complete the checklist or procedures as per the best practices in aviation during the pre-flight check, prior to engine start or before takeoff. Common to the occurrences was that the incidents could probably have been avoided had the pilot more diligently checked the aircraft before taking off. In two occurrences the pilot intended to land on a lake surface but, having failed to check the landing area by flying over it at a safe altitude, collided with a power line that crossed the lake. In a couple of occurrences the engine failed in mid-air and the pilot selected an unsuitable spot for the emergency landing. In both instances the pilot homed towards the aerodrome, which was not the safest option considering the circumstances. At least in ultralight pilot training, it is possible to have an effect on the selection of a safe course of action and the proper safety attitude of the flight instructors. In addition, recurring refresher instruction flights could weed out a pilot's possible unsound courses of action and improve his flying skills.

In four occurrences the pilot's limited or insufficient training was deemed to have contributed to the occurrence. The most common factor was the pilot's limited type training. In all occurrences the investigation commission believed that the pilot's type training was either limited or insufficient with regard to the demands of the aircraft type. As regards these occurrences the type rating training varied from 40 minutes to 16 hours. Common to the occurrences was that an accident or a serious incident occurred relatively soon, in terms of flight hours, after the pilot had received the type training. Aviation regulations do not define any minima for the flight hours, practices, or landings included in present differences and familiarisation training, so the extent of training is left to the discretion of the instructor and the student. Neither is the content of the differences and familiarisation training precisely defined. It, too, is left to the discretion of the instructor and the student. Last of all, no clear general instructions exist for differences and familiarisation training.

An inadequate flight manual or AOM only contributed to three occurrences. Yet in several cases shortcomings in them that could have contributed to an occurrence under different circumstances were discovered. In a couple of instances the flight manual did not mention the airspeed indicator error. In neither case was the pilot aware of the magnitude of the error and believed that the indicated airspeed was sufficiently higher than the stall speed. This contributed to the fact that the airspeed became so low that the aircraft stalled.

The poor construction or repair skills of the pilot, owner, operator or constructor either contributed or may have contributed to seven occurrences. While the location of construction or repairs varied, faulty construction or repairs in the engine's fuel system were a common factor in two instances. Other construction or repair sites included the airspeed indicator, pontoon, canopy, nose landing gear skid and aileron.

In five occurrences the aircraft, one of its components or systems was already faulty when the aircraft rolled off the manufacturer's site. In three occurrences the deficiency involved the airspeed indicator, which either indicated an airspeed that was too high or was otherwise unreliable. The three remaining deficiencies were dissimilar, devoid of any common factors. In one occurrence the seat harness attachment was too weak, in one occurrence the heating system incorporated combustible materials and in one instance the wheel brakes could not keep the aircraft at a standstill at full power.

Incorrect loading contributed to four occurrences. The aircraft was either overweight or its centre of gravity was outside the permissible range. All occurrences involved two-seater ultralight landplanes whose maximum takeoff mass was 450 kg. In three of the occurrences the aircraft had 17–85 kg of excess weight in relation to the MTOM. The performance values given in the flight manual are normally based on the MTOM, i.e. 450 kg. Excess weight degrades aircraft performance, rendering the flight manual's performance values useless. Excess weight affects the manoeuvrability of an aircraft and it may affect its controllability as well. Changes vary by type and they are not accurately predictable. Pilots should be aware how much excess weight increases, for example, the stall speed on the type in question. Training can make a difference in this.

Meteorological conditions either contributed or may have contributed to seven occurrences. In most cases wind conditions were the contributing factor. In three occurrences the wind was strong and/or gusty, making it more difficult to control the ultralight aircraft. Two occurrences were affected by a tailwind which, in one occurrence lengthened the takeoff distance and in the other increased the ground speed. In both occurrences the tailwind affected the pilot's action with the result that the aircraft stalled. Additionally, the lighting conditions contributed to two occurrences.

10.2 Improvement of ultralight aviation safety through accident investigation

The improvement of ultralight safety was mainly analysed by assessing the AIB's safety recommendations and their effect on the safety actions that were implemented as a result. The AIB issued altogether 14 safety recommendations as a result of the class B ultralight investigations that were started in the 2000s and which were completed by the end of May 2010. Of the recommendations 71 % were completed or partly completed by the end of May 2010. Most safety recommendations were directed at the civil aviation authority. The second highest number was directed at the Finnish Aeronautical Association (FAA). The aviation authority estimates that the safety actions that it implemented as a result of two safety recommendations were specifically carried out as a result of accident investigation. While the aviation authority and the FAA estimate that most of the safety recommendations that were directed at them and subsequently implemented contributed to safety actions, there have also been other contributing factors. Clear and concretely formulated safety recommendations tend to be implemented more often than wide-ranging and nebulous ones.

On the basis of the abovementioned, it can be stated that accident investigation has contributed to the implementation of safety actions in ultralight aviation. The implementation of safety actions can probably improve safety. Therefore, it is reasonable to estimate that accident investigation has positively contributed to the safety of ultralight aviation. Still, it is very difficult to assess the level of its input. The accident and damage statistics compiled for the study show that the safety level in ultralight aviation has, on average, improved in the 2000s and even more in the 1990s. Nevertheless, it is impossible to demonstrate how many accidents or incidents were prevented by virtue of accident investigation alone. There are many factors that contribute to the improved safety levels and it would be extremely difficult to isolate the specific role of accident investigation.

Another aim was to assess the effect of accident investigation on ultralight safety by analysing the changes in human factors that contributed to accidents, minor accidents and serious incidents in the 2000s. If, for example, it could be clearly shown than certain specific factors had been eliminated during the period of review as a result of some implemented safety recommendation, it would have been possible to reckon that accident investigation influenced the improvement of safety. However, the study established no such clear changes.

In Finland the AIB investigates all ultralight accidents and serious incidents defined in Annex 13 to the Convention on International Civil Aviation. Judging by the results of the questionnaire included in the study at least one third of European countries investigate ultralight accidents and serious incidents. The responses of many countries reflected the conviction that ultralight accident investigation can make a difference to overall flight safety or the safety of ultralight aviation. This corroborates the abovementioned assumption that accident investigation can positively influence the safety of ultralight aviation.

REFERENCES

When the title of the reference is in the Finnish language, its translation is shown in brackets.

(1) *Ollila, K*. Ilmailuhallitus ei rekisteröi höyhenkevyitä. Ilmailu (Civil Aviation Administration will not register featherlights. Ilmailu magazine), 1982. Vol. 1, p. 54.

(2) *Ollila, K. ja Ansa, H*. Ensimmäinen ultrakevyt Suomen taivaalla. Ilmailu (The first ultralight in the Finnish sky. Ilmailu magazine) 1982. Vol. 4, pp. 2–4.

(3) *Ollila, K*. Quick Silver Mx. Ilmailu magazine, 1982. Vol. 5, pp. 44–45.

(4) *Uola, M*. Suomen Ilmailuliitto 75 vuotta: 1919–1994. Suomen Ilmailuliitto ry (Finnish Aeronautical Association 75 years: 1919–1994. Finnish Aeronautical Association), 1994.

(5) *Raivio, J*. Liiton hallitus hyväksyi ultrakevytsopimuksen. Ilmailu (Association board accepts ultralight agreement. Ilmailu magazine), 1983. Vol. 2, pp. 38–39.

(6) *Korjula, M*. Höyhenkevyet täyttävät taivaan. Ilmailu (Featherlights fill the skies. Ilmailu magazine), 1982. Vol. 1, pp. 52–55.

(7) *Ollila, K*. Ultrakevytilmailun kolme ohjenuoraa. Ilmailu (The three guidelines of ultralight aviation. Ilmailu magazine), 1983. Vol. 3, pp. 40–42.

(8) *Ollila, K. ja Öster, J*. Suomen ultrakevytilmailu vuonna yksi. Ilmailu (Finnish ultralight aviation in year one. Ilmailu magazine), 1983. Vol. 10, pp. 2, 13.

(9) Ilmailumääräys AIR M5-2. Ultrakeveiden lentokoneiden lentokelpoisuus- ja rekisteröintivaatimukset. Ilmailuhallitus. Annettu 14.2.1983. (Aviation regulation AIR M5-2. Airworthiness and registration requirements for ultralight aircraft. Civil Aviation Administration. Issued on 14 February 1983)

(10) Ilmailumääräys PEL M2-70. Ultrakeveälentäjän lupakirja. Ilmailuhallitus. Annettu 14.2.1983. (Aviation regulation PEL M2-70. Ultralight Pilot Licence. Civil Aviation Administration. Issued on 14 February 1983)

(11) *Nores, K. ja Öster, J*. Ei ultrakevyt ole mikään surffilauta. Ilmailu (An ultralight is no surfboard. Ilmailu magazine), 1983. Vol. 10, pp. 4–6.

(12) *Ollila, K*. Ultrakevytlentäjien koulutusohjeet. Ilmailu (Training manual for ultralight pilots. Ilmailu magazine), 1984. Vol. 2, pp. 30–32.

(13) *Sievänen, L*. Valvontavastuu toi uudet velvoitteet. Ilmailu (Oversight responsibility involves new obligations. Ilmailu magazine), 1984. Vol. 4, pp. 16–17.

(14) *Renwall, R*. Ilmailun kevyet kuopukset. Ilmailu (The light toddlers of aviation. Ilmailu magazine), 1986. Vol. 4, pp. 36–38.

(15) Ultrakevytlentämisen 10 ensimmäistä vuotta. U&X (The first decade of ultralight aviation. U&X), 1991. Vol. 1, pp. 5–7.

(16) *Lähteenmäki, E*. Haastattelu. Onnettomuustutkintakeskus. Syyskuu 2009. (Interview. Accident Investigation Board. September 2009)

(17) Muutosmääräys M 1743/90. Ultrakeveät lentokoneet. Polttoainejärjestelmän tarkastus. Ilmailuhallitus. Annettu 7.9.1990. (Airworthiness directive M 1743/90. Ultralight aircraft. Fuel system inspection. Civil Aviation Administration. Issued on 7 September 1990)

(18) *Lähteenmäki, E. ja Vänttinen, T*. Tutkimuskertomus 13/92. Moottorivauriotutkimus Rotax UL 582-moottorin vaurioista aikana 1.1.1990–31.10.1991. Ilmailulaitos, 1992. (Investigation report 13/92. Engine damage investigation regarding damages to Rotax UL 582 engines between 1.1.1990–31.10.1991. Finavia 1992)

(19) *Lähteenmäki, E*. Luentokalvot. UL-onnettomuudet ja vauriot 1990–2002. (Overhead projector transparencies. UL accidents and minor accidents 1990–2002)

(20) Trafi Ilmailu. Kotisivut. Huhtikuu 2010. (Trafi Aviation. Home pages. April 2010)

(21) *Bengtström, T*. Ultrakevytlennon – moottoripurjelennon oppikirja, 2. painos. Suomen Ilmailuliitto ry, Experimental- ja ultrakevyttoimikunta, 2008. (Bengtström, T. Ultralight flying – motor powered gliding textbook. 2nd edition. Finnish Aeronautical Association, the Experimental and Ultralight Commission, 2008)

(22) European Civil Aviation Conference. Kotisivut. Helmikuu 2010. (European Civil Aviation Conference. Home pages. February 2010)

(23) Hawk Information Services Ltd. EASA study of microlight regulation within Europe. Päivätty 22.2.2010. (Dated 22 February 2010)

(24) Vuosikertomus 2009. Ilmailuhallinto. (Finnish Civil Aviation Authority, Annual report 2009)

(25) Suomen Ilmailuliitto ry. Kotisivut. Huhtikuu 2010. (Finnish Aeronautical Association. Home pages. April 2010)

(26) Sopimus harrasteilmailun viranomaisvalvonnan avustamisesta. Suomen Ilmailuliitto ry ja Ilmailuhallinto. Päivätty 25.4.2006. (Agreement on assistance with oversight on sport aviation. Finnish Aeronautical Association and Finnish Civil Aviation Authority. Dated 25 April 2006)

(27) Onnettomuustutkintakeskuksen vuosikertomus 2009. (Accident Investigation Board Finland. Annual report 2009)

(28) Council Directive 94/56/EC of 21 November 1994

(29) Council of the European Union. Proposal for a regulation of the European Parliament and of the council on investigation and prevention of accidents and incidents in civil aviation. Brussels, 12 March 2010.

(30) Ilmailumääräys AIR M5-10. Ultrakevyiden lentokoneiden lentokelpoisuus, valmistus, rekisteröinti ja huolto. Ilmailulaitos. Annettu 26.1.2004. (Aviation regulation AIR M5-10. The airworthiness, construction, registration and maintenance of ultralight aircraft. Finavia. Issued on 26 January 2004)

(31) Ilmailumääräys AIR M5-10. Ultrakevyiden lentokoneiden lentokelpoisuus, valmistus, rekisteröinti ja huolto. Ilmailulaitos. Annettu 25.11.1996. (Aviation regulation AIR M5-10. The airworthiness, construction, registration and maintenance of ultralight aircraft. Finavia. Issued on 25 November 1996)

(32) Ilmailumääräys AIR M5-1. Harrasterakenteisten ilma-alusten lentokelpoisuusvaatimukset. Ilmailulaitos. Annettu 25.11.1996. (Aviation regulation AIR M5-1. The airworthiness requirements of amateur-built aircraft. Finavia. Issued on 25 November 1996)

(33) Ilmailumääräys AIR M5-2. Harrasterakenteisten ilma-alusten rakentaminen. Ilmailulaitos. Annettu 25.11.1996. (Aviation regulation AIR M5-2. Construction of amateur-built aircraft. Finavia. Issued on 25 November 1996)

(34) Ilmailumääräys OPS M2-8. Lentotoiminta ultrakevyillä lentokoneilla. Ilmailulaitos. Annettu 2.12.1992. (Aviation regulation OPS M2-8. Flight operations on ultralight aircraft. Finavia. Issued on 2 December 1992)

(35) Ilmailumääräys TRG M1-7. Harrasteilmailun lentokoulutus. Ilmailuhallinto. Annettu 5.5.2009. (Aviation regulation TRG M1-7. Flight training in sport aviation. Finnish Civil Aviation Authority. Issued on 5 May 2009)

(36) Ilmailumääräys PEL M2-70. Ultrakevytlentäjän lupakirja. Ilmailuhallinto. Annettu 5.5.2009. (Aviation regulation PEL M2-70. Ultralight Pilot Licence. Finnish Civil Aviation Authority. Issued on 5 May 2009)

(37) Ilmailumääräys PEL M2-71. Ultrakevytlennonopettajan kelpuutus. Ilmailuhallinto. Annettu 5.5.2009. (Aviation regulation PEL M2-71. Ultralight Flight Instructor Rating. Finnish Civil Aviation Authority. Issued on 5 May 2009)

(38) Tutkinnan B6/2009L tutkintamateriaali. Onnettomuustutkintakeskus, 2009. (The research material of investigation B6/2009L. Accident Investigation Board, 2009)

(39) Koulutusohjelma moottoripurje- ja ultrakevytlentäjän lupakirjaa varten. Suomen Ilmailuliitto ry. Julkaistu 1.9.2008. (Curriculum for a Motor Glider Pilot Licence and Ultralight Pilot Licence. Finnish Aeronautical Association. Published on 1 September 2008)

(40) Koulutusohjelma moottoripurje- ja ultrakevytlentäjän lupakirjaa varten. Suomen Ilmailuliitto ry. Julkaistu 12.12.2004. (Curriculum for a Motor Glider Pilot Licence and Ultralight Pilot Licence. Finnish Aeronautical Association. Published on 12 December 2004)

(41) Koulutusohje ultrakevytlentäjän lupakirjaa varten. Suomen Ilmailuliitto ry. Julkaistu 16.3.1993. (Curriculum for an Ultralight Pilot Licence. Finnish Aeronautical Association. Published on 16 March 1993)

(42) Ultrakevytlennon opettajakurssin koulutusohjelma. Suomen Urheiluilmailuopisto Oy. Päivätty 23.9.2008. (Curriculum for an Ultralight Flight Instructor course. Finnish Sport Aviation Institute Ltd. Dated 23 September 2008)

(43) Suomessa rekisteröidyt ilma-alukset 1.1.1993. Ilmailulaitos. (Aircraft registered in Finland as of 1 January 1993. Finavia)

(44) Toimintakertomukset 1983–1993. Suomen ilmailuliitto ry. (Annual reports 1983–1993. Finnish Aeronautical Association)

(45) A-ultraluettelo 2007–2009. Suomen ilmailuliitto ry. (Class A ultralight catalogue 2007–2009. Finnish Aeronautical Association)

(46) Suomessa rekisteröidyt ilma-alukset 1.1.2010. Trafi Ilmailu. (Aircraft registered in Finland as of 1 January 2010. Trafi Aviation)

(47) Ilmailumääräys OPS M1-3. Lentotoimintatilasto. Ilmailuhallitus. Annettu 17.12.1973. (Aviation regulation OPS M1-3. Statistics on flight operations. Civil Aviation Administration. Issued on 17 December 1973)

(48) Ilmailutiedotus OPS T1-22. Lentotoimintatilasto. Ilmailuhallinto. Annettu 18.9.2009. (Advisory circular OPS T1-22. Statistics on flight operations. Finnish Civil Aviation Authority. Issued on 18.9.2009)

(49) Ultrakevyiden lentokoneiden lentotunnit 1991–2002. Trafi Ilmailu. (Ultralight aircraft flight hours 1991–2002. Trafi Aviation)

(50) Ilmailutiedotus OPS T1-1. Tilasto vuosittaisista lentotuntimääristä 1990–2002. Ilmailulaitos Lentoturvallisuushallinto. (Advisory circular OPS T1-1. Statistics on annual flight hours 1990–2002. Finavia. Flight Safety Authority)

(51) Ilmailuhallinto. Kotisivut. Marraskuu 2009. (Finnish Civil Aviation Authority. Home pages. November 2009)

(52) Lentotuntien ilmoitusprosentit 2003–2009. Trafi Ilmailu. (Flight hour reporting percentages 2003–2009. Trafi Aviation)

(53) Ultrakevyiden lentokoneiden, purje- ja moottoripurjelentokoneiden sekä yleisilmailulentokoneiden lentotunnit 2009. Trafi Ilmailu. (Ultralight aircraft, glider and powered glider as well as general aviation aeroplane flight hours in 2009. Trafi Aviation)

(54) Tutkijan ohje. Ilmailuonnettomuudet ja vaaratilanteet. Onnettomuustutkintakeskus, 2009. (Investigation Manual. Aviation accidents and incidents. Accident Investigation Board, 2009)

(55) Lento-onnettomuustilasto 1990. Ilmailulaitos. (Aviation accident statistics 1990. Finavia)

(56) Lento-onnettomuustilasto 1991. Ilmailulaitos Lentoturvallisuushallinto. (Aviation accident statistics 1991. Finavia. Flight Safety Authority)

(57) Lento-onnettomuus- ja vauriotilasto 1992. Ilmailulaitos C 10/93. Vantaa 27.10.1993. (Aviation accident and minor accident statistics 1992. Finavia C 10/93. Vantaa 27 October 1993)

(58) Lento-onnettomuus- ja vauriotilasto 1993. Ilmailulaitos C 8/94. Vantaa 15.10.1994. (Aviation accident and minor accident statistics 1993. Finavia C 8/94. Vantaa 15 October 1994)

(59) Lento-onnettomuus- ja vauriotilasto 1994. Ilmailulaitos C 5/95. Vantaa 18.9.1995. (Aviation accident and minor accident statistics 1994. Finavia C 5/95. Vantaa 18 September 1995)

(60) VASA Vuosiraportti 1995. Ilmailulaitos. (VASA annual report 1995. Finavia)

(61) Lento-onnettomuus- ja -vauriotilastot 1996–2009. Onnettomuustutkintakeskus. (Aviation accident and minor accident statistics 1996–2009. Accident Investigation Board)

(62) Ilmailumääräys OPS M2-1. Yleisilmailu – lentokoneet. Ilmailuhallinto. Annettu 21.12.2007. (Aviation regulation OPS M2-1. General aviation – aeroplanes. Finnish Civil Aviation Authority. Issued on 21 December 2007)

(63) Huoltotoiminta EASA Part M. Turvallisuustaso 2003–2005. Ilmailuhallinto. Esitelmä, Lappeenranta 4.11.2006. (Continuing Airworthiness and Maintenance EASA Part M. Safety level 2003–2005. Finnish Civil Aviation Authority. Presentation in Lappeenranta on 4 November 2006)

(64) Toimintakäsikirja. Onnettomuustutkintakeskus, 2010. (Operations Manual. Accident Investigation Board, 2010)

(65) ICAO Circular 216-AN/131. Human Factors Digest No. 1, 1989. Chapter 1.

(66) *Valonen, K*. Onnettomuustutkinnan vaikuttavuuden mittaaminen. Tutkielma 24.1.2010. (Measuring the input of accident investigation. Study. 24 January 2010)

(67) *Artimo, K*. Eera Finland Oy. Sidosryhmien kokemukset ja odotukset haastattelujen perusteella. Onnettomuustutkintakeskus, 2002. (Experiences and expectations of focus groups on the basis of interviews. Accident Investigation Board, 2002)

(68) Tutkintaselostusten lukijatutkimus. Onnettomuustutkintakeskus, 2006. (Investigation report reader survey. Accident Investigation Board, 2006)

(69) *Hiedanpää, M. ja Martikainen, H*. Haastattelu. Trafi Ilmailu. Toukokuu 2010. (Interview. Trafi Aviation. May 2010)

(70) Lentokelpoisuusmääräys M 3095/05. Comco Ikarus. Istuinvöiden kiinnitys. Ilmailulaitos Lentoturvallisuushallinto. Annettu 14.6.2005. (Airworthiness directive M 3095/05. Comco Ikarus. Seat harness attachments. Finavia. Flight Safety Authority. Issued on 14 June 2005)

(71) Lentokelpoisuusmääräys M 3102/06. Ilma-alusten pelastusvarjoista varoittaminen. Ilmailuhallinto. Annettu 15.11.2006. (Airworthiness directive M 3102/06. Warning of ballistic recovery systems on aircraft. Finnish Civil Aviation Authority. Issued on 15 November 2006)

(72) Lentokelpoisuusmääräys M 3091/05. Ultrakevyet lentokoneet. Nopeusmittarin merkinnät. Ilmailulaitos Lentoturvallisuushallinto. Annettu 14.6.2005. (Airworthiness directive M 3091/05. Ultralight aircraft. Airspeed indicator markings. Finavia. Flight Safety Authority Issued on 14 June 2005)

(73) Ilmailumääräys PEL M2-71. Ultrakevytlennonopettajan kelpuutus. Ilmailuhallinto. Annettu 20.12.2007. (Aviation regulation PEL M2-71. Ultralight Flight Instructor Rating. Finnish Civil Aviation Authority. Issued on 20 December 2007)

(74) Ilmailumääräys PEL M2-70. Ultrakevytlentäjän lupakirja. Ilmailulaitos. Annettu 12.1.2000. (Aviation regulation PEL M2-70. Ultralight Pilot Licence. Finavia. Issued on 12 January 2000)

(75) Ilmailumääräys PEL M2-70. Ultrakevytlentäjän lupakirja. Ilmailuhallinto. Annettu 20.12.2007. (Aviation regulation PEL M2-70. Ultralight Pilot Licence. Finnish Civil Aviation Authority. Issued on 20 December 2007)

(76) *Sucksdorff, J*. Haastattelu. Suomen Ilmailuliitto ry. Toukokuu 2010. (Interview. Finnish Aeronautical Associatoin. May 2010)

(77) Tutkintojen kustannusseuranta. Onnettomuustutkintakeskus. Toukokuu 2010. (Cost monitoring of investigations. Accident Investigation Board. May 2010)

Accident Investigation Board investigation reports included in the research material:

Investigation report C1/2000L. Ultralight aircraft accident at Mäntsälä on 5 1.2000. AIB 2000.

Investigation report C11/2000L. Ultralight aircraft minor accident at Parainen on 19.8.2001. AIB 2001.

Investigation report C11/2002L. Ultralight aircraft accident at Viitasaari on 16.11.2002. AIB 2003.

Investigation report C7/2003L. Ultralight aircraft accident at Kirkkonummi on 11.6.2003. AIB 2004).

Investigation report B1/2004L. Aviation accident at Hollola on 16.2.2004. AIB 2004.

Investigation report B3/2004L. Aviation accident at Mäntsälä on 24.8.2004. AIB 2004.

Preliminary report D1/2005L. Aviation accident at Viitasaari on 15.1.2005. AIB 2005.

Category D investigation report form D6/2006L. AIB 2006.

Investigation report B2/2006L. Ultralight aircraft accident at Aska, Sodankylä on 10.7.2006. AIB 2007.

Category D investigation report form D9/2006L. AIB 2006.

Category D investigation report form D11/2006L. AIB 2006.

Investigation report B3/2006L. Aviation accident at Lake Hirsijärvi on 8.8.2006. AIB 2007.

Category D investigation report D4/2007L. AIB 2007.

Investigation report C5/2007L. Incidents caused by an ultralight aircraft at Malmi aerodrome on 12.8.2007. AIB 2008.

Category D investigation report D2/2008L. Mid-air loss of control of an ultralight aircraft and an emergency landing at Vampula on 22.6.2008. AIB 2008.

Category D investigation report D5/2008L. Damage to an ultralight aircraft during landing in Hanko on 24.7.2008. AIB 2010.

Final draft of investigation report D2/2009L. Ultralight aircraft accident at Lahti-Vesivehmaa air-field on 16.1.2009. AIB 2010.

Category D investigation report D3/2009L. Ultralight aircraft accident at Helsinki-Malmi aero-drome on 21.4.2009. AIB 2009.

Category D investigation report D4/2009L. Aviation accident near Torbacka airfield on 28.4.2009. AIB 2010.

Final draft of investigation report B6/2009L. Aviation accident at Kauhava aerodrome on 4.8.2009. AIB 2010.

APPENDIX 1. CERTIFIED CLASS B ULTRALIGHT FLIGHT TRAINING ORGANISATIONS IN FINLAND IN AUGUST 2009

Unofficial translations shown in brackets

- Air Pilot ry
- Archipelago’s Aeroclub
- Etelä-Pohjanmaan Ilmailukerho ry (Southern Bothnia Aviation Club)
- Flight Club ry
- Hangon Lentokerho ry - Hangö Flygklubb
- Hämeenlinnan Ilmailukerho ry (Hämeenlinna Aviation Club)
- Hämeenlinnan ja Ympäristön Urheiluilmailijat ry (Sport aviators of Hämeenlinna and its Surroundings)
- Iin Ilmailukerho ry (Ii Aviation Club)
- Ilmasotakoulun Lentokerho ry (Air Force Academy Flight Club)
- Imatran Ilmailukerho ry (Imatra Aviation Club)
- Inkeroisten Ilmailukerho ry (Inkeroinen Aviation Club)
- Joensuun Ilmailukerho ry (Joensuu Aviation Club)
- Keski-Karjalan Ilmailukerho ry (Central Karelia Aviation Club)
- Keski-Suomen Ilmailijat ry (Aviators of Central Finland)
- Kevytilmailu - Light Aviation ry
- Kiitotiekaksviis ry (Runway 25)
- Kokkolan Ilmailukerho ry (Kokkola Aviation Club)
- Kuopion Ilmailuyhdistys ry (Kuopio Aviation Association)
- Lapinlahden Ilmailijat ry (Aviators of Lapinlahti)
- Länsilentäjät ry (Western Pilots)
- Mikkelin Ilmailuyhdistys ry (Mikkeli Aviation Association)
- Mäntsälän Ilmailukerho ry (Mäntsälä Aviation Club)
- Paimion Ilmailuyhdistys ry (Paimio Aviation Association)
- Pirkan Ilmailijat ry (Pirkka Aviators)
- Pudasjärven Ilmailukerho ry (Pudasjärvi Aviation Club)
- Päijät-Hämeen Ilmailuyhdistys ry (Päijät-Häme Aviation Association)
- Raahen Ilmailijat ry (Raahe Aviators)
- Salon Seudun Ilmailukerho ry (Salo Region Aviation Club)
- Star Pilot ry
- Suomen Urheiluilmailijat ry (Finland’s Sport Aviators)
- Tmi Mika Ruutiainen (Sole Proprietorship Mika Ruutiainen)
- Vihannin Ilmailijat ry (Vihanti Aviators)

APPENDIX 2. ALL ULTRALIGHT ACCIDENTS, MINOR ACCIDENTS AND SERIOUS INCIDENTS INVESTIGATED BY THE AIB FROM 1996–2009

Identifier	Title of investigation	Date of occurrence	Class of UL
B10/1996L	Accident at Rautavaara	11.8.1996	B
C10/1998L	Minor accident at Pattijoki	18.4.1998	B
C22/1998L	Minor accident at Kymi	26.9.1998	B
B1/1998L	Accident at Viitasaari	5.10.1998	B
C17/1999L	Minor accident at Viitasaari	4.8.1999	B
C1/2000L	Accident at Mäntsälä	5.1.2000	B
C11/2000L	Accident at Parainen	19.8.2000	B
C11/2002L	Accident at Viitasaari	16.11.2002	B
C7/2003L	Accident at Kirkkonummi	11.6.2003	B
B1/2004L	Accident at Hollola	16.2.2004	B
B3/2004L	Accident at Mäntsälä	24.8.2004	B
C1/2005L	Accident at Vammala	6.1.2005	A
D1/2005L	Minor accident at Viitasaari	15.1.2005	B
D6/2006L	Serious incident at sea off Turku	22.4.2006	B
B2/2006L	Accident at Sodankylä	10.7.2006	B
D9/2006L	Minor accident at Haapavesi	11.7.2006	B
D11/2006L	Minor accident at Oulunsalo	1.8.2006	B
B3/2006L	Accident at Lake Hirsijärvi	8.8.2006	B
D4/2007L	Minor accident at Pudasjärvi	3.2.2007	B
C4/2007L	Accident at Mustasaari	23.6.2007	A
C5/2007L	Serious incident at Helsinki	12.8.2007	B
D2/2008L	Minor accident at Vampula	22.6.2008	B
D3/2008L	Accident at Valkeakoski	7.7.2008	A
D5/2008L	Minor accident at Hanko	24.7.2008	B
D2/2009L	Accident at Lahti-Vesivehmaa	16.1.2009	B
B3/2009L	Accident at Hyvinkää	14.4.2009	A
D3/2009L	Accident at Helsinki	21.4.2009	B
D4/2009L	Accident at Inkoo	28.4.2009	B
B6/2009L	Accident at Kauhava	4.8.2009	B

APPENDIX 3. EXAMPLES OF SERIOUS INCIDENTS PURSUANT TO ANNEX 13 TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

- Near collisions requiring an avoidance manoeuvre to avoid a collision or an unsafe situation or when an avoidance action would have been appropriate.
- Controlled flight into terrain only marginally avoided.
- Aborted take-offs on a closed or engaged runway.
- Take-offs from a closed or engaged runway with marginal separation from obstacle(s). Landings or attempted landings on a closed or engaged runway.
- Landings or attempted landings on a closed or engaged runway.
- Gross failures to achieve predicted performance during take-off or initial climb.
- Fires and smoke in the passenger compartment, in cargo compartments or engine fires, even though such fires were extinguished by the use of extinguishing agents.
- Events requiring the emergency use of oxygen by the flight crew.
- Aircraft structural failures or engine disintegrations not classified as an accident.
- Multiple malfunctions of one or more aircraft systems seriously affecting the operation of the aircraft.
- Flight crew incapacitation in flight.
- Fuel quantity requiring the declaration of an emergency by the pilot.
- Take-off or landing incidents. Incidents such as undershooting, overrunning or running off the side of runways.
- System failures, weather phenomena, operations outside the approved flight envelope or other occurrences which could have caused difficulties controlling the aircraft, and
- Failures of more than one system in a redundancy system mandatory for flight guidance and navigation.

APPENDIX 4. SUMMARIES AND SHELL ANALYSES OF ULTRALIGHT ACCIDENTS, MINOR ACCIDENTS AND SERIOUS INCIDENTS INVESTIGATED BY AIB INCLUDED IN THIS RESEARCH MATERIAL

C1/2000L: Accident at Mäntsälä on 5 Jan 2000

Summary of investigation C1/2000L

On 5 January 2000 at 14:59 an accident happened in Mäntsälä to a Cora 200 Arius type ultralight aircraft, registration OH-U367. The pilot lost control of the aircraft at the final phase of the approach. The 58 year old pilot, the sole occupant, was not injured but the aircraft was badly damaged.

The pilot intended to fly from Helsinki-Malmi aerodrome to a field which was being used as a temporary ultralight airfield, close to his home in Mäntsälä. In the beginning of the flight the pilot made two touch-and-go landings on runway 27, the shorter runway at Helsinki-Malmi. Since he was happy with the way they went he proceeded to fly towards Mäntsälä. During the cross-country leg the left window began to fog and the pilot fully opened its vent hole. Up until then both vents were closed. As the pilot was opening the vent he glanced at the airspeed indicator but did not notice any change in its indication. The heater was on, which kept the windshield clear. The pilot decided to make a direct approach to the base leg of the airfield. He flew at 250 m and at 120 km/h on the base leg at which time he selected 15 degrees flap. He made a gentle descending turn to the final. In the middle of the final approach he selected 50 degrees flap; the indicated airspeed (IAS) at that point was 100 km/h and the altitude was approximately 150 m. At the end of the final approach the aircraft flew at approximately 35 m height and 75–80 km/h IAS. Engine power was set at 4000 rpm. At approximately 20 m and 70–75 km/h IAS he estimated that he would be able to make it and reduced engine power. At this point in time the aircraft strongly rolled to the left without warning. The pilot immediately added almost full power and applied full right aileron. It seemed for a moment that the aircraft would recover but then it banked again to the left and crashed into the field which was covered with approximately 20 cm of snow.

The pilot had received his basic flight training on a weight-shift controlled ultralight aircraft in 1986. In 1990 he received approximately 6 hours of training on a normally controlled aircraft, the Renegade Spirit class B ultralight. After this he flew on the type for approximately 10 years. In addition, he had accrued some flying experience on three other ultralight types. In August 1999 he purchased a Cora 200 Arius ultralight aircraft, the accident aircraft. The importer provided him with type training on it in August-September 1999, mainly at Helsinki-Malmi. The type training encompassed approximately 16 hours of flights with an instructor and 76 landings. Prior to the accident flight the pilot had not flown for approximately 3.5 months. His total flying experience on all ultralight aircraft types was approximately 361 hours, of which approximately 21 hours were on the accident type. Over the course of several years he had made hundreds of landings with the Renegade Spirit ultralight aircraft on the field which was next to the airfield he used on the accident flight. The accident type was more advanced than the Renegade Spirit; it was so demanding that the type training provided by the importer and training flights did not equip him with sufficient skills regarding the aircraft's characteristics or landing techniques on short runways. During the past 12 months he had flown approximately 30 hours which meant that his recent flying experience was relatively good. However, his ability to safely control the aircraft was degraded due to the long hiatus from his previous flight.

The accident aircraft was the first of its type in Finland at the time. In order to receive type-certification for it a flight test programme approved by the aviation authority had been required. The flight test programme was still underway when the accident happened. By chance, it had been discovered that static pressure fluctuation in the cockpit affected airspeed indication. The fluctuation of static pressure in the cockpit, in turn, was affected by the position of the vents and propeller wash. In September 1999 a test flight was flown to determine the airspeed indication error by using an additional airspeed indicator as a reference. The test flight was flown with the vents closed at 90–200 km/h, according to the aircraft's airspeed indicator. Results showed that at low airspeeds the airspeed indicator displayed an airspeed which was approximately 8 km/h higher than the true airspeed, and that the error grew as airspeed increased. In addition, the itinerary of the test flight included five stalls at the mass of 482 kg with the engine idling and wing flaps fully extended. The average stall speed, according to the reference airspeed indicator, was 63 km/h. By assuming that the aircraft's airspeed indicator display was 8 km/h too high, its indication was in the region of 70 km/h when the aircraft would stall. A demonstration flight that was flown after the accident found that the airspeed indication error increased somewhat when the vents were opened in the back. Judging by this the indicated airspeed was approximately 8–10 km/h higher than the true airspeed when the vents were closed or opened in the back. Moreover, the high power setting used during the approach may have increased the airspeed indication error so that the aircraft was already in the stall speed range when the indicated airspeed was 75 km/h.

The pilot was aware of the airspeed indication error to a degree, but he thought that the indication was pretty accurate at the approach speed range. He did not remember the effect of the position of the vents on the indication error, or on its magnitude. He considered 10–15 km/h to be a safe margin for 65 km/h which was the stall speed indicated in the flight manual and, therefore, he decided to maintain 75–80 km/h IAS on the final leg. He did not have access to the test flight report which had been written in September 1999. This would have informed him of the airspeed indication error at any given airspeed range. Neither was there any mention of the airspeed indication error in the flight manual. The errors in the aircraft's airspeed measuring system, which varied in magnitude and direction, had not properly been tested, nor were the aircraft operators informed of them.

At the end of the final leg the pilot needed lots of power, approximately 50 %, so as to maintain 75–80 km/h IAS with the flaps fully extended. He did not precisely know how to regulate power when adjusting the sink rate or how to use the control stick when adjusting the angle of attack and airspeed. At the end of the final leg, at 70–75 km/h IAS the aircraft was flying at the stall speed or very close to it. Nevertheless, the approach was stable and the pilot did not notice any sloppiness in controls as a symptom of an approaching stall. Since the runway was short, the pilot wanted to land as close as possible to the threshold of the runway which was ploughed onto the field. When he estimated that he would make it to the runway he reduced power. This resulted in an increased sink rate at which time he instinctively pulled on the yoke in order to prevent the aircraft from sinking. At this time airspeed decreased and the aircraft stalled immediately, without warning. Had he maintained sufficient engine power until touchdown, as the FAA's club manual regarding landings on short runways recommends, he would probably have made a normal landing. There was no time for the pilot to recover from the unexpected stall at a low altitude. The instinctively applied full opposite aileron probably only exacerbate the situation by increasing the angle of attack of the stalling wing. The only way to recover from the stall would have been by pushing on the stick but the low altitude did not permit this. An increase in engine power was no longer sufficient. The pilot did not fully master the technique of landing on a short runway at a low airspeed.

The accident was caused by the aircraft stalling at a low altitude at the end of the approach. The reduction of engine power which was made in conjunction with the decision to land caused an increasing sink rate, which the pilot attempted to counter by instinctively pulling on the stick. The angle of attack then increased and airspeed decreased, which resulted in a stall. Due to the low altitude the pilot was unable to recover from the stall. The aircraft's airspeed indicator error, of which the pilot was misinformed, contributed to the accident. While he believed that his approach speed was sufficiently high in relation to the stall speed, in reality he was flying at an airspeed which was very close to the stall speed. The following SHELL analysis presents the human factors that contributed to the accident.

No safety recommendations were issued.

SHELL analysis of investigation C1/2000L

L-S

The pilot's type rating training on the accident type was limited in relation to the demands of the aircraft, especially regarding landing technique on a short runway.

The pilot's flying experience on the aircraft type was limited. The pilot's recent flying experience was limited.

The pilot did not fully master the landing technique on a short runway at a low airspeed. The pilot did not recognise the symptoms of an approaching stall.

The aircraft's flight manual was lacking regarding the airspeed indication error. Neither had the operators been made aware of the errors. As a result, the pilot had no reliable information regarding the magnitude of the airspeed indication error at the approach speed range, nor of the effect of the vent positions on it.

L-H

The airspeed indication was too high. The airspeed indicator was already on the aircraft when it was delivered by the manufacturer.

L-E

-

L-L

-

C11/2000L: Accident at Parainen on 19 Aug 2000

Summary of investigation C11/2000L

On 19 August 2000 at around 21:30 an accident happened at Parainen. An Eurocub 912 Mk 1 ultralight floatplane, registration OH-U353, capsized during a water landing. The 35 year old pilot, the single occupant, was not injured. However, the aircraft was badly damaged.

At 21:10 the pilot took off for a cross-country flight from the shore of his acquaintance's summer cottage. He intended to fly back home to Parainen. Since the route meandered along the coastline and the weather was good he decided to practice touch-and-go water landings. After four touch-and-go landings he started the fifth landing from an altitude of 200 ft and at the approach speed of 60 knots (kt). At approximately 3–4 m from the surface of water he flared and at approximately 0.5 m he closed the throttle. The rear parts of the floats touched the water first and when the pilot closed the throttle, the floats entered the water at their full length. At the same time the aircraft rolled to the left and nosed over into the water. The right float flipped over lengthwise under the aircraft and popped to the surface after the aircraft had passed over it. It broke loose of the aircraft. At first the nose of the aircraft submerged all the way to the top of the windshield but then it returned to the surface. The pilot went on top of the aircraft from where the eyewitnesses that arrived at the site picked him up in their boat.

The pilot held a UPL licence and an ultralight flight instructor rating. His total flying experience on all ultralight types was approximately 374 hours, of which approximately 97 hours were on the accident type. During the past 90 days he had flown approximately 20 hours on the accident type.

The accident aeroplane was purchased from the manufacturer in 1995. The then Ålandic owner had purchased the floats as a kit from the manufacturer in the United States. The floats were first installed on the aircraft in the spring of 1998 in the Åland Islands. An aircraft inspector certified by Finavia had inspected and approved the float installation and recommended that the aircraft be issued a permit for it to ferry to Ranua, to where it had recently been sold. Furthermore, Finavia had ordered a specific flight test programme for the aircraft so as to study its characteristics regarding floatplane operations. When the aircraft arrived at Ranua at the end of May 1998 its new owner and the persons designated as test pilots realised that the float installation was too weak. Therefore, they decided to fabricate a completely new installation for the float attachment. During the test flights that were flown in August 1998 the float installation was redone in accordance with the test pilots' requirements. In May 1999 Finavia issued a Limited Certificate of Airworthiness for the aircraft, valid until the end of February 2002.

After this the aircraft was sold yet again. When the new owner from Dragsfjärd, who owned the aircraft at the time of the accident, purchased the aircraft from its previous owner in Ranua, the aircraft had been fitted on wheels. The new owner received the floats and their attachments from the previous owner, intending to install the floats in the same manner as had been done at Ranua. No detailed installation instructions from the installation process in Ranua existed and the new owner did not remember to ask the previous owner for photos taken during the installation. Nevertheless, he called him, asking for installation instructions over the telephone. The new owner installed the floats in May 2000 in accordance with the instructions he received over the telephone, which he partly misunderstood.

The floats had been installed three times and in a different manner each time. Particularly the second and third installation process contributed to the onset of the accident. During the second installation, at crucial points of the float attachment too soft of a material was used and different types of material were layered so that the attachment caused surfaces to wear and tear against each other. The cross braces between the pontoons had been bought from boating supplies. The intention was to complete the third installation in the same manner as the second one and by using the same parts, but it was done contrary to the second installation by, among other things not using locknuts in the attachment. The unlocked nut on the right float's second main attachment bracket had already been loose during several landings and the attachment bracket broke on the accident flight, after which the float separated from the aircraft. The attachment bracket broke at the same time as the cross braces broke into two. The structural integrity of the cross braces was insufficient. Moreover, the owner at the time of the accident had installed the landing gear in a different place on the floats compared to the installation done at Ranua. This was because he partly misunderstood the instructions given to him over the telephone. In addition to the faulty installation it was probable that the float attachments were not checked often enough. Had the attachments been checked before the accident flight or even between previous flights the loose attachment and possibly even the loosening of the nut could have been detected, as wear marks that are typically caused by loosening were found on the attachment parts.

The accident was caused by the detachment of the right float, which was the result an of inappropriate float installation. The following SHELL analysis presents the human factors that contributed to the accident.

No safety recommendations were issued.

SHELL analysis of investigation C11/2000L

L-S

The pilot did not check the float attachment in the pre-flight check during intermediate landings.

L-H

Unsuitable structural solutions were used in the aircraft's float attachments.

L-E

-

L-L

The new owner partly misunderstood the previous owner's instructions which he received over the telephone regarding the float installation.

C11/2002L: Accident at Viitasaari on 16 Nov 2002

Summary of investigation C11/2002L

An accident happened at Viitasaari aerodrome on 16 November 2002 at approximately 14:15–14:50 when, on a test flight and fitted on skids, a Rans Courier S-7 L ultralight aircraft, registration OH-U248, collided with the ground following an engine failure during takeoff. The 69 year old pilot, the sole occupant, was seriously injured and the aircraft was badly damaged.

The pilot intended to fly from Viitasaari aerodrome onto lake ice close to his home. The flight was included in the test flight programme. The pilot started the takeoff from the beginning of the runway at Viitasaari aerodrome. In order to improve acceleration, he used a technique in which the initial takeoff roll is done in a clean configuration. As he approached the rotation speed he meant to select 10 degrees flap, but by mistake he probably selected 40 degrees flap. When the aircraft was approaching the end of the runway the engine suddenly died. After this the aircraft rapidly decelerated to stall speed or close to it. The combined effect of the configuration, deceleration and the centre of gravity which was clearly in front of its forward limit caused a strong nose down movement, resulting in a rapidly steepening dive. The pitch angle could no longer be controlled. The aircraft collided with the ground at an approximate 50–60° dive angle, banked at approximately 30° to the left.

The pilot held a UPL licence. His total flying experience on all ultralight aircraft types was approximately 220 hours, of which approximately 147 hours were on class B and the rest on class A ultralights. His total flying experience on the accident type was 30 minutes. The pilot's limited flying experience on the type may have contributed to the inadvertent, erroneous wing flap selection. As a result of this his limited flying experience on the type may have contributed to the onset of the accident because the full flap selection made it more difficult for him to control the aircraft after the engine died.

In 2000 the pilot purchased the amateur-built, accident aircraft, which had been damaged in a minor accident. He intended to repair the damage and replace the engine on the aircraft with a used car engine, modified for aeroplane use. In February 2001 the pilot submitted a repair and modification permit application to Finavia. Between February 2001 and April 2002 the FAA processed the application several times and repeatedly requested information pertaining to the repair and modification as well as the supervisor of the construction. The pilot proposed the original owner of the aircraft as the supervisor but the FAA considered him ineligible and did not accept him for it. In November 2001 the pilot proposed another supervisor, whom the FAA accepted. In April 2002, as the FAA was recommending the approval for the modification, they inadvertently used the application form in which the aircraft's original constructor had been proposed as the supervisor. Because of this, in lieu of the FAA-approved second supervisor Finavia designated the aircraft's original constructor as the supervisor for the modification. The permit was issued in May 2002.

The person designated as the supervisor had first familiarised himself with the damage on the aircraft in the winter of 2001, at the time when the repair permit application was submitted. Then, together with the pilot, he had determined the areas and the procedures required in order to repair the damage. He only promised to supervise the damage repair, considering himself unqualified to supervise the engine modification. The supervisor was under the impression that the pilot would seek another person to supervise the engine modification. He did not understand the nature of the duty when he consented to be the supervisor, because normally a supervisor oversees the entire construction. He was surprised to learn that in May 2002 he had been accepted as the supervisor for the construction. Prior to that he thought that he had been considered ineligible for the post. This is why he had not monitored the construction after the first time he saw the damage in the winter of 2001. After having learned that he was the supervisor he went to see the aircraft in May 2002 and found that the work was already almost completed. After this he discussed the situation at Finavia with the accountable inspector. They finally decided that the structural integrity of the aircraft was to be inspected as best as possible. The second supervisor had seen the aircraft in the summer of 2001. By then the pilot had almost completed the repair and the engine modification and was only waiting for the permit to be approved. During this interval nobody had supervised the engine modification. In June 2002, before the aircraft inspection the supervisor inspected the aircraft twice. However, during the inspections he did not check the engine modification. On the basis of these inspections the supervisor had declared the aircraft airworthy. Following the aircraft inspection in June 2002 the aircraft was certified for test flying. In September 2002 Finavia issued a permit to fly for a test flying programme.

The supervisor's responsibility was to control that the build complies with aviation regulations and the conditions of the permit. He was also required to take corrective action regarding any detected nonconformities. From the onset, he should have monitored the build and flight testing until the aircraft received a limited airworthiness certificate. Since the pilot decided to complete the engine modification before obtaining a permit to do so, and because the wrong person was designated as supervisor as a result of human error to do with the responsibilities of Finavia and FAA, nobody supervised the engine modification. Moreover, according to aviation regulations the pilot should have submitted several different documents to Finavia before being able to obtain a build permit and a permit to fly. The documents submitted by the pilot are extremely insufficient and several documents required by aviation regulations do not even exist. For example, pursuant to aviation regulation, in conjunction with the aircraft inspection the pilot should have presented a construction report and an expert statement regarding the engine modification. However, the pilot had not had an expert inspect the engine modification and, therefore, no expert statement existed. The inspector recorded the nonconformity as a remark during the aircraft inspection. The investigation did not establish how much weight Finavia placed on the missing reports when they issued the build permit and the permit to fly.

During the engine modification the pilot made several structural changes to the engine. He had made a critical change to the fuel system which eventually caused the engine to die on the accident flight. The probable cause of the engine dying was a vapour lock in the fuel system which prevented fuel feed to the engine. A vapour lock can form when fuel vapours accumulate in the fuel pump and the fuel suction line due to an incorrect installation of the fuel return line. The engine modification caused the centre of gravity to move forward because the new engine was heavier than the old one. The pilot had not performed mass and balance calculations because he believed that this would not have provided reliable information regarding stability and controllability. Whereas the mass of the aircraft on the accident flight was below the MTOM, the centre of gravity was forward of the permissible limit. Both the position of the CG and the configuration contributed to the loss of control of the aircraft following the engine failure. It would have been possible to maintain airspeed and glide straight ahead in a clean configuration and a clean configuration would have made it easier to control pitch, regardless of the position of the GC. Had the CG been in the permissible range there would have been no problems in pitch control.

The accident was caused by the engine dying during takeoff and the resulting loss of control. The configuration and the nose-heavy CG contributed to the loss of control of the aircraft. The engine failure was caused by an incorrect fuel system construction during engine modification. The failure to supervise the engine modification partly contributed to the flawed installation. The following SHELL analysis presents the human factors that contributed to the accident.

The investigation commission issued four safety recommendations. The investigation commission recommended that the CAA's Flight Safety Authority supplement its regulation with regard to the supervision of amateur-built aircraft fabrication and require appropriate planning in powerplant modification and expert inspection of said modification as well as comments whenever powerplants other than aviation engines were modified to be used in aviation. In addition the investigation commission recommended that CAA's Flight Safety Authority expand the opportunities for the initial inspections of amateur-built aircraft with regard to the monitoring of the airworthiness of the aircraft and their equipment. The investigation commission recommended that the FAA pay special attention to the assessment of fabricators' skills during the construction permit application process.

SHELL analysis of investigation C11/2002L

L-S

The pilot had limited flying experience on the type, which may have contributed to the onset of the accident.

The supervision of engine modification failed.

L-H

The pilot had insufficient skills for the engine modification.

The centre of gravity was forward of the permissible range.

The pilot inadvertently selected full flap at takeoff.

L-E

-

L-L

-

C7/2003L: Accident at Kirkkonummi on 11 Jun 2003

Summary of investigation C7/2003L

On June 11 2003 at 12:17 an accident happened at Kirkkonummi when an Ikarus C42 ultralight aircraft, registration OH-U387, crashed on a field after having stalled in a climb following takeoff. The 53 year old pilot and the passenger were seriously injured and the aircraft was badly damaged.

In the morning prior to the accident flight the pilot drove to Kirkkonummi to take a look at a field on which he intended to land later in the day. The pilot determined that the field was suitable for landing and takeoff. Then he drove to Torbacka airfield. From Torbacka he took off and after approximately 15 minutes of flying he landed on the previously inspected field, in the heading of 080 degrees magnetic. From this field he picked up a passenger. He taxied to the western end of the field, approximately 60 m from the end and turned the engine off. The pilot and the passenger deplaned and manually turned it around towards the takeoff heading, 080 degrees magnetic. The pilot started the engine, fully extended the wing flaps to 40 degrees and started the takeoff run. The takeoff run was clearly longer than normal. The pilot continued to accelerate from the ground effect after liftoff. Then he banked left at approximately 30 degrees, climbing to approximately 10–15 m. The aircraft stalled during the climbing turn, rolled left and crashed into the field. The left wing hit the ground first, followed by the nose. The aircraft turned almost 180 degrees from the direction it came from. Both persons were seriously injured. In the crash the pilot's and the passenger's shoulder harnesses on their 4-point seat harnesses came loose at the top. Moreover, the pilot's second lap belt came loose. As a result, the pilot and the passenger hit their faces on the top edge of the instrument panel, which caused some of their serious injuries.

As a result of several factors, the takeoff run was estimated to be approximately 40 % longer than normal. These factors included tailwind, the excess weight of the aircraft, the uneven surface of the field and an incline, wing flap setting and possible prior impact damage to the engine. When the pilot inspected the field earlier in the morning the wind was coming from the east. This is why he had landed in the heading of 080 degrees, i.e. into a headwind. He selected the same direction for takeoff. The pilot believed that he would be airborne before reaching the more uneven section at the eastern and upper part of the field. He did not check the wind direction at the takeoff phase nor was there a windsock on the field. Right about the time of the takeoff, around noon, wind direction had changed which caused the pilot take off into a tailwind. At the time of the takeoff the aircraft was 17.5 kg overweight which degraded acceleration. There was newly-mowed hay on the field and the holes on the surface were large in comparison to the main landing gear tyre size. Wing flaps were fully extended, which increased drag and reduced acceleration as well as takeoff speed. On the other hand, this wing flap setting decreased takeoff speed and the aircraft became airborne earlier in comparison to a situation in which the takeoff run would have been made with less wing flap. It is difficult to precisely estimate the total effect of the wing flaps. In addition, the engine had possibly suffered impact damage earlier which probably decreased the maximum power on the accident flight from that prior to the damage. Reduced engine power degraded the aircraft's acceleration and climb rate.

The aircraft was designed and manufactured in Germany. In Germany ultralight operations are only permitted from licensed aerodromes. It is possible that the landing gear design did not sufficiently allow for the fact that outside Germany the aircraft would also operate from uneven fields. Ultralight aircraft landing gear is constructed to be as light as possible, due to the limited MTOM. The flight and operation manual's original English language version noted that the aircraft was only designed to operate from licensed aerodromes. This was not mentioned in the Finnish language flight and operations manual. As a result, the pilot was maybe oblivious to the fact that the aircraft design criteria did not necessarily include operations from uneven fields.

After takeoff, as a consequence of the longer-than-normal takeoff run, the pilot had to turn at a low altitude so as to avoid the trees and buildings at the side of the field. This resulted in the airspeed bleeding off to the stall speed and a stall. At that time the aircraft was flying so low, at approximately 10–15 m, that there was not enough altitude to recover from the stall. There were several factors that contributed to the stall. The excess weight and the bank angle increased the stall speed as well as the leaving the ground effect prior to the stall. According to the import inspection, required for type certification, the airspeed indicator displayed an airspeed that was 5 km/h higher than actual airspeed. According to the flight and operations manual the stall speed at the MTOM of 450 kg, with flaps fully extended and the engine idling, was 65 km/h. The airspeed indication was 70 km/h. The pilot was unaware of the airspeed indication error. The Finnish ultralight aircraft inspection manual did not provide any maximum permissible value for airspeed indication error. However, an error of this magnitude is too large, especially, if the pilot is uninformed of it. The problem is accentuated in demanding conditions, such as operating from short airfields. The engine was running at takeoff power in a climb, which decreased the stall speed when compared to the abovementioned stall speed with the engine at idle. In all, the stall speed on the accident flight was higher than that mentioned in the flight and operations manual.

The pilot held a UPL licence. Furthermore, he was a professional airline pilot. During the past 90 days he had flown approximately 2 hours on the accident type. His total flying experience on all aircraft types was approximately 17 000 hours, of which approximately 77 hours were on the accident type. This being the case, he had plenty of flying experience on jetliners in comparison to the accident type. On jetliners the onboard flight computer prevents the aircraft from reaching the stall speed. An unexpected situation in a climb on the accident flight may have led the pilot to apply erroneous controls, due to the differences in procedures for the two respective classes of aircraft. The accident aircraft was not fitted with a stall warning system – nor was one even required in ultralights. The pilot's considerable flying experience as a professional airline pilot may have contributed to the fact that he instinctively continued to pull on the control stick in a sudden abnormal situation, waiting for a stall warning.

The accident was caused by stalling at a low altitude in a climb, resulting with the aircraft colliding into the ground. The factors that contributed to the airspeed decreasing to stall speed were the airspeed indication which was too high as well as excess weight and the turn. The following SHELL analysis presents the human factors that contributed to the accident.

Two safety recommendations were issued. The investigation commission recommended that the CAA's Flight Safety Authority pay attention to the installation of seat harnesses on the Ikarus C42 ultralight aircraft and require the inclusion of airspeed indicator calibration charts in all ultralight aircraft flight manuals. The information in said charts shall rely on import inspections or flight tests.

SHELL analysis of investigation C7/2003L

L-S

The pilot's considerable flying experience as an airline pilot may have contributed to his action in an unexpected stall because jetliner procedures during stalling differ fundamentally from those of ultralight aircraft.

The pilot did not recognise the symptoms of an approaching stall.

The flight and operation manual did not mention the airspeed indication error or that the aircraft was only designed to operate from licensed aerodromes.

L-H

The airspeed indicator displayed an airspeed which was too high. The pilot was unaware of this. The airspeed indicator was installed by the manufacturer.

The seat harness attachments failed a load below that of airworthiness requirements. The seat harnesses were installed by the manufacturer.

The aircraft was overweight.

L-E

Takeoff was made into a tailwind. The terrain of the takeoff site in the direction of the takeoff was towards an incline. The unevenness of the takeoff surface was considerable in comparison to the main landing gear tyre size. There were obstacles at the takeoff site.

L-L

-

B1/2004L: Accident at Hollola on 16 Feb 2004

Summary of investigation B1/2004L

An accident happened in Hollola on 16 February 2004 at approximately 15:18. A Dynamic WT-9 ultralight aircraft, registration OH-U415, collided with the ground on a cross-country flight. The aircraft became inverted and the pilot fell through the canopy to the ground. The 51 year old pilot was killed and the passenger was seriously injured.

Earlier that afternoon the pilot and the passenger took off from Hyvinkää aerodrome for Vesivehmaa aerodrome. After a short stopover at Vesivehmaa they intended to return to Hyvinkää. They took off from Vesivehmaa at approximately 15:10. The aircraft was flying with excess weight and its centre of gravity was well outside the permissible aft limit. During the cross-country flight, at approximately 600 m altitude and roughly 8 km south of Vesivehmaa, the aircraft suddenly got into an uncontrollable flight condition, a nose-high attitude from which it inverted into an upside down position. The pilot did not have his seat harness fastened and while the aircraft was inverted he fell through the canopy to the ground. Thereafter the aircraft plunged, still inverted, into an open field approximately 800 m away and disintegrated into several pieces on impact. The passenger had his seat harness fastened and remained in his seat until the moment of impact, becoming trapped under the upside down aircraft. The pilot died as a result of his fall and the passenger was seriously injured in the collision with the ground.

The aircraft was imported to Finland in July 2002. Since it was the first of its type in Finland at the time, it had to complete a test flying programme. On the importer's test flights it was found that the aircraft had negative longitudinal stability when the centre of gravity was at 360 mm, i.e. at the forward limit of the CG range. In order to improve the longitudinal stability a fixed trim tab was installed on the horizontal stabiliser. After this modification the type certification inspector had noted that the longitudinal stability was just barely acceptable. According to the manufacturer's English language flight manual and weighing certificate the CG range within the permissible flight mass range (up to 450 kg) was 20–30 % of the length of the mean aerodynamic chord (MAC), which was 1185 mm. Following the importer's test flights the permissible range of the CG in the Finnish language flight manual was made stricter than that of the English language manual. The importer's test flights did not cover the utmost aft CG ranges. According to the Finnish manual the permissible CG range was 20–28.5 % MAC, which corresponded to 315–415 mm. The values regarding the permissible CG range in the Finnish language manual and weighing certificate were not identical. This was due to the fact that the weighing certificate's values were based on the manufacturer's weighing which was done in 2002 and that they were not retroactively amended to reflect the stricter Finnish limits. Aviation regulations did not provide any clear guidance with regard to the harmonisation of values in cases where the CG range had been modified as a result of the aircraft's flight characteristics. The weighing certificate, one of the flight manual's appendices, was not found during the investigation.

On the accident flight the mass of the aircraft was approximately 535 kg, i.e. 85 kg over the MTOM 450 kg. The CG was at approximately 451 mm. This is clearly aft of the permissible limit. Furthermore, it must be taken into consideration that the test flights had been flown by complying with the mass limitations, hence, the real effects of such excess weight on flight characteristics had never been demonstrated. It is probable that substantial excess weight combined with even a small violation of the aft CG limit affect the flight characteristics in an unpredictable manner. With the aircraft being unstable on the accident flight, a gust or sudden deflection of the control surfaces may have caused the aircraft to suddenly depart into a nose-high attitude.

The pilot received his training for a UPL licence in March-July 2003 on an Ikarus C42 ultralight aircraft. He received a passenger carrying rating in August 2003. The pilot received his type rating training for the accident aircraft type in December 2003. The type training flight lasted 40 minutes and it included five landings. His total flying experience on ultralights was approximately 50 hours, 1.5 of which on the accident type. Since the passenger had no previous flying experience, the aircraft was in an uncontrolled state after the pilot fell through the canopy. The pilot's total flying experience on ultralights and his type training on the accident type was limited. According to aviation regulations no less than five hours of cross-country flights, at least three of which with an instructor, were required for a UPL licence. This amount was insufficient. There had also been shortcomings in his training, especially, with regard to aircraft loading and the determination of the CG. The FAA's flight training manual for a UPL licence, approved by Finavia, listed teaching and competence requirements for each topic. Topics related to the loading of ultralights had the highest competence requirement, level D, which meant having complete command, including proficiency tests.

The accident was caused by the fact that the excess weight and a CG aft of the permissible limits made the aircraft longitudinally unstable. As a result of a wind gust or an inadvertent horizontal stabiliser deflection the aircraft rapidly departed into an uncontrollable nose-high attitude and became inverted. At this time the unbuckled pilot fell through the canopy to the ground. The reason why the pilot had unbuckled his seat harness may have been that the he had tried to reach the baggage compartment in the back. The result of such a movement would only move the CG further towards the rear, making the aircraft statically and dynamically unstable. The movement along the longitudinal axis was so sudden and unexpected that the pilot could not apply corrective action. The following SHELL analysis presents the human factors that contributed to the accident.

Three safety recommendations were issued. The investigation commission recommended that the FAA ensure that during basic and advanced instructor training instructors make certain that students fully understand the D-marked topics and that their competence is ascertained through practical examples and competence examinations. The CAA's Flight Safety Authority was advised to pay attention to the control characteristics and performance values of different ultralight aircraft types and, when necessary, specify the requirements set for type rating training. Finally, it was recommended that the CAA's Flight Safety Authority consider raising the requirements for an Ultralight Pilot Licence to correspond to the quality and function of present ultralight aircraft types.

Appendix 4/10 (29)

SHELL analysis of investigation B1/2004L

L-S

There were shortcomings in pilot training, especially, with regard to aircraft loading and the determination of the centre of gravity. The pilot had limited training on the type.

The pilot had limited flying experience on the type

Mass and balance calculations were omitted during flight planning.

The pilot probably unbuckled himself during the flight.

The values regarding the permissible CG range in the Finnish language manual and weighing certificate were not identical.

L-H

The CG was considerably aft of the permissible range. The aircraft was overweight.

L-E

-

L-L

-

B3/2004L: Accident at Mäntsälä on 24 Aug 2004

Summary of investigation B3/2004L

An accident happened at Mäntsälä on 24 August 2004 at approximately 16:43. An amateur-built Colibri MB 2 ultralight aircraft, registration OH-U373, collided with the ground after the canopy opened in flight. The 78 year old pilot, the sole occupant, died in the accident and the aircraft was destroyed.

The pilot arrived at Mäntsälä airfield in the afternoon for a practice flight. At first he wanted to practice the takeoff run because he thought it was difficult to control the aircraft on the ground. He made four or five takeoff runs on the runway, during which he had difficulties in maintaining the heading of the runway. After each run the pilot stopped the aircraft, kept the engine running and opened the canopy in order to discuss the situation with the people who were present at the time. The canopy opened to the right, over to the top of the right wing. The pilot presumably did not check that the canopy handle lever was in the locked position before takeoff and the handle lever remained partially open. He took off at approximately 16:25, flew on the east side of the airfield for 10–15 minutes after which he flew over the airfield towards Mäntsälä. At the approximate altitude of 150–200 m the canopy handle locking lever accidentally opened. When this happened the vacuum caused by the air current snatched the canopy open; it then smashed into the right wing and broke. The pilot was exposed to a fairly strong airstream in the open cockpit. The large canopy which was now open to the right caused a fairly strong aerodynamic drag. As a result of this the nose swung to the right, the aircraft rolled around its longitudinal axis to the right and went into a dive. The aircraft collided with the ground at a fairly high airspeed and at an angle of 40–50 degrees, approximately 700 m from where the canopy opened. The engine was running all the way to the ground.

The pilot started flying in 1983, at which time he received his PPL licence. He began to construct the aircraft in 1986. Between 1983–1986 he amassed approximately 100 flight hours on different aircraft types, approximately 35 of which on the aircraft he owned and partially built himself. The aircraft was roughly the same construction then as it was at the time of the accident. Hence, it can be said that the pilot was fairly familiar with the accident type. Once before the canopy had opened in mid-air, but since it separated from the aircraft, the pilot managed to land the aircraft undamaged. At the time of the accident the landing gear was of a different type, which may have caused the difficulties in controlling the aircraft on the ground. The pilot quit flying after the 1986 minor accident and took a hiatus of 15 years in flying. In 2003 when he again became enthusiastic about flying, he wanted to be completely retrained on ultralights. The training took into account his age and temperament. Even though he scored about average in theoretical instruction, he had difficulties in flight training at first because he had forgotten a great deal. His flying style was less precise than average and some hesitation was evident in emergency procedures. Still, his flying skills were clearly satisfactory. The pilot received his UPL licence in April 2004. After he began his retraining he had accrued approximately 23 hours on all aircraft types. His limited recent flying experience contributed to the onset of the accident.

There were no requirements for canopy lock construction in the aviation regulations or instructions pertaining to ultralight aircraft. Therefore, in amateur-built ultralights its construction reflected the constructor's concept of what constitutes adequate safety. From the standpoint of safety the accident aircraft's canopy locking system was lacking because there was no safety latch to prevent accidental openings. In addition, the possible absence of a canopy latch spring in the locking system contributed to the opening of the handle. The spring was not found after the accident, which means it is possible that it was not in its place at the time of the accident flight.

The probable cause of the accident was the opening of the canopy handle lever during flight. As a result of this the canopy opened. The strong aerodynamic drag of the large lopsided canopy caused the nose to swing, making the aircraft roll around its longitudinal axis to the right and go into a dive. The situation was so dynamic that the pilot did not have the time to recover from the steep dive. The following SHELL analysis presents the human factors that contributed to the accident.

No safety recommendations were issued.

SHELL analysis of investigation B3/2004L

L-S

The pilot had limited recent flying experience.

The pilot had a rough flying style.

The pilot presumably did not check that the canopy handle was locked before takeoff.

L-H

The canopy locking system made it possible for the canopy to open in mid-air.

L-E

-

L-L

-

D1/2005L: Minor accident at Viitasaari on 15 Jan 2005

Summary of investigation D1/2005L

A minor accident happened at Viitasaari on 15 January 2005 at approximately 11:40. An Avid Flyer STOL ultralight aircraft, registration OH-U303, struck a power line that crossed a narrow strait and, as a result, collided with the lake ice. The 31 year old pilot and the passenger sustained minor injuries and the aircraft was badly damaged.

The pilot and the passenger took off from Kärväskylä airfield at approximately 11:10. At first they flew along Lake Kolima over the centre of Pihtipudas to Lake Alvajärvi, on the northwestern side of Pihtipudas. From there they backtracked to Lake Kolima following the same route. During the flight the pilot had the idea of landing on Lake Kolima ice. He then gradually descended all the way down to 5–10 m. His intention was to check for water on the ice or under the snow and accordingly select a suitable spot for landing. He flew on the western part of Lake Kolima, following the contours of the shoreline at times, at a very low altitude for at least the final 15 km. He homed towards Kattilasalmi strait where a three-wire power line crossed the strait at an approximate 6 m height, at its lowest. The pylons on the shore were 240 m apart. As he was glancing between the lake ice on the side and the front sector he noticed the power line too late to avoid the wires. The wires made contact below the propeller hub and caught the main landing gear which resulted in an almost vertical crash onto the lake ice approximately 20 m after the collision with the wires. The aircraft then nosed over onto its back and continued sliding on the ice for approximately 5 m.

The power line at Kattilasalmi strait was not marked on the aeronautical chart, nor did the pilot carry a chart on the flight. He was unaware of the position of the power line. The pilot flew a long distance at a very low altitude over the lake before hitting the power line. Even though the flying weather was good the bright sunshine from the front right, approximately six degrees over the horizon, combined with the snow-covered ice dazzled the pilot, making it more difficult for him to detect early enough the suddenly appearing power line. Had the pilot first flown over the landing spot at a safe altitude he would have had a good chance to notice the dark power line against the backdrop of white lake ice, notwithstanding the sunshine. The airspeed at the moment of impact with the wires was approximately 97 km/h and decreased considerably before the collision with the ice. The reduced kinetic energy and proper seat harnesses contributed positively to the survival of the pilot and the passenger in the crash. The aircraft maintained its form fairly well in the crash.

The accident was caused by a collision with a power line at a very low altitude. The pilot did not first fly over the landing spot at a safe altitude before descending to a low altitude. The lighting conditions contributed to the accident, making it more difficult for the pilot to detect the power line early enough. The following SHELL analysis presents the human factors that contributed to the accident.

No safety recommendations were issued.

SHELL analysis of investigation D1/2005L

L-S

The pilot did not first fly over the landing spot at a safe altitude before descending to a low altitude

L-H

-

L-E

The dazzling lighting conditions made it more difficult for the pilot to detect the power line early enough

L-L

-

D6/2006L: Serious incident at sea off Turku on 22 Apr 2006

Summary of investigation D6/2006L

A serious incident happened at sea off Turku on 22 April 2006 at 12:40. A Breezer ultralight aircraft, registration OH-U486, was on a cross-country flight when a fire broke out in its heating system. The 43 year old pilot, the sole occupant, received minor injuries and the aircraft's heating system sustained fire damage.

The pilot intended to fly an approximately hour-long local flight over the sea, off Turku. He took off from Turku aerodrome at 12:31. At 12:40 he reported that there was a fire in the footwell of the cockpit. The fire was in the aircraft's heating system, on the engine side of the firewall. Flames and smoke entered the footwell for a while as well as hot aluminium parts through the firewall's feed-through conduit. The pilot turned towards the aerodrome and, a moment later, reported to the air traffic control that the fire was out. The pilot was cleared to the base leg of runway 26 and at 12:50 he landed uneventfully.

The heating duct that led warm air from the heat exchanger into the cockpit as well as its control valve on the firewall was made of combustible material and was destroyed in the fire. The plastic control valve in the firewall feed-through conduit had melted, letting hot aluminium parts and the potential of an incipient fire into the cockpit. Nevertheless, the fire did not spread into the cockpit, it only left singe marks. Materials used in these locations of the heating system should not be easily flammable. Aerostyle GmbH, the German manufacturer of the aircraft, chose to use combustible materials in these heating system components. Both the fire and its cause were reported to the aircraft's manufacturer immediately after the event.

The accident was caused by the manufacturer's flawed decision to use combustible material in the heating system parts that burned. The following SHELL analysis presents the human factors that contributed to the accident.

One safety recommendation was issued. The investigation commission recommended that the aircraft manufacturer replace the duct and valve materials with incombustible materials. In addition, it was recommended that the fireproofing of all ultralight aircraft firewall structures and feed-through conduits be checked during importation and inspections.

SHELL analysis of investigation D6/2006L

L-S

-

L-H

There was combustible material in the aircraft's heating system, which was due to the manufacturer's flawed material selection.

L-E

-

L-L

-

B2/2006L: Accident at Sodankylä on 10 Jul 2006

Summary of investigation B2/2006L

An accident took place in Sodankylä on 10 July 2006 at 14:25. The pilot of an Ikarus C42 ultra-light floatplane, registration OH-U369, lost control of the aircraft in the traffic pattern and the aircraft vertically collided with the ground. The 52 year old pilot, the sole occupant, perished in the accident and the aircraft was badly damaged.

On the morning of the accident the pilot began his briefing for the first flight of the day by checking the aviation weather on the Internet. The wind forecast was 10 kt and in the next forecast it was 15 kt. On his first flight he carried a passenger to the centre of Sodankylä. Apart from the strong wind the flight was otherwise uneventful. On that flight the pilot told the passenger that the airspeed indicator was not functioning properly. The pilot landed on Kitinen river in the centre of Sodankylä. He partly tugged the aircraft onto the shore but did not tie it to anything. After this he and went with the passenger for a cup of coffee and to get some fuel. While he was away the strong wind blew the aircraft off the shore and into the open river from where the local rescue service towed it back. The passenger stayed in the centre of Sodankylä. Before the next flight, the accident flight, the pilot pumped fuel into the aircraft. It is not known whether he checked the flying weather before the accident flight. He intended to fly from the centre of Sodankylä to the village of Aska and land by the cottage that his friend owned on the same river. Once he arrived at Aska he circled left around the intended landing spot and commenced a second circle. At this phase he was flying at approximately 10–50 metres. When the pilot flew the second circle into the downwind intending to turn to the left, the aircraft suddenly flipped over and dove vertically into the ground.

The pilot's total flying experience on all aircraft types was approximately 190 hours, approximately 30 of which on the accident type. He received floatplane training on the accident aircraft in August-September 2004. After the floatplane training he had amassed approximately 20 hours on the accident aircraft during two years, encompassing 19 flights and 88 landings. Of the 19 flights only five were solo flights or flights with a non-pilot licensed acquaintance. During these five flights he had made altogether 53 landings, 49 of which on a single hour-long flight. Takeoffs and landings performed in this manner did not provide the pilot with adequate flying experience for floatplane landings at an unfamiliar location. The pilot's total flying experience during the past 90 days was approximately five hours on the accident aircraft. Hence, his recent flying experience was limited.

Apart from the strong and gusty wind the flying weather was good. On the accident day the wind increased in strength from the morning until late in the afternoon. It is possible that when the pilot prepared for the flight in the centre of Sodankylä the wind was not as strong as it was at the accident site. At the accident site the wind was so strong and gusty that it was challenging even for the rescue helicopter crew. The MTOM of the helicopter was 4250 kg. The accident chain of events began to happen when the pilot flew into a longitudinal wind at a relatively low altitude. An inexperienced pilot may find it difficult to maintain proper airspeed because the ground speed is easily sensed as high in a strong tailwind. Furthermore, it may be difficult to avoid sideslipping in a longitudinal wind. If an aircraft stalls in a sideslip, it may go into a tailspin. This is probably what happened to the pilot on the accident flight.

The aircraft had been washed a few days before the accident. The airspeed indicator was sticking during flights that followed the washing, which is a typical symptom of water in the pitot-static system. Since the sticking seemed to have disappeared on its own, no action was taken to remove any possible water from the system. It is still possible that airspeed indication was not reliable at the time of the accident. This may have contributed to the accident if the indicated airspeed was higher than true airspeed, in which case the pilot believed that he still had a safe margin before the stall speed. This theory is supported by the fact that, on the previous flight, the pilot told the passenger that the airspeed indicator was not functioning properly. While no water was found in the pitot-static system after the accident, this does not rule out the possibility that there may have been water in the system on the accident flight. The airspeed indicator was destroyed in the crash and, therefore, it could not be tested for any other possible defects.

The accident was probably caused by stalling while sideslipping in strong and gusty wind. The pilot's limited recent flying experience contributed to the accident. That the airspeed indicator was sticking could not be completely ruled out as a contributing factor. The following SHELL analysis presents the human factors that contributed to the accident.

No safety recommendations were issued.

SHELL analysis of investigation B2/2006L

L-S

The pilot's recent flying experience was limited.

The pilot did not recognise the symptoms of an approaching stall.

L-H

The aircraft's airspeed indicator was probably unreliable, which may have contributed to the onset of the accident.

L-E

The wind was strong and gusty.

L-L

-

D9/2006L: Minor accident at Haapavesi on 11 Jul 2007

Summary of investigation D9/2006L

A minor accident happened at Haapavesi airfield on 11 July 2006 at 23:35. Following takeoff, the pilot of an EV-97 Eurostar ultralight aircraft, registration OH-U432, decided to land in the sector in front of them for safety reasons. Neither the 55 year old pilot nor the passenger sustained any injuries, but the aircraft was damaged.

At 20:35 the pilot and the passenger took off for a cross-country flight from Kemi-Tornio aerodrome towards Kuortane. They made an intermediate stop at Ranua from where they proceeded to Haapavesi airfield for more fuel. They carried 18 litres of fuel in a plastic canister which was placed in the passenger's footwell. At Haapavesi airfield the pilot poured all of the fuel in the canister into the aircraft's tank. Following this, the pilot taxied to the runway, took off and continued to climb straight ahead with the wing flaps at position 1. The aircraft became airborne at too low of an airspeed and at a very sharp angle. At approximately 100 m into the takeoff run, roughly 4 m off the surface of the runway, the aircraft drifted to the right. The pilot corrected the heading to the left, which resulted in the aircraft losing altitude and the left wing touching the runway and being damaged. The pilot continued the flight, correcting the heading to the right and to the left. Finally the aircraft turned to the left. The pilot continued to climb over a field at a sharp angle and at a low airspeed. Since the aircraft was no longer properly controllable, the pilot decided to land on the field ahead of them for the sake of safety. The aircraft was sharply banked to the right as it came over the field, but it levelled off before touchdown. During the course of the landing they flew under a power line and taxied over four ditches, at which time the aircraft sustained more damage.

The pilot was too hasty in the takeoff and so neglected to complete the routine takeoff checklist as per the flight manual. The checklist included, among other things, trimming. Takeoff occurred at a speed which was too low. During the takeoff the pilot either ignored airspeed monitoring, or did not do it sufficiently. The same applies to the steep climb angle. He focused his attention on the tachometer reading and poor controllability, which was caused by the too low speed. The aircraft was trimmed to cross-country flight conditions when it arrived at Haapavesi. As a result of filling the fuel tank the CG moved aft, albeit within the permissible range. The pilot should have retrimmed the aircraft after adding fuel to the tank. The controllability of the aircraft was poor, caused by the changed mass and the lack of retrimming. The tail-heavy condition, combined with the lack of retrimming, may have contributed to the fact that the aircraft tended to become airborne at an airspeed which was too low. The pilot let this happen. The pilot decided to abort the climb and land on the field to their right, but he did not consider the possibility of landing on the remaining section of the runway.

The occurrence was caused by a climb speed that was too low which resulted in poor controllability. Contributing factors included insufficient airspeed monitoring during the takeoff and climb as well as failing to complete the takeoff checklist and trim the aircraft. The following SHELL analysis presents the human factors that contributed to the accident.

The aircraft was fitted with a ballistic parachute recovery system. An inactivated ballistic parachute system can pose a great danger to persons that are assisting the people in an aircraft following an accident. One safety recommendation was issued. The investigation commission recommended that the Finnish Civil Aviation Authority together with the FAA and AIB design a warning marker that would forewarn of a ballistic parachute system, and indicate the location of the rocket motor.

SHELL analysis of investigation D9/2006L

L-S

The pilot failed to complete the takeoff checklist as per the flight manual, which resulted in the omission of trimming the aircraft.

The pilot did not sufficiently monitor airspeed during the takeoff and climb, which is why he took off and climbed at an airspeed that was too low.

L-H

-

L-E

-

L-L

-

Appendix 4/16 (29)

D11/2006L: Minor accident at Oulunsalo on 1 Aug 2006

Summary of investigation D11/2006L

A minor accident happened at Oulunsalo on 1 August 2006 at 09:55. The pilot of a CT 2 K ultralight aircraft, registration OH-U391, had to make a forced landing following an engine failure on a cross-country flight. The 32 year old pilot, the sole occupant, sustained minor injuries and the aircraft was damaged.

The pilot intended to fly from Ranua airfield to Oulu aerodrome. He took off from Ranua at approximately 09:10. After about 20 minutes into the flight the pilot noticed that the right wing fuel tank was not being depleted and that it was possibly malfunctioning. After this observation the pilot continued to fly normally according to his flight plan, believing that he would make it to his destination even if he only had the fuel in the left tank available. Once he arrived at reporting point Toppi at Oulu control zone, the engine died. He called Oulu air traffic control by radio and told them his engine had died at Toppila and that he would make an emergency landing on Muikku field which was on the Oulunsalo side of Kempele bay. At that time his altitude was 1600 ft and his intended emergency landing site was approximately 10 km ahead, on the opposite shore of Kempele bay. At first the pilot believed that he would make it all the way but when he came closer to the Oulunsalo shoreline he considered the risk of gliding over the wooded strip between the sea and Muikku field to be a too high a risk. He then selected an area at the shore of Korkeakoski as his new emergency landing site. During the landing the aircraft nosed over.

An overly long hose had been installed on the fuel system during maintenance. During the flight this hose, as a result of being bent, flattened out at a turn in the fuel line junction, located between the airframe and the wing. This blocked fuel flow from the right tank and the engine died. The hose type was not certified for aviation; it was not even required for ultralight aircraft. Tests demonstrated that the type of hose in question could bend over by itself at a tight corner when exposed to fuel.

When the pilot noticed that the right tank was not being depleted he should have landed for safety reasons. There were many good forced landing sites along his route, even a new ultralight airfield at the village of Ii. Once the engine died he selected a field which was over 10 km away, beyond a body of water. At the onset of the glide he was flying at 1600 ft. Over the opposite shore he had little altitude and there was a strong risk of not making it all the way. Had the pilot acted in a different manner, he could have avoided a forced landing and the minor accident.

The cause of the occurrence was the installation of an overly long hose on the fuel system and its flattening out, which blocked fuel flow to the engine so that the engine died. The pilot’s action after noticing that the fuel tank was not being depleted as well as his action following the engine failure also contributed to the occurrence. The following SHELL analysis presents the human factors that contributed to the accident.

No safety recommendations were issued.

SHELL analysis of investigation D11/2006L

L-S

The pilot should have landed for safety reasons once he noticed that the right fuel tank was not depleting. There were many good forced landing sites along his route.

The pilot selected a field for his forced landing site which was over 10 km away, beyond a body of water. There was a strong risk of not making it all the way.

L-H

An overly long hose had been installed on the fuel system.

L-E

-

L-L

-

B3/2006L: Accident at Lake Hirsijärvi on 8 Aug 2006

Summary of investigation B3/2006L

An accident took place at Lake Hirsijärvi in Kisko on 8 August 2006, at 20:16. An Ikarus C42S ultralight floatplane, registration OH-U396, struck a power line and crashed into Lake Hirsijärvi. The 63 year old pilot, the sole occupant, perished in the accident and the aircraft was destroyed.

The pilot flew one flight earlier on the day of the accident: between 15:30 and 16:30 he had flown from Inkoo to Jussarö and back. On that flight he first checked the landing site by flying low above the water, following which he landed on the water. An acquaintance of the pilot lived on Lake Hirsijärvi and they had agreed on flying together the next day. However, since the flying weather was good, the pilot wanted to check the lake already on the evening of the day before the flight. He planned the flight to Lake Hirsijärvi using several references. He used at least the topographic chart on his GPS and studied the satellite picture of Lake Hirsijärvi on Google Earth. He took off on the accident flight from the Inkoo archipelago towards Lake Hirsijärvi at approximately 19:45. During the cross-country leg at Lake Seljänalanen in Karjalohja, the pilot apparently inspected the landing site and flew as low as 6 m above the lake surface. Then he continued on towards Lake Hirsijärvi. He approached the southern part of Lake Hirsijärvi from the east. When over the lake, the pilot descended to a height of 20–30 m above the lake surface, flying northwest over the potential landing site. Flying at 20 m, the aircraft struck the wires of a power line at an airspeed of 115 km/h. As a result, the aircraft crashed into the lake and remained afloat upside down.

Neither source that the pilot used for flight planning showed the power line. Nor was it marked on Finavia's aeronautical chart. Despite the flight planning the pilot remained unaware of the power line. He had probably never been to Lake Hirsijärvi before. There are innumerable power lines in Finland like the one at Lake Hirsijärvi that are unmarked on charts and difficult to detect from the air. All power lines are not marked on charts. Therefore, when operating from airfields or water areas other than those that are specifically arranged for flight operations, there is always the danger that the planned takeoff or landing site is not free of obstacles.

On the accident flight the pilot checked the landing site at Lake Hirsijärvi from a very low level, at approximately 20 m height. The FAA's ultralight floatplane training manual was used in the floatplane training the pilot had received. The manual provides guidelines for the purpose of checking the landing site. According to the manual the pilot must always check the landing site from three different altitudes: approximately 1000 ft (305 m), 300–500 ft (90–150 m) and 15–30 ft (5–10 m). The manual continues to state that the pilot must simultaneously scan the surrounding terrain, especially, in the landing and takeoff sector and to pay particular attention to power lines. The procedure chosen by the pilot did not comply with the training manual as regards altitude. He was not in the habit of checking the landing site from three different altitudes. Instead, he directly descended to a low altitude.

There were no warning or attention markers on the power line and it was extremely difficult to detect it from the air. There are typically no warning or attention markers on power lines. They are only required in the vicinity or aerodromes. The grey visibility conditions and the sun which was possibly shining at a low angle from the opposite side of the lake may have made it more difficult for the pilot to detect the power line. It was probable so, on the accident flight, that the power line at Lake Hirsijärvi was only detectable from the pylons on both sides of the lake. However, the pylons were shadowed by trees and their tops were below treetop level. As a result of this it was almost impossible to detect the power line from the air.

The accident was caused by colliding with a power line when flying at a low level over a lake. The pilot was unaware of the power line that crossed the lake. He had not flown the first inspection of the landing site at a safe altitude before descending to a low altitude and it was very difficult to detect the power line from the air. The grey visibility conditions and the sun which was possibly shining at a low angle from the opposite side of the lake may have made it more difficult for the pilot to detect the power line from the air at the time of the accident. The following SHELL analysis presents the human factors that contributed to the accident.

No safety recommendations were issued.

SHELL analysis of investigation B3/2006L

L-S

Contrary to the instructions in his seaplane training the pilot did not fly the first inspection of the landing site at a safe altitude before descending to a low altitude.

L-H

-

L-E

The grey visibility conditions and the sun which was possibly shining at a low angle from the opposite side of the lake may have made it more difficult for the pilot to detect the power line from the air.

L-L

-

D4/2007L: Minor accident at Pudasjärvi on 3 Feb 2007

Summary of investigation D4/2007L

A minor accident happened at Pudasjärvi aerodrome on 3 February 2007 at 15:30. The nose landing gear skid of an Ikarus C42B ultralight skidplane, registration OH-U454, broke off at takeoff. The 59 year old pilot, the sole occupant, was not injured but the aircraft was damaged.

The pilot intended to make a couple of touch-and-go landings on the snow-ploughed runway. During the second takeoff the front part of the nose landing gear skid attachment box was bent over by the force of the airstream. This considerably decreased airspeed and caused a nose-down momentum. From the symptoms the pilot deduced that the engine had lost some power and, for safety reasons, he landed on the remaining part of the runway which was unploughed. At touchdown the front tip of the skid made first contact with the snow, bending the nose landing gear under the aircraft. The aircraft came to a halt on its nose in the snow.

The owner of the aircraft had constructed the skids, which he fabricated from snowboards. The main landing gear skids were longer and wider than the nose landing gear skid. The skins of the skids were made of plastic and covered a glued laminated timber core. In addition, a wear surface was installed on the bottom of the nose skid as well as a thin keel in the middle. A rectangular attachment box was installed on top of the skid, which connected the nose skid to the nose landing gear. The attachment box created a point of discontinuity to the flexibility and structural integrity of the skid, which is why the skid broke exactly at the front edge of the box during the accident takeoff. Furthermore, the holes that had been made for snowboard bindings compromised the skid's structural integrity. The wooden core of the nose skid had already evidently been broken during previous taxiing or landings on rough snow surfaces. During the accident flight's takeoff the tip of the skid ahead of the attachment box was bent strongly downwards by the force of the airstream. The added drag caused the pilot to believe that the engine had lost some power. No technical faults or anything pointing towards loss of power were found during engine tests.

The occurrence was caused by the nose landing gear skid, constructed from a snowboard, breaking at takeoff. This caused such a change in the aircraft's flight characteristics that the pilot assumed that the engine had lost some power. The pilot made a landing in the snow for safety reasons at which time the broken skid overstressed and broke the nose landing gear. The following SHELL analysis presents the human factors that contributed to the accident.

No safety recommendations were issued.

SHELL analysis of investigation D4/2007L

L-S

-

L-H

The nose landing gear skid which was fabricated from a snowboard was too weak and it broke off at takeoff.

L-E

-

L-L

-

C5/2007L: Serious incident at Helsinki on 12 Aug 2007

Summary of investigation C5/2007L

A serious incident occurred at Helsinki-Malmi aerodrome on 12 August 2007 between 18:24 and 18:53. The serious incident was caused by the unintended taxiing and takeoff of a Skyranger V.Max ultralight amphibian, registration OH-U495. The 53 year old pilot, the sole occupant, was not injured but the aircraft sustained minor damage.

The pilot intended to taxi from apron 2 across runway 18/36 to the aircraft's own stand on apron 1. In order to ease entry into the left seat the throttle had probably been pushed fully forward, i.e. to the full power setting. The pilot did not complete an engine start checklist, nor did he fasten his seat harnesses. The pilot started the engine by placing one hand on the wheel brake lever which was on the control stick and by turning the ignition switch to the start position with his other hand. Since the throttle lever was pushed fully forward the engine lunged straight into full power. The aircraft immediately began to roll, which the pilot tried to stop with wheel brakes. He did not succeed in this nor, in the unexpected situation, was he able to reduce engine power or turn the engine off from the ignition. Despite the braking action the aircraft only accelerated. The aircraft crossed runway 18/36 and continued towards apron 1 on a taxiway. There were several aircraft on both sides of the taxiway to apron 1 but at the time of the occurrence there were no aircraft or persons on the route of the aircraft. The pilot taxied at a high speed along the taxiway centreline, rolling from side to side. He was braking hard all the time, concentrating on steering as well as remaining on the taxiway and avoiding collisions. Since the taxiway turned towards taxiway F and the runway 27 holding position where hangar 1 was, and there were parked aircraft ahead, the pilot turned the aircraft, rolled to the left, parallel to taxiway F, and performed a takeoff. After the takeoff the pilot flew towards reporting point DEGER. During the climb the pilot regained his composure, found the throttle lever, set cruise power and buckled up. He also turned the VHF radio on and called Malmi ATC, requesting approaching instructions via reporting point NOKKA. After almost 30 minutes of flying, at 18:53, the pilot landed normally on runway 36.

The pilot held a UPL licence and had received basic UPL training on an Ikarus C42 aircraft. He had also flown on the Dynamic W9. Prior to the incident the pilot had received theoretical knowledge instruction for the Skyranger V.Max. In July 2007 he had flown one 50 minute-long type rating training flight on a Skyranger V.Max amphibian. In August 2007 the pilot had flown a 35 minute-long flight with the aircraft's owner. The pilot's total flying experience on the type was limited and more than a month had passed from his previous flight. These flights were also his first ones on an amphibian. His type rating training was limited, considering that the type training flight was his first flight on an amphibian. The pilot's total flying experience on ultralight aircraft was approximately 94 hours.

The cockpit layouts of all aircraft types the pilot had flown were completely dissimilar to each other. On the Ikarus C42 the throttle lever is positioned in front of the seat, between the legs. It is used with the left hand because the right hand controls the aircraft. The ignition switch is in the middle of the instrument panel. On the Dynamic W9 the throttle control knob is placed in the middle of the instrument panel. It is used with the right hand, while the left hand is used to control the aircraft. The ignition switch is in the middle of the instrument panel. On the Skyranger V.Max the throttle lever is at the left edge of the instrument panel. It is used with the left hand because the right hand controls the aircraft. The ignition switch is in the middle of the instrument panel. There is no parking brake. Rather, there is a wheel brake which is operated from the control stick. The position of the throttle in the cockpits of different aircraft types varied. Moreover, the shape of the throttle lever was dissimilar. These factors contributed to the fact that the pilot could not locate the throttle lever while was concentrating on taxiing in the middle of a surprising situation. Even though the pilot's type rating training met the requirements of aviation regulation PEL M2-70, it was still inadequate because the aircraft in question was an amphibian and its cockpit layout crucially differed from the types he had previously flown.

In order to ease ingress and egress the throttle lever is pushed forward which means that it is then at the full power setting. The throttle should have been pulled back to the idling position prior to engine start. The position of the throttle lever was probably overlooked before starting the engine. When it comes to cockpit checks and procedures the pilot did not treat taxiing in the same manner as embarking on a flight. He did not use checklists or fasten his seat harness. The checklists are only in the flight manual, which was not in the aircraft at the time of the occurrence. Had the pilot completed the engine start checklist, he would have also checked the position of the throttle lever. Once the engine started the wheel brakes could not hold the aircraft at a standstill. The pilot's workload exceeded his capacity to locate the throttle lever or turn the engine off from the ignition while he was concentrating on steering, staying on the taxiway and avoiding a collision.

The occurrence was caused by the inadvertent throttle lever position being at full power during engine start. Contributing factors included the failure to complete the checklist, inadequate type rating training, limited flying experience on the type in question and the fact that the wheel brakes could not keep the aircraft at a standstill. The following SHELL analysis presents the human factors that contributed to the accident.

Two safety recommendations were issued. First, the investigation commission recommended that the Finnish Aeronautical Association draw up general instructions and a generic checklist for taxiing and engine runups with ultralight aircraft. In addition, it was recommended that ultralight flight instructors' basic and refresher training emphasise the correct use of checklists. Second, the investigation commission recommended that the Finnish Civil Aviation Authority amend the content of the type rating training segment in PEL M2-70 so as to better take into account the effect of different ultralight aircraft cockpit layouts and technical characteristics in training.

SHELL analysis of investigation C5/2007L

L-S

The pilot's type rating training was limited.

The pilot's flying experience on the type was limited.

The pilot failed to complete the engine start checklist and, as a result, he left the throttle lever at full power during engine start.

L-H

Wheel brakes could not keep the aircraft at a standstill at full power. The wheel brakes were installed by the manufacturer.

The pilot's skills in operating cockpit equipment were inadequate.

L-E

-

L-L

-

D2/2008L: Minor accident at Vampula on 22 Jun 2008

Summary of investigation D2/2008L

A minor accident happened at Vampula on 2 June 2008 at approximately 22:20. A Quad City Challenger ultralight aircraft, registration OH-U545, was on a test flight when the pilot lost control of the aircraft and made a forced landing on a field. The 42 year old pilot, the sole occupant, was not injured in the occurrence but the aircraft was badly damaged.

Two days before the occurrence flight the pilot noticed that the left aileron's bellcrank trunnion bolt and its push-pull rod were considerably bent while the aircraft had been parked. The pilot changed the bolt and straightened the bent rod before the day of the occurrence flight. Already on the first test flight of the occurrence day the pilot noticed that the aileron effect was weaker compared to the previous test flights. The pilot took off from Vampula airfield at 22:10 for the second test flight of the day, the occurrence flight, and climbed to approximately 200 metres. The weather was windier than during the previous test flights. Since the pilot had major difficulties in controlling the aircraft he decided to return to the airfield and land. The right turn to the base leg was never completed even though the pilot moved the control stick all the way to the right – up against his thigh. He said that he had full power at that time. The wind caught the aircraft and it went into a left tailspin. After the pilot managed to recover from the tailspin the aircraft still made two full circles to the left at half power. When the pilot increased power the aircraft went yet again into a tailspin. Even though the pilot recovered from this tailspin he could no longer stop the loss of altitude and prevent the aircraft from turning to the left. Aided by an updraft the aircraft cleared a narrow strip of woods and finally made a forced landing on a field close to Vampula airfield.

The pilot had a UPL licence which he received in 2001. His total flying experience on ultralights was approximately 34 hours, of which approximately 3 hours were on the accident type. His total flying experience and his experience on the type was limited and spread over eight years. The aircraft was the first of its kind in Finland at the time and, therefore, a flight test programme approved by the Finnish Civil Aviation Authority was required. Under aviation regulations test flight results were to be recorded for the purpose of writing a flight test report. The results could demonstrate that the flight test requirements had been met and they would also be used to provide sufficient basic information and limitations for the flight manual. The pilot did not keep records of the test flights he flew. He estimated that his limited flying experience made it more difficult to analyse the information generated on the test flights. Pursuant to aviation regulations the person flying the test flights was to have sufficient experience.

While the cause for the damage on the left aileron control was not clearly established it is possible that someone had vandalised the aircraft by simultaneously holding onto the aileron and powerfully turning the stick. The pilot repaired the damaged aileron unsatisfactorily. After the minor accident it was discovered that the left aileron hardly moved downwards under aerodynamic forces. The causes of this were the elongated hole of the trunnion bolt and play in the entire aileron system. The left aileron did not generate enough effect to recover the aircraft from a tailspin. The left aileron's loose shroud material only weakened the aileron effect. Furthermore, the pilot was a big man and his thighs limited the sideways movement of the control stick. According to the pilot the wind was gusty at the time of the occurrence flight; the Finnish Meteorological Institute's comments corroborate this observation. The gusty wind probably made it more difficult to control the damaged aircraft.

The pilot said that the airspeed indicator (0–140 km/h) on the instrument panel was unreliable. He had installed a tube anemometer (10–80 mph) outside the cockpit for the purpose of airspeed indication. Because of the instruments' unreliable indications, cross-referencing and the partially closed cockpit, it was difficult for the pilot to judge airspeed on the basis of airflow. Aviation regulations do not require type-certification from flight control instruments that are used in ultralight aircraft. Nevertheless, they have to be suitable for the purpose that they are intended. Anemometers are commonly used as airspeed indicators in weight-shift controlled ultralights, for example, which normally fly at considerably lower airspeeds than surface-controlled ultralights. An anemometer was unsuitable for use in this aircraft because the installation location was prone to disturbances and the scale's range did not reach 100 mph, the highest permissible airspeed. The unreliable airspeed indication probably contributed to the airspeed bleeding off to the extent that the aircraft stalled and departed into a tailspin.

The cause of the accident was that the aircraft stalled and went into a left tailspin. After that the inadequate aileron effect prevented the pilot from regaining control of the aircraft. The following SHELL analysis presents the human factors that contributed to the accident.

One safety recommendation was issued. The investigation commission recommended that the Finnish Civil Aviation Authority clarify the test pilot's flying experience requirements and provide the required regulations to the FAA.

SHELL analysis of investigation D2/2008L

L-S

The pilot's total flying experience was limited, accrued over a long period of time. The pilot's experience on the type was limited.

L-H

Airspeed indications were unreliable. One airspeed indicator was installed by the manufacturer and the other was installed by the pilot himself.

The pilot repaired the damaged left aileron inadequately. Furthermore, the aileron's shroud material was loose, which made the aileron effect inadequate.

L-E

The wind was gusty.

L-L

-

D5/2008L: Minor accident at Hanko on 24 Jul 2008

Summary of investigation D5/2008L

A minor accident happened at Hanko airfield on 27 July 2008 at approximately 16:55. A CTSW ultralight aircraft, registration OH-U547, veered off the runway and turned over following the landing. The 56 year old pilot and the passenger sustained minor injuries and the aircraft was badly damaged.

The pilot intended to land at Hanko airfield. He was arriving from a cross-country flight from Turku. Up until the landing the flight was uneventful. At the end of the approach the airspeed was approximately 100 km/h and wing flaps were set at 15 degrees. The wind was gusty and at a height of approximately 4–5 m the aircraft sank faster than usually. The pilot tried to counter this by adding power. The first touchdown occurred approximately 100 m from the threshold. It was a hard landing. Concurrently with the touchdown a gust of wind made the aircraft bounce back into the air and drift to the left. The second touchdown followed approximately 20 m down the runway. Yet again the aircraft bounced into the air after which the aircraft veered off the runway to the left. When the aircraft traversed a grassy area the nose landing gear collapsed and the propeller hit the ground. The aircraft nosed into the ground and turned over its right wing, ending up inverted and facing the direction from where it came.

The pilot received his UPL licence in the autumn of 2007. His total flying experience on ultralights was approximately 53 hours. The pilot's experience on the type was 3.5 hours. His previous flight on the type in question took place approximately one month prior to the accident flight. The pilot had limited flying experience on the type and limited total flying experience.

The flying weather was suitable for the cross-country flight. The forecasted westerly wind strength in the Hanko region was approximately 10 kt. Both the pilot and the persons who were at Hanko airfield at the time estimated that the wind did not exceed 16 kt, the aircraft type's maximum crosswind component. Nevertheless, the wind at the airfield was variable, both in direction and in strength. A moment before the first touchdown the wind direction and strength probably changed. The end of the approach became steep, the flare was abrupt and the landing was hard. Just before touchdown a gust of wind probably caused the aircraft to drift to the left. After this the pilot no longer managed to return the aircraft to the runway centreline and the aircraft veered off the runway.

The probable cause of the occurrence was the loss of control of the aircraft due to the variable wind direction and strength prior to landing. The pilot's limited flying experience on the type as well as his limited total flying experience were contributing factors. The following SHELL analysis presents the human factors that contributed to the accident.

No safety recommendations were issued.

SHELL analysis of investigation D5/2008L

L-S

The pilot's flying experience on the type was limited. The pilot's total flying experience was limited.

The pilot lost control of the aircraft during the course of the landing.

L-H

-

L-E

The wind was variable in direction and in strength.

L-L

-

D2/2009L: Accident at Lahti-Vesivehmaa on 16 Jan 2009

Summary of investigation D2/2009L

An accident happened on 16 January 2009 at Lahti-Vesivehmaa airfield at approximately 09:45. Shortly after takeoff an ATEC Zephyr 2000 ultralight aircraft, registration OH-U502, stalled and collided with the ground. The 49 year old pilot, the sole occupant, was seriously injured and the aircraft was badly damaged.

The pilot intended to fly two touch-and-go landings on his own at Lahti-Vesivehmaa airfield in the morning and then fly a cross-country flight to Pori with a passenger. Since the aircraft had been stored for six days in an unheated hangar, the engine heater was plugged in before the flight. The pilot carried out the daily inspection and detected a few frozen droplets of water on the wing, but did not notice any hoarfrost. He taxied to the holding position of runway 07 and completed the rest of the pre-flight checks. All indications were normal. Wing flaps were in position one, i.e. at 15 degrees. During the climb the aircraft first gently drifted to the left and then, at approximately 50 m height, the nose turned rapidly to the left at which time the aircraft stalled. The pilot tried to counter the left turn by applying the right rudder and right aileron. This, however, was not sufficient to halt the turn and the aircraft went into a dive. The pilot tried to lift the nose by pulling back on the stick and, at the same time, applying full right rudder. Full power was on during the dive. The aircraft collided with the ground on an access road on the left side of runway 07, turning approximately 180 degrees in relation to the takeoff heading.

The pilot had a UPL licence. He started his theoretical instruction for the licence in June 2008, followed by flight training in July 2008 with a Eurofox 3K ultralight aircraft. He received his UPL licence in December 2008. His total flying experience on ultralights was approximately 48 hours, of which approximately 7 hours on the accident type. One month before the accident he had completed familiarisation training for the type in question and approximately one week prior to the accident he had passed a proficiency check flight for a passenger carrying rating. His total and type-specific flying experience was limited, which contributed to the accident.

The recognition of a gradually developing stall and recovery from one is normally included in flight training. If an aircraft stalls in a climb, the stall is sudden and an inexperienced pilot does not have time to recognise its typical symptoms: buffeting, slackening of flight controls and nose-down pitching. According to the pilot the flight controls felt stiff as the aircraft was turning to the left. On the accident flight the stall developed rapidly during the climb and the pilot did not recognise the symptoms of an incipient stall. The pilot's corrective action was erroneous, resulting in a sideslipping turn to the left and a rapid loss of altitude. When the aircraft was in a steep left bank, the full back stick was yet another factor increasing the rate of the turn.

The aircraft's wing profile UA(2)-180 was developed in the 1980s for ultralight aircraft. The performance of the profile is based on a laminar flow. The laminar wing profile is sensitive to wing contamination. Contaminants on the wing, such as water droplets, hoarfrost or ice reduce the maximum lift coefficient and increase the stall speed. The aircraft's flight and operations manual prohibits flying in icing conditions. The manual also gives mention to degradation in wing performance due to rain but fails to speak of the detrimental effects of other contaminants to wing performance. A thin layer of hoarfrost and some frozen droplets of water were observed on the wing approximately 30 minutes after the accident. The pilot said that he did not observe any frost on the wings when the aircraft was inside the hangar. It is possible that the temperature in the hangar was slightly higher than the outside temperature. In such conditions frost could have formed when the aircraft was taken outside. Frost formation could also have occurred during taxiing. According to meteorological information, no such large temperature fluctuations were present below 100 m that could have caused sudden frost formation. The investigation could not confirm whether there was frost on the wings at the time of the accident.

The accident was caused by a rapidly developing stall during the climb. The pilot did not realise that he was in a stall, nor was his corrective action proper. Instead, the aircraft continued to turn to the left and collided with the ground. Contributing factors included the pilot's limited total flying experience and his limited experience on the type as well as possible frost on top of the wing. The following SHELL analysis presents the human factors that contributed to the accident.

One safety recommendation was issued. The investigation commission recommended that the aircraft manufacturer add a clear mention to the Flight and Operations Manual that the pilot must make certain before each flight that the wings, stabilisers and control surfaces are free of snow, ice, hoarfrost or other contaminants.

SHELL analysis of investigation D2/2009L

L-S

The pilot's flying experience on the type was limited. The pilot's total flying experience was limited.

The pilot did not recognise the rapidly developing stall in a climb.

L-H

-

L-E

Favourable conditions for hoarfrost, which may have resulted in hoarfrost formation on top of the wing before the accident.

L-L

-

D3/2009L: Accident at Helsinki on 21 Apr 2009

Summary of investigation D3/2009L

An accident happened on 24 April 2009 at Helsinki-Malmi aerodrome at 12:57. The pilot of an Ikarus 42B ultralight aircraft, registration OH-U478, lost control of the aircraft during the landing. The 39 year old pilot, the sole occupant, was uninjured but the aircraft was badly damaged.

Earlier on the day of the accident the pilot took off on a cross-country flight from Helsinki-Malmi aerodrome to Utti. The flight was uneventful. In Utti the pilot took a break and briefed for the return leg, the accident flight. While joining the base leg of runway 18 at Helsinki-Malmi aerodrome, the pilot noticed that the aircraft was too high. The pilot reduced airspeed and set the flaps to position one. On the final approach the pilot noticed that the aircraft was above the normal glide slope and that the airspeed was too high. As the aircraft was approaching the ground, the pilot flared the glide angle. The aircraft came very close to the ground, whereafter it went into a climb. In order to avoid stalling the pilot increased power a little. Soon thereafter the pilot applied full power, resulting in loss of control of the aircraft. The aircraft turned to the left and came to a halt on the left side of runway 18 on the grass strip between the runway and the taxiway. The nose and the right wing were on the ground and the aircraft was turned approximately 260 degrees in relation to the landing direction.

The pilot had a UPL student pilot licence. There had been several one or two week-long pauses in the early stages of the pilot's flight training. The pilot progressed slower than average in the beginning of the training. After the instruction flights were flown without long pauses the pilot advanced more rapidly. During the training the pilot had a tendency to take the control stick a little to the left at landing, at which time the aircraft banked to the left. Nonetheless, training corrected this tendency. The skill test before the first solo flight went normally. The cross-country flight from Helsinki-Malmi aerodrome to Utti aerodrome and back was the pilot's first solo cross-country flight. Before this flight the pilot's flying experience on all ultralight aircraft, including the accident type, was approximately 31 hours.

The first solo cross-country flight to a new aerodrome was relatively demanding for the pilot. There were many things to take into account. While the pilot's alertness level was good, the demanding flight had already taxed the pilot's energy prior to the approach to Helsinki-Malmi. Traffic at Helsinki-Malmi was quite busy when the pilot was approaching the traffic circuit. This, on top of the challenging cross-country flight, stressed the pilot to the extent that concentration on the approach was somewhat lax. As a result, the pilot had too much altitude and airspeed on the base leg and the final approach. The pilot tried to rectify this by reducing power and by changing the configuration. Still, there was not that much extra airspeed and altitude on the final. When the pilot flared the aircraft it came very close to the ground. Thereafter the aircraft wanted to climb, due to the extra airspeed and possibly stronger wind. The lower-than-normal mass of the aircraft also probably contributed to the behaviour of the aircraft. When the height increased the pilot added full power. At this stage the pilot lost situational awareness. As a result the pilot failed to make a clear decision regarding a go-around or associated correct procedures, or the procedures were inadequate. Propeller torque, caused by the increase in power, as well as the possible erroneously applied left stick caused the change in heading and a strong bank to the left. The strong thrust in relation to the small mass also contributed to the bank and the change in heading.

The cause of the accident was loss of control during landing when the pilot increased engine power at a low airspeed. The loss of situational awareness, which was a result of the pilot failing to make a clear decision regarding a go-around or associated correct procedures, or that the procedures were inadequate, was a contributing factor. The following SHELL analysis presents the human factors that contributed to the accident.

No safety recommendations were issued.

SHELL analysis of investigation D3/2009L

L-S

The pilot's flying experience on the type was limited. The pilot's total flying experience was limited.

The pilot lost control of the aircraft during the landing.

L-H

-

L-E

-

L-L

-

D4/2009L: Accident at Inkoo on 28 Apr 2009

Summary of investigation D4/2009L

An accident happened in Inkoo on 28 April 2008 at approximately 21:06 when the engine of a Dynamic WT-9 ultralight aircraft, registration OH-U474, died following takeoff. The 44 year old pilot and the passenger were not injured but the aircraft was destroyed.

The pilot and the passenger intended to fly from Nummela via Torbacka airfield to Helsinki-Malmi aerodrome. The aircraft landed on Torbacka runway 27 at 20:55. After the landing the pilot taxied to a stand close to the threshold of runway 27 and parked the aircraft. After they had stretched their legs for a while, the pilot inspected the aircraft before the next flight. He started the engine at 21:02 and taxied to runway 27 for takeoff. The pilot did not use the separate checklist cards that were onboard the aircraft or the flight manual's checklists during the inspection or on the flight. The pilot commenced the takeoff at 21:05:25. At a height of approximately 13 m he began a right climbing turn towards Helsinki-Malmi aerodrome. At 21:06:12, over the right traffic circuit's downwind leg at 65 m height, the engine died. The pilot banked at approximately 60 degrees and turned more than 90 degrees to the right towards an open field beyond a strip of woods, next to the runway. After the pilot had cleared the strip of woods he noticed a power line. Due to the low altitude and airspeed the nose landing gear struck the power line, severing the highest wire. Following this the aircraft went out of control and collided with the field. The cockpit remained intact. Neither the pilot nor the passenger sustained any injuries but the aircraft was destroyed.

No technical faults on the aircraft or the engine that would have preceded the accident were found in testing. The inspection of the engine revealed that the engine ran for 45 seconds after the fuel cocks were closed. On the accident flight the engine died 47 seconds after takeoff. There was a flight manual onboard which covered all aircraft operating checklists in detail. Moreover, the aircraft had separate plastic coated checklist cards which were written and abridged from those in the flight manual. The pilot did not use the checklists before takeoff because he believed that the he was already so familiar with the aircraft that he no longer needed to use any checklists whatsoever. Had the pilot used the checklists he could have probably avoided the accident because the proper position of the fuel cocks would have been checked before takeoff. All pilots and, especially, those with limited flying experience or those that fly seldom, should always use the aircraft's checklists. The pilot had limited flying experience. His total flying experience was approximately 53 hours, of which 10 hours were on the type in question. In addition, he completed the takeoff checks in a hurry. The haste was primarily caused by the fact that they had approximately 8 minutes until sunset. Twilight lasted approximately 52 minutes after sunset and the aircraft had to make it to Helsinki-Malmi aerodrome before nightfall. It is likely that the pilot or the passenger closed the open fuel cock selector knob before takeoff or at takeoff, accidentally and due to haste. As a resulted the carburettor was starved of fuel and the engine died.

After the takeoff the pilot started a 180 degree turn from a low altitude at a 20–40 degree bank angle before crossing the end of the runway. During the entire initial climb the aircraft flew at a low airspeed, at approximately 100 km/h. This is an unsafe practice. According to the flight training manual one must climb straight ahead in the direction of the runway to a safe altitude, and simultaneously try to reach the flight manual's climbing airspeed of 110–120 km/h as soon as possible. Once the engine died the pilot selected the field next to the threshold of runway 27 as his forced landing site. In order to make it to the field he turned more than 90 degrees towards it at an approximately 60 degree bank angle. Because the engine died at a low airspeed and altitude the pilot could not reach or maintain 120 km/h, the best glide ratio airspeed. The steep turn towards the runway profoundly reduced his chances in succeeding at the emergency landing. By using wing flaps the pilot would probably have managed to improve the glide performance to the extent that he would have cleared the power line. Moreover, wing flaps would have reduced the stall speed and the pilot would have been in a better position to control the touchdown. The safer alternative would have been to select one of the open fields in the front sector as the site for the emergency landing. Due to the low altitude and low airspeed the pilot had very little time to make a controlled forced landing. Because he was concentrating on the landing, he no longer had the time to complete the aircraft's emergency procedures following engine failure, such as checking the position of the fuel cocks.

The probable cause of the accident was that the fuel cocks were inadvertently closed right before takeoff or during takeoff. This resulted in the engine dying during the climb. Because of the emergency landing site selection, the low altitude and low airspeed the emergency landing failed. The pilot's limited flying experience, haste and inadequate checks before takeoff were contributing factors. The following SHELL analysis presents the human factors that contributed to the accident.

After the investigation was completed it became evident that one fuel cock had been open and the other one closed before the accident flight. It is probable that the pilot or the passenger inadvertently closed the open fuel cock selector knob before takeoff, after which both fuel cocks were closed. Their intention had been to open the cock that was closed, in which case both fuel cocks would have been open.

No safety recommendations were issued.

SHELL analysis of investigation D4/2009L

L-S

The pilot's flying experience on the type was limited. The pilot's total flying experience was limited.

The pilot did not complete all procedures as per the checklist before takeoff.

The pilot's course of action during the initial climb was unsafe because of the low altitude and low airspeed.

The pilot did not select a forced landing site from the sector ahead.

L-H

It is likely that the aircraft's open fuel cock was inadvertently closed right before takeoff or during takeoff.

L-E

The pilot and the passenger were in a hurry to make it to their destination before nightfall.

L-L

Failure in communication between the pilot and passenger with regard to pre-takeoff procedures.

B6/2009L: Accident at Kauhava on 4 Aug 2009

Summary of investigation B6/2009L

An accident happened at 19:08 on 4 August 2009 at Kauhava aerodrome. An EV-97 Eurostar, ultralight aircraft was on a training flight when it collided with the ground. The 38 year old ultralight pilot, pilot A and the 44 year old student ultralight flight instructor, pilot B, were killed in the crash and the aircraft was destroyed.

Pilot A had an over two years' hiatus in flying. He decided to restart his ultralight hobby in July of 2009 and had become a member of the Air Force Academy Aviation Club. A week before the accident flight he flew the first flight with the accident aircraft after the hiatus, with pilot B, the pilot who had trained himself to be a flight instructor at the Air Force Academy Aviation Club. The purpose of the flight was probably to regain pilot A's flying currency and control of an aircraft in general. It also included three landings. According to logbook entries, that flight lasted 35 minutes and it went well. The pilots agreed on yet another flight, probably at the behest of pilot A. No detailed information exists regarding the content of the second flight. However, the goals probably included takeoff and landing practice as well as various engine failure practice.

At the onset the pilots flew four left traffic circuits. The first one was a standard traffic circuit. The three following ones were flown at 1200 ft QNH and they included engine failure practice on the downwind leg, ending in spot landings. During the third circuit for a spot landing pilot B called that the landing would end in a stop-and-go, after which they would practice engine failure at takeoff. After they came to a halt on the runway pilot B called that they would start the simulated engine failure at 500 ft QNH (150 m), i.e. 349 ft (106 m) AGL, from where they would turn back and land on the runway. From there on pilot B was probably the Pilot Flying (PF). It is likely that he intended to instruct and demonstrate the manoeuvre to pilot A, who would follow gently on the controls. Takeoff occurred from runway 35, close to taxiway E. The aircraft climbed normally to the altitude from which they started the simulated engine failure. After this the engine was set to idle and the nose was dropped considerably. Simultaneously the aircraft started a right descending turn towards the runway at a bank angle of 30–45 degrees. After the aircraft had turned approximately 180 degrees its altitude was approximately 50 m, still turning at a bank angle of 30–45 degrees. When the glide angle became more gradual the airspeed decreased below the stall speed; the aircraft stalled, abruptly rolled to the right and went into a dive. It eventually collided with the ground at an almost vertical attitude heading northwest.

Both the pilot and the student flight instructor had received their ultralight training. This was mainly done at Kauhava and they had flown all of their UPL training flights on the OH-U507. Both of them had flown a little over 30 hours in ultralight flight training. In emergency landing training both of them were also shown a procedure according to which one would turn back towards the runway or movement area following engine failure at takeoff. Their flight instructor no longer recalled whether the students actually flew the manoeuvre themselves or whether they only followed gently on the controls while the instructor flew the manoeuvre. Pilot A's total flying experience was approximately 47 hours: all of it on the OH-U507. Pilot B had started gilder and PPL training in the autumn of 2007. He had completed the Finnish Sport Aviation Academy's ultralight flight instructor course in 2009. His total flying experience was approximately 287 hours, of which 149 hours on the accident type. His flying experience was accrued at a steady state between 2006 and 2009. Pilot B's flying experience was relatively high and his flying currency was good.

The flights in the ultralight flight instructor course syllabus were to be flown during nine days at Räyskälä in May 2009. OH-U507 was used as one of the course's aircraft. According to the syllabus emergencies at takeoff were to be flown on practice number 7, which is flown on two flights: first on an instruction flight and then on an instruction practice flight. Pilot B flew instruction flight number 7 at Räyskälä. The flight included no such simulated engine failures which resulted in a turn-back towards the runway or movement area. Poor flying conditions held back the planned schedule. When the flight syllabus phase in Räyskälä ended pilot B had not yet completed the compulsory instruction practice flight number 7. The Finnish Sport Aviation Academy's flight instructor course instructor phoned the Air Force Academy Flying Club's chief flight instructor and explained how the missing flight should be flown. This particular flight instructor was not the same person with whom pilot B had flown instruction flight number 7. On instruction practice flight number 7 the intention was to simulate engine failures by gradually lowering the altitude from which they are commenced until the point when a turn-back is no longer possible due to the low altitude. The purpose of this was to make the pilot aware of the altitude below which turn-backs were no longer possible.

The Air Force Academy Flying Club's ultralight training had not previously instructed turn-backs to the runway. Neither had the chief flying instructor any experience of them. Nonetheless, he flew the missing instruction practice flight number 7 with pilot B at Kauhava in accordance with the instructions he had received. He also wrote a report of the flight. According to the summary they practiced four such simulated engine failures during which they turned back towards the runway. The first one was started at 500 ft AGL by making a headwind turn-back towards the runway. Their notes stated that the remaining altitude was 175 ft. The second simulation was started at 400 ft AGL, done in a similar fashion. The remaining altitude was 50 ft. Then they made two simulations from 350 ft: one into a headwind and the second into a tailwind. The remaining altitude was recorded as 'low' and when they made a tailwind turn on the second attempt, they noted that they would no longer have made it to the runway. Both attempts ended in go-arounds. As far as the chief flight instructor could remember, pilot B had the controls during the manoeuvres. In June 2009 pilot B successfully completed an ultralight flight instructor skill test and he received his student ultralight flight instructor rating. Pilot B had to train at least two student pilots up to the UPL licence in order to receive an ultralight flight instructor rating. Pilot B was recorded in the Air Force Academy Flying Club's training organisation approval. A supervising flight instructor and one student pilot were assigned to him. The supervisor was aware of the progress of pilot B and his student. However, he was not previously aware of the other flights that pilot A and pilot B were going to fly.

Pilot B had assumed the practice of calling out loud 500 ft QNH during the climb after takeoff. This was the sign that a turn-back would be possible if there was an engine failure. Also on the accident flight he decided to commence the turn-back from 500 ft QNH. On the basis of his training pilot B did not have the required skills to instruct turn-backs. On the accident flight it was probably pilot B who controlled the aircraft for the first time from the right seat during turn-backs. On the accident aircraft type the airspeed and the turn and bank indicators are on the left side of the instrument panel. Flying the aircraft from the right seat in situations which require constant airspeed monitoring and sideslip control is a demanding manoeuvre and requires lots of practice. Regarding pilot B there were serious shortcomings in the flight instructor course's abnormal and emergency procedures training. In flight instructor training there should be no instructor-specific differences as to the content of instruction flights, or how things are taught. In this case pilot B, having successfully completed the flight instructor course, was left with a misguided impression with regard to the principles of teaching abnormal and emergency procedures. Moreover, when it comes to turn-backs, he was definitely unprepared for simultaneous flying and teaching.

The aircraft's takeoff mass on the accident flight was 482 kg which exceeded the maximum takeoff mass of 450 kg by 32 kg. The centre of gravity was in the permissible range. On the basis of the inspection of the aircraft, which included the inspection of control and wing flap systems as well as the powerplant and maintenance history, the aircraft was fully airworthy prior to the accident. The engine was running when the aircraft collided with the ground. The weather was good for ultralight operations.

The accident was caused by stalling during the turn. Due to poor airspeed monitoring the airspeed bled off during a turn-back, a technically demanding manoeuvre. Stall recovery was not possible because of the low altitude. Contributing factors included the prevailing culture in ultralight training in which some flight training organisations or individual flight instructors instructed students in abnormal and emergency procedures training them to turn back towards the movement area even from very low altitudes in conjunction with simulated engine failures following takeoff. The following SHELL analysis presents the human factors that contributed to the accident.

Six safety recommendations were issued. The investigation commission recommended that Trafi Aviation clarify the content of Aviation Regulation PEL M2-71, making it unambiguous with regard to the rights of the student ultralight flight instructor rating holder. The investigation commission recommended that the Finnish Aeronautical Association prepare written guidelines for the instructors that supervise student flight instructors in sport aviation. The investigation commission also recommended that the Finnish Aeronautical Association lead a process in which the syllabi for ultralight pilots and flight instructors be made more detailed, and that instructions on how to fly manoeuvres as well as vital safety limits and goals for learning be included in the curricula. The investigation commission recommended that Trafi Aviation lead the preparation of written proficiency standards for the instructors of sport aviation flight instructor courses, and that opportunity for training which provides such proficiency be arranged. The investigation commission recommended that Finavia and the Emergency Response Centre Administration update their mutual measures and instructions related to air accidents. The investigation commission recommended that Trafi Aviation take action against the flying of aircraft exceeding the maximum takeoff weight.

SHELL analysis of investigation B6/2009L

L-S

The turn-back manoeuvre from a low altitude had been demonstrated or taught to pilot B during his ultralight pilot and ultralight flight instructor training. Ultralight pilot or ultralight flight instructor flight training syllabi do not include instructions for a turn-back.

Pilot B’s flying experience with regard to flying and teaching turn-backs towards the runway was limited.

Pilot B did not sufficiently monitor the airspeed which resulted in the airspeed bleeding off to the stall speed. Pilot B did not recognise the approaching stall.

L-H

The aircraft was flying with excess weight.

L-E

-

L-L

-

APPENDIX 5. PHOTOGRAPHS OF ULTRALIGHT ACCIDENTS, MINOR ACCIDENTS AND SERIOUS INCIDENTS INVESTIGATED BY AIB INCLUDED IN THIS RESEARCH MATERIAL

Cora 200 Arius ultralight aircraft OH-U367 after an accident at Mäntsälä, occurrence 1 (investigation C1/2000L).

Rans Courier S-7 L ultralight aircraft OH-U248 after an accident at Viitasaari, occurrence 3 (investigation C11/2002L).

Ikarus C42 ultralight aircraft OH-U387 after an accident at Kirkkonummi, occurrence 4 (investigation C7/2003L).

Dynamic WT-9 ultralight aircraft OH-U415 after an accident at Hollola, occurrence 5 (investigation B1/2004L).

Colibri MB 2 ultralight aircraft OH-U373 after an accident at Mäntsälä, occurrence 6 (investigation B3/2004L).

Appendix 5/4 (10)

Avid Flyer STOL ultralight aircraft OH-U303 after an accident at Viitasaari, occurrence 7 (investigation D1/2005L).

Breezer ultralight aircraft OH-486 after a serious incident at Turku aerodrome, occurrence 8 (investigation D6/2006L).

Ikarus C42 ultralight aircraft OH-U369 after an accident at Sodankylä, occurrence 9 (investigation B2/2006L).

Eurostar EV-97 ultralight aircraft OH-U432 after a minor accident at Haapavesi, occurrence 10 (investigation D9/2006L).

CT 2 K ultralight aircraft OH-U391 after a minor accident at Oulunsalo, occurrence 11 (investigation D11/2006L).

Ikarus C42S ultralight aircraft OH-U396 after an accident at Lake Hirsijärvi, occurrence 12 (investigation B3/2006L).

Ikarus C42B ultralight aircraft OH-U454 after a minor accident at Pudasjärvi, occurrence 13 (investigation D4/2007L).

Skyranger V.Max ultralight aircraft OH-U495 after a serious incident at Helsinki-Malmi, occurrence 14 (investigation C5/2007L).

Appendix 5/8 (10)

Quad City Challenger ultralight aircraft OH-U545 after a minor accident at Vampula, occurrence 15 (investigation D2/2008L).

CTSW ultralight aircraft OH-U547 after a minor accident at Hanko airfield, occurrence 16 (investigation D5/2008L).

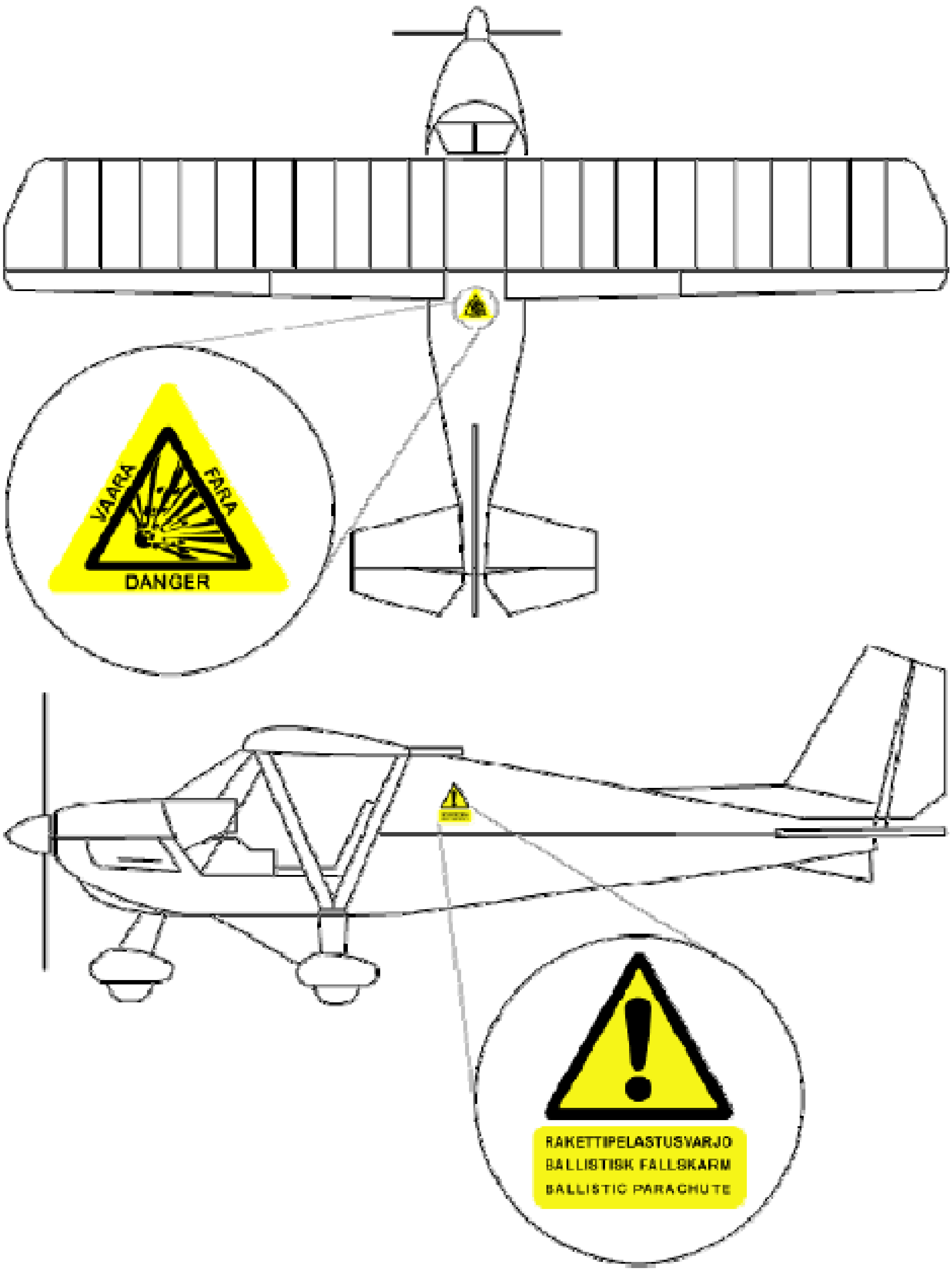
ATEC Zephyr 2000 ultralight aircraft OH-U502 after an accident at Lahti-Vesivehmaa airfield, occurrence 17 (investigation D2/2009L).

Ikarus C42B ultralight aircraft OH-U478 after an accident at Helsinki-Malmi aerodrome, occurrence 18 (investigation D3/2009L).

Dynamic WT-9 ultralight aircraft OH-U474 after an accident at Inkoo, occurrence 19 (investigation D4/2009L).

EV-97 Eurostar ultralight aircraft OH-U507 after an accident at Kauhava aerodrome, occurrence 20 (investigation B6/2009L).

APPENDIX 6. A SCHEMATIC DIAGRAM OF BALLISTIC PARACHUTE RECOVERY SYSTEM WARNING MARKERS



APPENDIX 7. THE QUESTIONNAIRE SENT TO ECAC MEMBER STATES AND CANADA WITH REGARD TO ULTRALIGHT ACCIDENT INVESTIGATION

1. Do you investigate any ultralight aviation accidents and/or incidents?	
	Yes.
	No.

2. If you investigate ultralight aviation accidents and/or incidents, what type of accidents and/or incidents do you investigate?

3. If you investigate ultralight aviation accidents and/or incidents, on what basis do you investigate them? For example based on the legislation requirements or the benefit for the flight safety in general?

4. If you do not investigate ultralight aviation accidents and/or incidents at all, on what basis do you not investigate them?

5. If you do not investigate every ultralight aviation accident and/or incident or if you do not investigate them at all, does some other investigating body investigate them in your country? For example some association, club or police?	
	Yes. Name/names of the investigating body/bodies?
	No.

6. If some other investigating body investigates ultralight aviation accidents and/or incidents in your country, what type of accidents and/or incidents does it investigate?

7. If ultralight aviation accidents and/or incidents are investigated in your country, how many ultralight aviation accidents and/or incidents are investigated officially on a yearly basis in your country? You can give an estimated number of investigations per year, if you do not have specific statistics.

8. If ultralight aviation accidents and/or incidents are investigated in your country, how many safety recommendations are given on a yearly basis in your country concerning officially investigated ultralight aviation accidents and/or incidents? You can give an estimated number of safety recommendations per year, if you do not have specific statistics.

9. If you investigate ultralight aviation accidents and/or incidents now, how are you going to investigate them in the future?

10. If you do not investigate ultralight aviation accidents and/or incidents now, are you going to start investigating them in the future?	
	Yes. When?
	No.

11. If you do not investigate ultralight aviation accidents and/or incidents now, have you investigated them in the past?	
	Yes. When did you stop investigating them?
	No.

12. Free word about the topic.