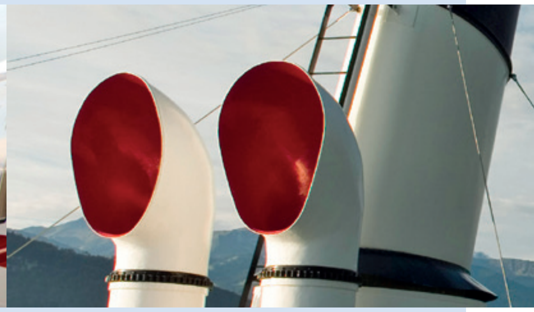
Swiss Transportation Safety Investigation Board STSB
Annual Report 2016



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Swiss Transportation Safety Investigation Board STSB

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1 Editorial

1,561 notifications relevant to safety were received in 2016. 159 investigations were initiated. 97 investigations were completed. Besides a great deal of dedication, what else is behind these bare statistics?

In 2016, the Swiss Transportation Safety Investigation Board (STSB) continued to focus on its core tasks – the investigation of accidents and serious incidents in civil aviation, public transport by road, rail and cable car as well as inland and maritime navigation. As different as these modes of transport may be, the causes of events relevant to safety are not. Time and time again, human error is a leading factor. Such errors hardly occur in standard operation, which is designed to deliver efficiency and safety through well-organised processes. This standard operation has a strong influence on the everyday life of those involved, promotes routine and becomes their central body of experience. Everybody is working to ensure that extraordinary situations arise even more rarely. However, a consequence of this is that expectation of the normal turn of events means that in some cases those responsible for safety no longer recognise extraordinary situations. Of course, this can be remedied, for example, through training courses using simulators, which are based on situations which rarely arise in reality. Nevertheless, routine holds an incredible power. This gives rise to the theory that the more smoothly the operation runs, the more technical aids are necessary which support those involved during operation, draw attention to irregularities and provide guidance for handling situations adequately and safely. This requires constant investment in technical infrastructure.

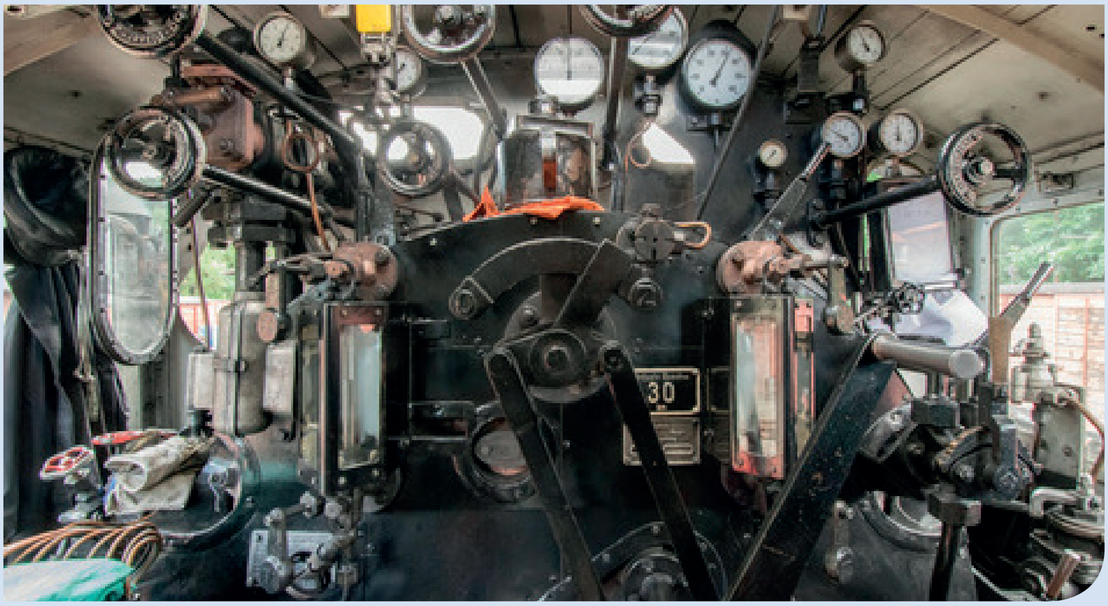
The Investigation Bureau of the STSB is confronted by the power of the routine in two senses, namely by its own routines and by routines in transport operations. In the case of an incident or accident, it is necessary to decide whether a more detailed investigation of the incident should be initiated at all. Might the findings of the accident investigation potentially have a certain preventative effect? Could there be systemic causes hiding behind the superficial error of a person involved in an event? Experience helps when making this decision but, at the same time, it can be a factor in making incorrect decisions. That is why an investigator never makes this decision on his/her own. If an investigation is initiated, you must free yourself from your own expectations as to the cause of the accident, let the facts speak for themselves, draw the correct conclusions from them, potentially formulate safety recommendations and advice, and then address these correctly. The circle is only closed when the findings of the STSB reach transport operations once again.

It is also the task of the STSB, which is an extra-parliamentary board, to monitor the international environment and respond to changes in good time. Internationalisation continues to increase in the area of the railways in particular. The European Union revised directive 2004/49/EC on railway safety completely in 2016. This also includes the guidelines for the independent investigation of accidents and serious incidents in railway operations. One crucial element is that with the new EU directive, certain executive powers, such as those for the approval of railway vehicles, are to move from the national supervisory authorities for safety to the bodies of the EU. This means that the safety recommendations of the national safety investigation authorities will now also have to be addressed to EU bodies. Whether and how Switzerland wants to incorporate these new rules into national legislation is a matter to be examined by 2018 and to be decided by the relevant authorities.

The environment is changing, but the meaning behind the work of the STSB remains: open, independent and unprejudiced investigation into the causes of events relevant to safety shall continue to make a valuable contribution to public safety in the future.

Pieter Zeilstra
Chairman of the extra-parliamentary board

2 Management summary



In 2016, a total of 1,561 notifications concerning accidents and hazardous occurrences were received by the STSB. An analysis of these notifications led to 159 safety investigations being opened. 40 investigations of accidents and serious incidents as well as one study were concluded and a further 57 summary investigations of events of lesser importance were carried out. As part of its investigations, the STSB issued a total of 35 safety recommendations and 10 safety advices during 2016.

The reporting year was characterised by an average number of accidents and hazardous situations in public transport, while an above-average number of accidents and serious incidents occurred in the area of civil aviation.

Concerning the federally licensed operation of railways, buses and cable transport, the figures for the analysed event categories compared to the longer-term trend show that the accident rates for 2016 are in line with the long-term average. Individual event categories, such as collisions at level crossings without controls, show considerable improvement once again.

In terms of motorised aircraft with a take-off mass of up to 5,700 kg, the accident rate improved significantly in 2016 and the accident rate for helicopters was at the level of the long-term average. For gliders, an above-average accident rate was reported. Compared to the previous years, a significant increase in the number of airproxes between manned and unmanned aircraft (drones) was observed.

This annual report includes, among other things, a summary of all of the safety recommendations and safety advice issued by the STSB in 2016. A short introduction and a statement of the reasons why they were addressed to the appropriate supervisory authority or the relevant stakeholders have been added. Details on the progress of implementation are also given – where these are already available – for each safety recommendation.

Based on the statistics, the analysis of significant data over a period of several years was continued. It is therefore possible to show the development of the accident figures and accident rates for the years 2007 to 2016 for motorised aircraft with a maximum permissible take-off mass of less than 5,700 kg, for helicopters and for gliders. With regard to rail accidents, the notifications were evaluated according to various event types. The annual report also explains the methodology which was used for this analysis.

To facilitate readability of the annual report, detailed statistical data and compilations have been provided in the form of annexes.

3 Board

3.1 Business of the board

Core task

Continuity has been the strategic focus of the STSB in the last few years. However, continuity should not be understood as purely consolidating the status quo, but rather as steady, ongoing development without any breaks or gaps: ongoing development of the organisation and its operations and processes to enable it to master the core task of the safety investigation board efficiently and effectively. This essentially means investigating those events which arise from the legal mandate and which also show a high risk potential. Safety deficits from incidents and accidents must be uncovered through a logically deduced analysis of the causes and the risks reduced together with partners in the national safety network.

Changes in personnel

The motto of continuity applied to the work and composition of the board in particular until late 2016. However, significant changes in personnel were due at the end of the reporting year: after five years working at the board, André Piller (chairman) and Yvonne Muri (member of the board) left the STSB. Both shaped the organisation, its setup and the efforts to standardise processes and optimise quality with a blend of prudence and patience, persistence and consistency.

In appointing the new board, the Federal Council aimed to anchor knowledge of railways, cable transport and navigation as modes of transport in the board along with legal and aviation expertise, so that it could ensure expert dialogue with the investigators. With effect from the beginning of 2017, the Federal Council has newly elected two people to the extra-parliamentary board.

The board is comprised as follows:

Chairman of the extra-parliamentary board (new):
Mr Pieter Zeilstra, lic. phil. nat., NDS ORL ETH, born 1962, former vice director of the Federal Office of Transport (FOT) and head of the safety division in its capacity as the national safety authority for public transport.

Member of the board (new):
Ms Inge Waeber, born 1966, self-employed lawyer and notary in Fribourg, lecturer in employment law at the hotel and catering employers' association in Fribourg, former deputy of the public prosecutor in the canton of Fribourg.

Member of the board (previous):
Mr Werner Bösch, dipl. chem. ETH, born 1949, in office since November 2011. Former Swissair airline pilot and head of basic pilot training; former head of the flight operations division at the Federal Office of Civil Aviation (FOCA) as deputy director.

Focus

The combined administrative, organisational and personnel measures taken last year are making an impact: the majority of the objectives set were achieved. Efforts to raise awareness of occupational health and safety were started at an initial training event. Here, the focus was on handling modern equipment as well as appropriate behaviour in different situations for employees at accident sites. The focus topics defined for this year lie in the following areas:

Effectiveness: Focus on the core task;

Quality: Producing reports that are easy to understand and represent added value for partners in the safety network;

Employees: The path chosen – i.e. to increasingly involve employees in organisational issues and in processes such as setting annual objectives – should continue to be pursued.

Thanks

The board thanks all partners in the safety network for their constant endeavours to improve the safety level, the employees of the STSB and, last but not least, the outgoing members of the board for their commitment during the founding period of the STSB.

3.2 Personnel

The appointment of a new full-time investigator for aviation incidents in April 2016 enabled the STSB to once again reach the target headcount for full-time specialists in this area with five investigators. An investigator for incidents involving the railways, buses, cable transport and inland navigation left the STSB at the end of September, meaning that there are currently only four full-time investigators available for the modes of transport mentioned. Filling the new position of technical investigator in January 2016 brought greater in-depth knowledge of recording devices, and meant that the prompt evaluation of systems frequently used in aviation and maritime navigation could be significantly improved.

During the reporting year, the STSB was able to recruit 16 new part-time investigators and one intern for specific analysis on a mandate basis, while 8 part-time investigators who worked for the STSB for many years left their positions. At the end of 2016, the STSB had more than 115 part-time investigators with specialist knowledge across all modes of transport that can be the subject of an investigation.

In terms of training and development, the emphasis was placed on training and developing the skills of the newly appointed full-time and part-time investigators. For those full-time and part-time employees who are deployed at aircraft accident sites, a training course on occupational health and safety at accident sites was held in August 2016.

3.3 Finances

In the reporting year, the Swiss Transportation Safety Investigation Board had a budget of 8.59 million Swiss francs at its disposal. Of that, 7.51 million francs were actually needed. Around 1 million francs were not needed because of understaffing, because purchases were deferred and because investigation expenditure on reports from external experts, for example, came in under budget, even though a relatively large number of investigations had to be opened in the reporting year. This sum covers the STSB's entire personnel and operating expenditure. As in other countries, the work of the Swiss Transportation Safety Investigation Board represents a basic service provided by the state to improve safety. The work of the STSB is therefore almost exclusively financed from the public purse. All STSB products, in particular the final reports of investigations, are provided free of charge on the internet, for example. Printed and bound copies of these reports can be purchased for a fee individually or by subscription if required. The sale of these printed products generated a total of 42,600 francs in 2016, and represented the STSB's only regular external source of income.

4 Investigation Bureau

4.1 Overview of investigation findings

During 2016, the STSB received a total of 1,561 notifications concerning accidents and hazardous occurrences. 159 safety investigations were opened, around one in ten cases. A total of 97 investigations into accidents and serious incidents were completed, as well as one study. These included 57 summary investigations of incidents of lesser importance. 40 final reports (see annexes 1 and 2), 57 summary reports and 2 interim reports were published. As part of its investigations, the STSB issued a total of 35 safety recommendations and 10 pieces of safety advice during 2016. At the end of the year, 221 investigations were still in progress.

58 investigations concerning aviation incidents were completed. 27 final reports (see annex 1) and 31 summary reports were published. One interim report concerning an incident was published. With regard to aviation, 18 safety recommendations and 8 pieces of safety advice were issued. At the end of the year, 142 investigations were in progress.

For the five modes of transport (rail, cable transport, bus, inland navigation and maritime navigation), 13 final reports, 26 summary reports and 1 interim report were completed and published on the Internet in the reporting year. 2016 saw a total of 16 safety recommendations issued in final reports, 1 recommendation issued in an interim report and 2 pieces of safety advice issued. At the end of the year, 79 investigations were in progress relating to the modes of transport of rail, cable transport, bus, inland navigation and maritime navigation.

4.2 Overview by mode of transport

Aviation

1,219 notifications of aviation incidents were received in 2016, which were assessed based on the legislation. To be able to evaluate the danger, it was necessary to use additional technical resources, especially where two aircraft had inadvertently converged (airproxes). Based on these assessments and evaluations, 35 investigations of accidents and 58 investigations of serious incidents were opened. This included 13 airproxes with a high or considerable risk of collision. A detailed investigation was opened into 33 events, while the initial findings of the accident investigation prompted a summary report for 60 incidents.

The Avro 146-RJ100 regional passenger aircraft used by Swiss aviation companies had already repeatedly been the subject of fault reports related to technical incidents in recent years. These included problems with the landing gear, steering controls, landing flaps or hydraulics system. This year also saw frequent reports of incidents in which gases or smoke had developed on the aircraft, which affected those on board through an unpleasant odour or toxic effects. Altogether, the STSB received 15 fault reports concerning incidents of this type, with eight of those arriving in October alone. In four of these cases, the STSB initiated an investigation.

Compared to previous years, a significant increase in the number of airproxes between conventional manned aircraft and unmanned aircraft (drones) was observed. Three investigations were opened in relation to this.

Although resources for search and rescue have improved greatly over the last few decades, accidents in general aviation have been observed time and time again in the last five to ten years where the aircraft and crew could only be found and rescued after a considerable delay. This is why the STSB – in collaboration with the relevant parties – conducted a comprehensive study on the topic of search and rescue (SAR) in Switzerland, which was completed in 2016. The study was published on the STSB website and sent to the subscribers of the final reports. In order to improve the applicability of the findings, the essential elements of the study were briefly summarised. In particular, the organisation and working methods of SAR, illustrated using an example SAR case and accompanied by recommendations for service providers and service users, is now available in a brochure. This is provided to flight schools free of charge and available at airports for information purposes. The same information can also be accessed on the microsite www.sar-booklet.ch designed for use with tablet computers and smartphones.

In 2016, one passenger and four crew members were fatally injured in accidents involving aircraft in Swiss territory and involving Swiss-registered aircraft abroad. Three passengers, four crew members and two other individuals suffered serious injuries.

Railways

In 2016, 298 reports of events relevant to safety on the railways were received of which 32 concerned trams. In 61 cases, an investigator attended the scene. An investigation was opened in 56 cases.

The more significant events include – in chronological order – the collision between a historical steam train and freight wagons in Sihlbrugg (canton of Zurich) on 20th February 2016, the head-on collision between two passenger trains in Corcapolo (canton of Ticino) on 26th April 2016, the collision between an ICE and a coach in Interlaken (canton of Bern) on 20th May 2016, the derailment of a passenger train in Horw (canton of Lucerne) on 5th June 2016, the collision between a wagon involved in a shunting operation and a freight train in Chiasso (canton of Ticino) on 16th July 2016, and two cases of a runaway train in Andermatt (canton of Uri) on 1st September 2016 and 28th November 2016. In addition, there was an emphasis on the investigation of shunting accidents.

In the events reported to the STSB, 57 passengers, 12 transport company employees and 136 other individuals suffered injuries in connection with the railways (including trams). The most common cause of personal accidents is careless behaviour by individuals crossing over the tracks in a manner that is not permitted. In practice, the transport or infrastructure companies cannot exert any control over such incidents.

Cable transport

18 notifications involving cable transport were received. In 3 cases, an investigator attended the scene. An investigation was initiated into 2 incidents. Both investigations concern a vehicle crash.

10 passengers, 2 employees of cable car companies and 1 other individual suffered injuries in the reported events. Most frequently, passengers suffered injuries while entering or leaving a cable car.

Buses

The STSB was alerted to 12 incidents concerning buses. An investigation was initiated in connection with one incident.

6 passengers, 2 bus company employees and 2 other individuals suffered injuries in the reported events. 7 out of the 12 events were related to a fire in which nobody was hurt. The majority of injuries to persons were the result of buses colliding with other means of transport.

Inland navigation

In 2016, the STSB was alerted on 6 occasions. An investigation was opened in 4 cases.

The more significant events include the collision of a motor vessel with the jetty in Küsnacht (canton of Zurich) on 20th April 2016 and the collision of two steamboats on Lake Lucerne (canton of Lucerne) on 19th August 2016.

17 passengers, 3 employees of navigation enterprises and 1 other individual suffered injuries in the reported events.

Maritime navigation

During 2016, eight incidents involving sea-going vessels which fly the Swiss flag were reported to the STSB. In the following three cases, the STSB opened a safety investigation: two sailors were seriously injured as a general-purpose cargo vessel was leaving the port of Leixoes in Portugal in rough seas. In another general-purpose cargo vessel, the main engine blew up as it was arriving at Swinoujscie in Poland. As a result, the ship was disabled and ran aground briefly. In the China Sea south of Shanghai, a collision took place between a Swiss bulk cargo vessel and a fishing vessel flying the Chinese flag. Nobody was injured in the last two accidents.

5 Safety recommendations and safety advice

5.1 General

In the first half of the last century, accidents in the transport sector were usually investigated by individual supervisory authorities. However, since these may be involved in causing an accident or a hazardous situation as a result of their activity, a separation of tasks and powers has developed over the course of recent decades: in most countries, in addition to the supervisory authority, an independent, state-run safety investigation body also exists, which is expected to impartially clarify the reasons for an accident or a serious incident. Since the introduction of the EU safety directive, this also applies to incidents on the railways in EU countries. Because of the above-mentioned separation of powers, the investigative body itself cannot impose measures to improve safety, but can only propose them to the relevant authorities. Consequently, these retain their full responsibility. The safety investigation body – the STSB in Switzerland – approaches the relevant supervisory authorities by expounding a possible safety deficit and issuing corresponding safety recommendations as part of an interim or final report. It is then up to the relevant supervisory authority, together with the stakeholders concerned, to decide whether and how the safety recommendations should be implemented.

In 2003, the European Union established the European Aviation Safety Agency (EASA), which is to provide uniform and binding rules on aviation safety in the European aviation sector on behalf of the member states. Since that time, the EASA has increasingly exercised its authority, particularly in the areas of technology, air traffic, aviation safety and aerodromes. The national supervisory authorities primarily play an executive and mediating role and their exclusive competence is increasingly limited solely to the nationally regulated aspects of civil aviation. Since Switzerland decided to participate in the EASA, this change also applies to Swiss civil aviation. For this reason, the Swiss Transportation Safety Investigation Board addresses its safety recommendations concerning aviation to either the EASA or the Federal Office of Civil Aviation depending on the area of competence.

In terms of the railways, regulations from the EU are constantly increasing in importance. In particular, they concern technical interoperability for international transport. However, full safety supervisory authority over the railways continues to reside with the national supervisory authorities for safety. Therefore, under article 48 paragraph 1 of the Ordinance on the Safety Investigation of Transport Incidents (OSITI), all safety recommendations concerning the railways are addressed to the Federal Office of Transport (FOT). The OSITI implements provisions equivalent to those in the EU safety directive (2004/48/EC) into Swiss law. This EU safety directive is part of the annex to the Overland Transport Agreement between Switzerland and the EU. However, the EU revised the safety directive completely in 2016. In accordance with this, certain enforcement powers are to be transferred to the EU authorities. If Switzerland follows this development, it would be conceivable that certain recommendations from the STSB concerning the railways would also be addressed to the EU authorities in future.

With regard to maritime navigation, the European Union established the European Maritime Safety Agency (EMSA) in 2002. It is intended to reduce the risk of accidents at sea, the pollution of the seas through maritime navigation and the loss of human life at sea. EMSA advises the European Commission on technical and scientific matters concerning the safety of maritime traffic and in relation to preventing the pollution of the seas by ships. It plays a part in the ongoing development and updating of legislative acts, the monitoring of their implementation and in assessing the efficacy of existing measures. However, it has no authority to issue directives over Switzerland. Any safety recommendations from the STSB are therefore addressed to the Swiss Maritime Navigation Office as the national supervisory authority.

In licensed inland navigation in Switzerland, it is primarily national regulations that apply. Consequently, recommendations from the STSB are addressed to the Federal Office of Transport as the national supervisory authority for safety.

Having received a safety recommendation, the supervisory authorities inform the STSB of the measures taken which arise from the safety recommendations. If no measures have been taken, the supervisory authorities justify their decision. The measures taken by the supervisory authorities in relation to the safety recommendations are categorised as follows by the STSB:

- **Implemented:** Measures have been adopted which are very likely to significantly reduce or eliminate the identified safety deficit.
- **Partially implemented:** Measures have been adopted which are very likely to slightly reduce the safety deficit or eliminate it in part, or a binding implementation plan with a defined timeline is at hand and has been initiated which is very likely to lead to a significant reduction in the safety deficit.
- **Not implemented:** No measures have been adopted which have led or will lead to any noteworthy reduction in the safety deficit.

With the Ordinance on the Safety Investigation of Transport Incidents (OSITI) having come into force on 14th December 2014, the STSB began issuing safety advice in addition to the safety recommendations where necessary. As stated above, safety recommendations are addressed to the relevant supervisory authorities and propose improvements which can only or, at least, primarily be brought about through guidelines from or the supervisory activities of this body. However, occasionally safety deficits also become apparent as part of an investigation that cannot be eliminated by amending rules or regulations and direct supervisory activity, but rather by changing or improving risk awareness. In such cases, the STSB formulates safety advice, which is addressed to particular stakeholders or interest groups in relation to transport. This is intended to help the people and organisations concerned to recognise a risk and provide possible approaches for sensibly dealing with it.

All of the safety recommendations and safety advice issued by the STSB in interim or final reports during 2016 are set out below. To aid understanding, these are accompanied by a brief description of both the incident concerned and the safety deficit which is to be eliminated. The implementation status at the end of March 2017 can be found at the end of each safety recommendation. The current implementation status of safety recommendations and further details can be found on the homepage of the Swiss Transportation Safety Investigation Board.

5.2 Aviation

Accident involving a UH-1H helicopter in Rüthi (canton of St. Gallen), 20/12/2012

On 20th December 2012, the pilot intended to fly from Balzers Heliport to St. Gallen-Altenrhein Airport in a Bell UH-1H helicopter. During the flight, the occupants noticed very strong vibrations and an abrupt yaw to the right on the helicopter's axis. The pilot intermittently lost control of the helicopter during this phase. The pilot subsequently decided to make an emergency landing. During the landing, the helicopter was destroyed and one occupant was seriously injured.

Safety deficit
The helicopter was registered in the 'historic' subcategory within the 'special' category of the aircraft register. When this registration took place, the Federal Office of Civil Aviation no longer applied the Type Certificate (TC) H3SO, in which relevant operational restrictions were recorded. Consequently, these sensible restrictions lost their validity. Although operational restrictions were made in the permit to fly, these only applied to the type of flight. The number of passengers on board was not limited. This was not risk-conscious.

Safety recommendation no. 506, 23/12/2016
The Federal Office of Civil Aviation (FOCA) should assess on a case-by-case basis which restrictions are necessary for the operation of aircraft in the 'historic' subcategory within the 'special' category.

Implementation status
Awaiting response.

Safety deficit
The helicopter was registered in the 'historic' subcategory within the 'special' category of the aircraft register. The helicopter type UH-1H has complex systems and requires in-depth expertise for maintenance work. From the STSB's point of view, the operator of the helicopter was not qualified for an approval to carry out maintenance work on this aircraft himself. Normally, maintenance work for such models has to be performed by qualified maintenance staff in appropriately qualified organisations.

Safety recommendation no. 507, 23/12/2016
The Federal Office of Civil Aviation (FOCA) should review the process of obtaining approvals for carrying out and certifying maintenance work on aircraft in the 'historic' subcategory within the 'special' category. They should also define and implement stricter requirements in order to ensure the level of quality required.

Implementation status
Awaiting response.

Collision between a glider and a motorised aircraft near Auenstein, 06/06/2013

On 6th June 2013, a collision occurred between a glider and a motorised aircraft in the Auenstein area. The glider was fitted with a Flarm collision warning system and the motorised aircraft was fitted with a Mode S transponder.

Safety deficit
The safety deficit generally concerns all aircraft categories and was determined based on several investigations from the last few years. These show that airproxes and collisions between aircraft occurred time and again. The meaning and limits of the 'see and avoid' principle were generally unknown to the transport users. The use of 'see and avoid' without technical support could not prevent airproxes and, in particular cases, collisions. The majority of aircraft were not fitted with collision warning systems. In addition, the collision warning systems installed were not mutually compatible. In the present case, the glider fitted with a Flarm could not receive the signal from the motorised aircraft's Mode S transponder.

Safety recommendation no. 498, 02/03/2016
In collaboration with the stakeholders, the Federal Office of Civil Aviation (FOCA) should increase all crew members' awareness concerning the risk of collisions and intensify the training and professional development of crew members in the use of the 'see and avoid' principle and of collision warning systems.

Implementation status
Partially implemented. In a letter dated 9th May 2016, FOCA advised that it fundamentally agrees with the safety recommendation and makes the following statement: the topic of 'see and avoid' was already being extensively taught as part of basic training and advanced training courses. From the perspective of FOCA, additional measures are not necessary. However, FOCA deems it feasible to raise awareness among pilots of motorised aircraft that they should avoid popular glider areas or to carry out extensive airspace surveillance when flying through these areas. In addition, contact was established with the Aero-Club to include these issues at the next safety-related events of 2016. FOCA will also publish material on this topic in specialist journals.

Safety recommendation no. 499, 02/03/2016
In collaboration with the stakeholders and the European Aviation Safety Agency (EASA), the Federal Office of Civil Aviation (FOCA) should develop a concept for introducing compatible collision warning systems for general aviation that are based on international civil aviation standards as well as create and enact a plan of action for short-term, medium-term and long-term implementation.

Implementation status
Partially implemented. In a letter dated 9th May 2016, FOCA advised that it fundamentally agrees with the safety recommendations and makes the following statement: in collaboration with the Aero-Club, FOCA will raise awareness among owners and pilots of motorised aircraft that they should equip motorised aircraft with collision warning devices (Power Flarm).
In a letter dated 27th April 2016, the EASA advised that it is investigating this topic and has published the corresponding study EASA.2011.07. This study concluded that collision warning devices of this kind should be lightweight, inexpensive and compatible. The EASA accordingly recommended developing a technical standard for collision warning devices for general aviation. Various systems are already available and are widely used. The EASA has encouraged the installation of one of these systems (Flarm) and makes the corresponding directives available so that this device can be fitted as a standard change. The EASA is continually monitoring the development of further solutions and has begun another internal study to evaluate other measures.

Serious incident involving a helicopter at Zurich Airport, 06/06/2013

On 6th June 2013, a pilot took off in an Agusta A109 SP helicopter for a technical flight in order to carry out a functional check on the rescue winch. A winch operator was on board and a mechanic was on the ground with the prepared load of 250 kg. The mechanic's task was to attach the load to the winch hook at the given time. The winch cable broke when the test load was being lifted.

Safety deficit
The findings of the investigation lead to the conclusion that before the load was lifted, the hoist cable had become snagged behind the nut which attaches the rescue hoist handle assembly, and subsequently broke under stress. The design of the rescue hoist attachment assembly was identified as the causal factor.

Safety recommendation no. 528, 30/12/2016
In collaboration with the helicopter manufacturer, the European Aviation Safety Agency (EASA) should introduce technical measures to ensure that the hoist cable is prevented from snagging on the rescue winch attachment assembly.

Implementation status
Awaiting response.

Serious incident involving aircraft CTLS-ELA in Gland on 12/07/2013

On 12th July 2013, a Flight Design CTLS-ELA aircraft took off from La Côte for a flight to Neuchâtel. When flying over the trees at the end of runway 4, the engine began to sputter and then cut out suddenly. The pilot was able to perform an emergency landing. The cause of the insufficient fuel supply was established as being the design of the fuel system which could not sufficiently eliminate emerging gas bubbles. Tests carried out by the aircraft manufacturer showed that a fuel return pipe into the tank eliminates the gas bubbles.

Safety deficit
No electric fuel pump was fitted in the aircraft involved even though it was stipulated in the German edition of the installation manual.

Safety recommendation no. 505, 15/03/2016
In collaboration with aircraft manufacturer Flight Design GmbH, the European Aviation Safety Agency (EASA) should ensure that the manufacturer takes suitable measures to minimise the development of gas bubbles in the fuel sys-

tem of Flight Design CTLS aircraft and to ensure that any gas bubbles that may be present are sufficiently eliminated.

Implementation status

Not implemented. In a letter dated 7th June 2016, the EASA advised that it has investigated the topic with the type certificate holder Flight Design, which carried out further tests on the aircraft involved in the serious incident and was able to detect neither a warning about low fuel pressure nor the engine cutting out. Based on these findings, the EASA believes that despite the possible presence of gas bubbles, the fuel system is reliable and robust, and that no other measures need to be taken.

Accident involving a Cabri G2 helicopter in Wichtrach, 13/07/2013

On 13th July 2013, a flight instructor and a trainee pilot carried out a training flight with a Cabri G2 helicopter. Whilst completing landing exercises, the crew heard a loud noise which was followed by the development of an odour. Together with a mechanic, they carried out in-depth inspections in open terrain. The parties involved saw the loose power supply unit for the strobe light in a recess next to the main rotor transmission and the singed surface coating of the foam air filter in close proximity to the exhaust as possible explanations for what had been noticed during the flight. During the subsequent flight back, which took 10 minutes, the odour developed again, followed by smoke coming from the engine bay. The flight instructor immediately initiated a precautionary landing. In the process, the cooling fan of the air cooling system disintegrated and caused further collateral damage in the engine bay and engine failure. Subsequently, the crew successfully carried out an autorotation.

Safety deficit

The investigation showed that the failure of the cooling fan could be attributed to fatigue in the material, inadequate constructive design and the material not complying with the required specifications. It also became clear that the service bulletins which had been published by the manufacturer were not sufficient to guarantee safe operation.

Safety recommendation no. 502, 03/10/2016

The European Aviation Safety Agency (EASA) should ensure that the manufacturer Hélicoptères Guimbal immediately checks the operational safety of the cooling fan in the cooling system of Cabri G2 helicopters across the entire fleet and draws up an appropriate inspection programme for continued operation.

Implementation status

Partially implemented. In a letter dated 24th November 2016, the EASA addresses the binding service bulletins and airworthiness directives published by helicopter manufacturer Hélicoptères Guimbal and by the EASA. The relevant checks uncovered several components with fractures. The checks could be carried out without any particular problems. The EASA acknowledges the necessity to improve the production process for the front disc of the cooling fan (see safety recommendation no. 503). The manufacturer believes that fracture development is primarily dependent on the number of start-stop cycles. Accordingly, these figures were included and published in airworthiness directive 2016-0033 by the EASA.

Safety recommendation no. 503, 03/10/2016

The European Aviation Safety Agency (EASA) should ensure that the manufacturer Hélicoptères Guimbal undertakes appropriate measures to prevent the occurrence of a disintegration of the cooling fan in the cooling system of Cabri G2 helicopters.

Implementation status

Implemented. The manufacturer Hélicoptères Guimbal adapted the production process for the front disc of the cooling fan to achieve an even material thickness and reduce residual tension in the material. In addition, the number of mounting points was doubled and new screws were used. The modified version has been installed in new helicopters since the end of 2015. The inspection requirements outlined in the airworthiness directive remain unchanged. Hélicoptères Guimbal also developed a front disc made from composite material. This was approved by the EASA in July 2016 and has been available for retrofitting to the existing fleet since September 2016.

Airprox between two commercial aircraft at Geneva Airport, 31/03/2014

A Boeing 737-800 performed a visual approach to runway 5 at Geneva Airport in good weather conditions. When it was approximately 7.5 NM away from the displaced runway threshold, the air traffic controller allowed a Fokker 100 to taxi to the take-off position at the start of the runway. To speed up the flow of traffic, he also gave advance clearance for a PC12 to take off from taxiway Z, which merges into runway 5 in the first third. Subsequently, he waited until the PC12 had reached a sufficient distance before giving the Fokker 100 clearance for take-off. The Runway Incursion Monitoring and Conflict Alert Sub-system (RIMCAS) then signalled the impending airprox between the Boeing 737-800 and the

Fokker 100 via an orange warning light. As the air traffic controller was looking to the outside to manage the traffic by sight, he did not notice the visual warning. 15 seconds later, a red warning light was emitted combined with an acoustic alarm, meaning that the airprox was rated as critical and that immediate corrective action was necessary. When the acoustic alarm was emitted, the air traffic controller deemed it unsuitable for the Boeing 737-800 to perform a go-around and therefore gave the approaching aircraft clearance to land. When the approaching aircraft flew over the displaced runway threshold, its distance from the Fokker 100, which was taking off, corresponded to just half of the minimum distance.

Safety deficit

This serious incident showed that the parameters of RIMCAS only offer support during low visibility procedures (LVP) to warn the air traffic controller of potential airproxes. In the present case, the first warning came at a time when it was too late for air traffic control to intervene.

Safety recommendation no. 508, 06/12/2016

The Federal Office of Civil Aviation (FOCA) should ensure that the parameters of the Runway Incursion Monitoring and Conflict Alert Sub-system (RIMCAS) are reviewed so that the system is also an effective safety net in weather conditions other than those of low visibility.

Implementation status

In a letter dated 7th March 2017, FOCA gave the following response: RIMCAS is a safety net and should not be seen or used as a planning tool. Alarms generally cause attention to be diverted and lead to an increase in 'head-down time'. It is questionable whether an adjustment to the parameters of RIMCAS could have prevented the inadequate separation in this case.

Accident involving a motorised aircraft in Grenchen, 05/07/2014

On 5th July 2014, a Flight Design CTSW aircraft was involved in an accident when landing at Grenchen Airport. The weather conditions were windy and dry. The pilot sustained serious injuries in the accident and the aircraft was destroyed. Fire did not break out.

Safety deficit

Because of the degree of damage to the aircraft, in particular because of the burst fuel tanks, the risk of an outbreak of fire nevertheless had to be taken into account at the accident site. The quickest possible deployment of immediately operational and effective fire control was therefore advisable. Following the accident, the emergency personnel took measures, which to some extent were not systematically oriented to an emergency response in the event of fire. The risk associated with the ballistic recovery system installed in the aircraft was also not appropriately assessed. This posed additional risks for the injured pilot as well as the emergency personnel. The STSB came to the conclusion that there are similar problems not only in Grenchen, but also at other airports. The Swiss Transportation Safety Investigation Board therefore considers it sensible to examine the training and operating procedures of airport fire services and, if necessary, improve them.

Safety recommendation no. 523, 19/12/2016

Together with airport management, the management of airport fire services and Swiss fire service institutions, the Federal Office of Civil Aviation (FOCA) should examine the extent, content, implementation and effectiveness of airport firefighter training as well as the designated procedures and, if necessary, take adequate measures to reach the expected level of readiness for operation.

Implementation status

Partially implemented. As part of its supervisory duties, the Federal Office of Civil Aviation entered into a contract with the Zurich protection and rescue service (Schutz und Rettung Zürich – SRZ) to be able to make use of experts when reviewing the infrastructure, training and assessment of emergency exercises in the field of fire and rescue services. In addition, experts from the Service de Sécurité (SSA) at Geneva Airport, Birrfeld Aerodrome and Vienna Airport are being used to support the training of airport fire services. On 7th February, FOCA asked the chiefs of aerodrome to submit an assessment report after each training by the experts. On 29th June 2017, a meeting is scheduled with the aerodrome commanders at FOCA to discuss collaboration with the experts and training at aerodromes. Due to risk-based considerations, FOCA is also planning an inspection at aerodromes which do not conduct training with specialists from the SRZ or the SSA. The results of these inspections will subsequently be discussed with the chiefs of aerodrome and the managers of the airport fire services and, as far as necessary, suitable measures will be prescribed. In addition, FOCA will amend directive AD 1-001, chapter 5 (minimal training), so that the airports Bern-Belp, Lugano and St. Gallen-Altenrhein will also have to complete a 2-hour training course with an expert in aircraft firefighting.
According to the Swiss fire service federation (Schweizerischer Feuerwehrverband – SFV), their organisation has no knowledge of aircraft firefighting. However, it supports the approach that the training of airport fire services should mainly be conducted by experts from the SRZ and SSA professional fire services. As a result of collaboration between

FOCA, the SFV, the SRZ and the SSA, three one-day courses on 'accidents involving small aircraft and helicopters' are scheduled under the guidance of the SFV for 13th June 2017 in St. Gallen-Altenrhein, 15th September 2017 in Grenchen and 26th October 2017 in Samedan.

Safety deficit

The CTSW aircraft is an ultralight aircraft; in Switzerland, it is licenced in the 'ecolight' subcategory. The weather conditions at the time of the accident were windy. The approach was made with a flap position of 40°. The Swiss Transportation Safety Investigation Board determined that, among other things, the approach speed chosen by the pilot was too low and a causal factor in the accident. The pilot stated in the course of the investigation that he had normally flown at a speed of 85 to 90 km/h in the last part of a final approach for landings with flaps at 40°, and at about 90 to 95 km/h in turbulent conditions. As justification for this speed he referred to the rule which states that the approach speed is 1.3 times the stall speed in the landing configuration (VS0). In the present case, this equates to around 85 km/h. The self-compiled checklist used by the pilot required an approach speed of between 80 and 90 km/h with flaps at 40°. The approach speed calculated retrospectively from the available data was constantly around 80 km/h; about 20 km/h below the approach speed of "approx. 100 km/h" specified in the flight and maintenance manual. Given the prevailing wind conditions, the established practice of increasing the approach speed by a third of the wind speed during strong headwind would have supported an approach speed of between 105 and 110 km/h.

Safety advice no. 6, 28/12/2016

The widespread rule in aviation that the approach speed is 1.3 times the stall speed in the landing configuration (VS0) is only partially applicable to aircraft of comparatively low mass – especially ecolight or ultralight aircraft. The relationship between momentum and air resistance implies a higher approach speed for such aircraft than that which results from the rule. In addition, this rule should only be used if the aircraft manufacturer does not specify an approach speed.

Safety deficit

The aircraft was equipped with a ballistic parachute system (ballistic rescue system with rocket propellant, hereafter referred to as BPS). This system was not activated prior to or as a result of the impact. The cover on the BPS's firing aperture was intact, still sealing the BPS's firing aperture mounted into the deck of the fuselage. During the intervention from the emergency responders and emergency services, there were people in the danger area (blast radius) of the BPS on a number of occasions. Over the course of the work on the accident site, a splint was fitted on the BPS release handle in the cockpit by a local aircraft mechanic to ensure that the BPS was not unintentionally activated via the release handle. However, as damage to the structure in the area of the BPS was likely, sudden activation of the BPS during the investigation at the accident site and the subsequent recovery could not be ruled out.

Safety advice no. 7, 28/12/2016

If a ballistic parachute system (ballistic recovery system with rocket propellant) is not activated during an aircraft accident, one has to assume a threat to the emergency services from the ballistic parachute system – the ballistic parachute system can be activated by working on the wreckage even when the release mechanism in the cockpit is secured. If an unreleased ballistic parachute system is identified at an accident site, it is prudent to mark the blast radius of the ballistic parachute system in addition to the general cordoning-off of the accident site. It is recommended to cordon off a funnel-shaped area at an angle of about 60° and a distance of 100 metres from the firing aperture in the direction of the blast using barrier tape or cones. Entry into this sector should be avoided unless absolutely necessary. Survivors should be removed from the danger zone as quickly as possible. If possible and necessary for the safety of rescue operations, measures should be adopted as described in STSB's safety recommendation no. 454. Primarily, this includes blocking the release cable as close to the igniter unit as possible. This can be done using crimping pliers, for example, by crimping the release cable to the cable sheath as close as possible to the rocket and without displacing the cable in its cover and therefore blocking it.

Accident involving a motorised aircraft at Beromünster Airfield, 13/12/2014

On 13th December 2014, a pilot began the take-off run in a Cessna 182J motorised aircraft on the grass runway 34 at Luzern-Beromünster Airfield. Four parachutists were on board and were sitting on the floor of the aircraft without seatbelts fastened. Due to the wet weather, the grass runway was very soft and slightly frozen in places. The aircraft did not reach the required speed for lift-off during the take-off run and rolled across the end of the runway. In order to avoid rolling into a drainage ditch, the pilot pulled back on the control stick immediately before the ditch. The aircraft took off, crossed the ditch and then crashed into the soft, wet farmland.

Safety deficit
During the investigation, the flight preparation was found to be incomplete and a contributory factor in the accident. There was a particular lack of criteria for the decision to possibly abort take-off.

Safety advice no. 4, 13/12/2016
A compilation of investigated incidents which occurred at Luzern-Beromünster Airfield shows that, when operating at the limits of flying performance, concise deciding factors for when to abort take-off need to be defined. One possible deciding factor is outlined in the Alaskan Off-Airport Operation Guide of the US Federal Aviation Administration (FAA) as follows, "Establish and mark a go/no-go decision point for take-off. One way to do this is to clearly mark the halfway point of your available take-off area. Calculate 70% of your lift-off speed i.e. 50 mph x .70 = 35 mph. Check your airspeed as you approach the decision point and if you're less than 70% of lift-off speed – abort. Reduce your load, lengthen your runway, or wait for more favourable take-off conditions."

Accident involving an AT-3 R100 motorised aircraft in Riggisberg, 07/04/2015

On 7th April 2015, the engine of an Aero AT-3 R100 aircraft stalled during a training flight, resulting in an emergency landing.

Safety deficit
As part of the safety investigation, it was established that, with Rotax 912 engines whose oil tank features a suction pipe without a slotted end, a maintenance mistake can lead to a situation that causes sudden engine failure. Since 2013, the engine manufacturer has been delivering Rotax 912 engines with modified oil tanks that feature an oil suction pipe with a slotted end and a recessed partition. This modification prevents the partition from being sucked shut and the associated interruption of the oil supply.

Safety advice no. 5, 23/12/2016
Even if one were to argue that a critical situation cannot arise if all components are completely reinstalled and maintenance is completed correctly in accordance with the guidelines, the modification does represent a simple and cost-effective optimisation of the lubrication system. For this reason, the Swiss Transportation Safety Investigation Board recommends upgrading the relevant engines.

Near collision between a helicopter and a touring motor glider in Samedan, 20/07/2015

On 20th July 2015, an airprox occurred south-west of Samedan Airport in the area of reporting point HN between an approaching helicopter and a departing touring motor glider. The helicopter was using a special approach procedure that was only documented in an internal paper of the airport operator and was only permitted for helicopter companies based at Samedan Airport. These procedures lead via reporting point HN, which is within the airport's traffic pattern. When approaching and taking off via this reporting point, the traffic pattern must therefore always be crossed. In addition, the runway axis is also usually crossed twice. Approaches along these routes also require a steep descent due to the topographic conditions with the result that the traffic pattern is also crossed vertically at a steep angle. One of the approaches also runs parallel to the slope of Piz Padella where many gliders fly in the summer months, which is also indicated in the visual approach chart.

Safety deficit
The serious incident showed that these special approach and take-off procedures carry inherent risks. In addition, the special procedures and, in particular, reporting point HN were not published. This also posed a risk because not all airspace users were informed about the procedures applied. Furthermore, using non-published reporting points on the radio is confusing for outsiders and creates uncertainty.

Safety recommendation no. 509, 19/12/2016
Together with the airport operator and the local helicopter companies, the Federal Office of Civil Aviation (FOCA) should check the special approach and take-off procedures for helicopters at Samedan Airport.

Implementation status
Partially implemented. FOCA supports the safety recommendation. An application for the publication of the HN route for helicopters in Samedan has already been submitted to FOCA and is currently being assessed in the Framework Briefing group.

Safety deficit
The failure to publish a take-off procedure already had a facilitating influence on the respective serious incidents in previous investigations.

Safety recommendation no. 510, 19/12/2016

The Federal Office of Civil Aviation (FOCA) should ensure that all approach and departure procedures at all Swiss aerodromes are published for aviation personnel, even if perhaps only a limited group of people are permitted to use these procedures.

Implementation status

Partially implemented. FOCA supports the safety recommendation and is actively addressing the issue by developing a situation-based and risk-based solution for each aerodrome concerned. Based on a risk assessment, the aerodromes concerned are classified in the following order of priority:

1. Samedan
2. Sion, Locarno, Grenchen, Bern-Belp
3. St. Gallen-Altenrhein, Zurich, Lugano, Buochs
4. Yverdon, Sitterdorf, La Côte, Lausanne
5. Mollis, Kägiswil, Raron, St. Stephan
6. Remaining aerodromes with no air traffic control
7. Remaining aerodromes, heliports, mountain landing sites that have no publication

In parallel to this, a publication is planned for instrument flights with no air traffic control in Grenchen, for the university hospital (Inselspital) in Bern and for the Low Level IFR Route Network (LFN).

For the revision, FOCA plans the following course of action: whenever possible, all local flight procedures should be revised or annulled. If the local procedures are safer than those published, they should be legalised and published. FOCA will take these steps together with the aerodromes in the order of priority outlined above.
Regardless of the prioritisation mentioned, in the event of changes to the operation regulations and where former military aerodromes are redesignated as civil ones, it should always be checked whether unpublished local procedures exist and how they have to be revised if necessary. Over the course of 2017, FOCA will contact the individual chiefs of aerodrome to establish an individual procedural plan and schedule for the revision of the approach and take-off procedures.

Safety deficit

Both of the aircraft involved in the serious incident were fitted with Flarm technology collision warning systems. The touring motor glider's Flarm device was configured as type 1, which is the device's factory configuration and resulted in a 'glider' voice notification in the helicopter's Flarm device. However, the touring motor glider was almost exclusively, and also in this case, operated as a motorised aircraft, which means a configuration as type 8, 'powered aircraft', would have been more appropriate and probably would have made the visual search for aircraft easier, too. The appropriate configuration of the Flarm systems is important because the configuration influences the algorithms that are used and an inappropriate configuration can therefore result in warning characteristics that are somewhat less than perfect. In addition, the configuration determines the type of aircraft which is reported to the other transport users and thereby possibly influences the way in which they watch out for unidentified traffic. In a previous investigation of an airprox between two helicopters, the inappropriate configuration of a Flarm device already had a certain influence on the serious incident.

Safety advice no. 8, 19/12/2016

All operators of Flarm systems should ensure that the configuration of the devices is appropriate and complies with the intended use and purpose of the aircraft in question.

Safety advice no. 9, 19/12/2016

Designers of Flarm systems should evaluate the possible types of configuration and adapt them if necessary. In the case of devices with voice notification, the corresponding voice output should be checked and adapted if necessary.

Accident involving an MCR-ULC towplane at Locarno Airport, 13/12/2015

On 13th December 2015, a pilot took off from Locarno Airport for a tow flight with an MCR-ULC aircraft. A few seconds after taking off, he noticed that the aircraft engine began to run erratically and some of the circuit breakers tripped at the same time. A few seconds later, the aircraft's engine failed at an altitude of around 20 m above ground. The pilot was able to perform an emergency landing in the towplane, which was damaged in the process. The glider being towed was able to release and land safely.

Safety deficit

In the MCR-ULC aircraft with a Rotax 914 engine, fuel supply is ensured by two electrical fuel pumps. A failure of both fuel pumps, which can, among other things, occur due to a complete outage in the power supply, leads to engine failure. The rectifier regulator, which rectifies and regulates the alternating current from the generator, requires a constant input voltage from the battery in order to operate. In the event of battery failure, the rectifier regulator automatically switches itself off in order to prevent internal damage and strong fluctuations in the output voltage of the regulator, which would subsequently damage further electrical systems. As a result, the power supplies in the electrical system of the MCR-ULC, consisting of a generator with a rectifier regulator and a battery, are not designed to be redundant. Disconnection of the battery from the on-board power supply due to a short circuit, an interruption in the ground cable, a failure of the master relay or simply due to the master switch being switched off, for example, leads to the failure of both fuel pumps and subsequently to engine failure because of a lack of fuel. A comparison with other aircraft types registered in Switzerland that are fitted with a Rotax 914 engine shows that the power supply is the same as that of the MCR-ULC. Accordingly, the risk of an engine failure due to a lack of redundancy in the power supply is also present in these aircraft types.

Safety recommendation no. 511, 14/07/2016
The European Aviation Safety Agency (EASA) and the Federal Office of Civil Aviation (FOCA) should take appropriate measures to ensure that the electrical system of aircraft types operated with Rotax 914 engines is equipped with a redundant power supply for the two electrical fuel pumps.

Implementation status
Not implemented. The Federal Office of Civil Aviation sees no need for action and the European Aviation Safety Agency is working together with the engine manufacturer to assess the situation.

Safety advice no. 10, 14/07/2016
Operators and owners of aircraft with Rotax 914 engines should ensure that the electrical system in their aircraft does not exhibit any defects. It is also recommended that the electrical system of all aircraft with Rotax 914 engines be fitted with a warning light for the rectifier regulator to detect a failure of the rectifier regulator or alternator and the discharging of the battery at an early stage.

Study on the organisation and effectiveness of civil aviation search and rescue (SAR) services in Switzerland, 26/10/2016

Factual information
Emergency locator transmitters (ELTs) are the official SAR resource of the International Civil Aviation Organisation. When working correctly, they usually ensure both that an alarm is activated quickly and that the position of the accident site is communicated with sufficient accuracy so that the accident location can be found quickly and in a targeted manner by search helicopters using direction finders.

Safety deficit
In Switzerland, the installation of an ELT is not mandatory for all aircraft. However, installation is highly recommended. Reasons for not installing an ELT include administrative and technical obstacles which lead to complex and therefore expensive installation procedures. Operating aircraft without an ELT represents a safety deficit because an essential and efficient SAR resource is deliberately not being used and the chances of a successful SAR mission are therefore reduced a priori.

Safety recommendation no. 513, 26/10/2016
The Federal Office of Civil Aviation (FOCA) should consider making the installation of Emergency Locator Transmitters (ELTs) or comparable devices mandatory for all aircraft operated in Switzerland.

Implementation status
Awaiting response.

Safety recommendation no. 514, 26/10/2016
The Federal Office of Civil Aviation (FOCA) should reduce the administrative and technical obstacles for ELT installation as much as possible.

Implementation status
Awaiting response.

Safety deficit
Several cases are known in which the ELT was destroyed by the accident or transmission of the signals was prevented or restricted. Automatic emergency locator transmitters are only accepted by users and useful if they work reliably.

Safety recommendation no. 515, 26/10/2016
Together with the European Aviation Safety Agency (EASA), the Federal Office of Civil Aviation (FOCA) should make an effort to improve ELTs in terms of construction and installation so as to ensure that they work correctly in all cases if possible.

Implementation status
Awaiting response.

Factual information
The provision of search and rescue (SAR) services with their multi-layered and complex processes inevitably requires the collaboration of various specialists. These can often be found in existing organisations that specialise in providing certain services, which however inevitably leads to interfaces. Therefore, FOCA as the supervisory authority of the SAR and the Rescue Coordination Centre (RCC) as the coordination centre of an SAR mission have a critical task to complete: they must organise the interfaces appropriately and already be maintaining constant communication in preparation for a mission so that, in the event of an emergency, the required organisations and their expertise can be relied on immediately and without any friction.

Safety deficit

Interfaces inevitably lead to longer processes and always carry the risk of losing information or of misunderstandings. As the study showed, valuable time can be lost due to interface processes not being optimally defined.

Safety recommendation no. 516, 26/10/2016

Together with the Rescue Coordination Centre (RCC), the Federal Office of Civil Aviation (FOCA) should assess how the organisation of the search and rescue (SAR) services can be optimised with regards to interface issues.

Implementation status

Partially implemented. When the mandate for the operation of the RCC was transferred from the Swiss air rescue service to the cantonal police force in Zurich with effect from 1st January 2016, the existing interfaces were analysed and, where possible, optimised. In particular, interface coordination was introduced and the interface between the RCC and the Air Force was clarified and adjusted. The RCC mandate is scheduled to be transferred to the Air Force on 1st January 2020. A change such as this would allow another interface to be eliminated (alerting and searching within the same organisation) and the sovereign tasks within the federal administration to be integrated optimally with the pre-existing SAR tasks of the Air Force.

Safety deficit

Although regular meetings take place in particular between the main participants (FOCA, the RCC and the Air Force), institutionalised meetings or even practical exercises involving all interface partners have so far not been scheduled. For more complex cases, it would be conceivable to work in an interdisciplinary team at a common location. This would enable direct communication, permanent interaction and critical enquiries and would therefore lead to a fruitful collaboration between the different organisations. Working in parallel and in a structured way is of paramount importance for the RCC. It is doubtful whether the capacity of just one employee is sufficient in every case to make all the necessary clarifications simultaneously and on time. It is also difficult for an individual person to possess the competence required in all areas of aviation. This raises the question of whether a form of organisation should be aimed for in the RCC which allows other trained staff to be purposefully involved in a mission when necessary. As the study showed, valuable time can be lost by working in a sequential rather than a parallel manner.

Safety recommendation no. 517, 26/10/2016

Together with the Rescue Coordination Centre (RCC), the Federal Office of Civil Aviation (FOCA) should assess and, if necessary, adapt the organisation and operation of the RCC.

Implementation status

Implemented. In 2014 and 2015, FOCA and REGA recognised together that the organisation and operation of the former RCC could no longer meet the needs and demands of the future. FOCA could not finance large-scale expansion of the RCC. On 1st January 2016, the mandate for the RCC was therefore transferred from the air rescue service to the cantonal police force in Zurich. In the process, one operations centre was made redundant, amongst other things, and compared to the previous solution, three dispatchers are now available per shift instead of one. A process for using the Flarm data was created and the Skyguide radar data is also systematically requested and evaluated. In the future, FOCA aims to hold regular meetings with the main participants to exchange information.

Safety deficit

Investigations for this study showed that there is a general lack of information with regards to SAR amongst all parties that are potentially directly affected by the search and rescue services, i.e. airspace users from all categories. On the one hand, this concerns the organisation of SAR itself and, in connection with this, the possibilities and limits of SAR organisation. On the other hand, deficits were also established with regards to the technical and organisational options available to each individual for triggering and accelerating a contingent SAR mission. Unfounded opinions with regard to SAR can lead to inadequate actions and false expectations on the part of those directly involved. Lack of knowledge or incorrect knowledge with regards to SAR can have severe consequences in an emergency.

Safety advice no. 13, 26/10/2016

All airspace users should possess adequate knowledge with regards to SAR organisation as well as the technical and organisational options for triggering and accelerating an SAR mission. Training centres and flight instructors should ensure that the necessary knowledge is taught during pilot training as well as further training and refresher seminars.

5.3 Railways

Collision and derailment of a wagon during a shunting operation in Solothurn, 29/12/2014

On 29th December 2014 in Solothurn, a shunting operation collided with a mainline locomotive standing on its destination track. The foremost wagon of the shunting operation derailed with both bogies. The mainline locomotive and the foremost wagons were severely damaged. There were no injured parties.
The collision can be attributed to the fact that the foreman shunter was too late in realising that the mainline locomotive was standing on his route.

Safety deficit
The route to the designated destination was not clear. During shunting operations, the responsibility for ensuring safety lies almost exclusively with the shunting staff. If there is a difference between the expectation of a clear route to the designated destination and the actual situation (the wrong destination track, an obstacle on the route), the likelihood of a collision or derailment increases. The accumulation of comparable events shows that the current process does not have a sufficient effect.

Safety recommendation no. 91, 28/04/2016
The FOT (Federal Office of Transport) should develop solutions at the levels of technology, process and people that will reduce the risk of collisions during shunting operations with a ground signal displaying 'drive with care'.

Implementation status
Partially implemented. The FOT states that it will carry out an in-depth analysis of the issue at the levels of technology, process and people in cooperation with the railway companies involved. The FOT would develop long-term solutions and implement the outcome point by point. However, the implementation would take some time and, as such, the preliminary implementation date was defined as 31st December 2017.

Safety deficit
The tracks were covered in snow. The train driver sought to clear the snow from double slip 134 with a broom. Shortly afterwards, the train driver saw an approaching shunting operation. As soon as he became aware of the impending collision, he threw the broom away, waived his arms in the air and shouted "Stop".
Too little or nothing is known about the guidelines on the appropriate safety measures for work on the line by those that carry out such work only occasionally.

Safety recommendation no. 92, 28/04/2016
The FOT should ensure that all people who are possibly involved in work on the line are trained in this regard and, where necessary, should provide refresher courses.

Implementation status
Partially implemented. The FOT states that the responsibility for ensuring that staff have the required knowledge, skills and qualifications for their tasks and that these are refreshed or updated regularly lies with the railway companies. The FOT would formulate an appropriate piece of advice regarding risk and, as part of its safety monitoring activities, systematically check that the requirements have been implemented at the railway companies.

Side-on collision between an S-Bahn (city rail) train and a regional train in Rafz, 20/02/2015

On 20th February 2015, shortly after 06:40 in Rafz, on the track near the exit towards Schaffhausen, a regional train collided with the side of an S-Bahn train. The collision can be attributed to the fact that the S-Bahn train driver incorrectly believed that he could depart when a 'Stop' signal was displayed.

Safety deficit
During the investigation, the cause of the accident was identified to include the following factor: the kind of cooperation in the driver's cab, which gave the impression of mutual control and thereby made it impossible to recognise the error in a timely manner.
The investigation found that, among others, the following factors contributed to the accident:

- The coincidental synchronisation of the signal positions which the locomotive crew involved mistakenly believed to be applicable to their own train.
- Self-imposed time pressure.

The parties were not sufficiently aware of the influence they are mutually exposed to when working together in the driver's cab. The S-Bahn train driver started the departure process when the trainee train driver was not ready for departure. The trainee train driver acknowledged the announcements made by the train driver in order to avoid delaying departure. Not all parties were ready to depart. The STSB believes that this kind of teamwork is not unique to this accident, and in fact highlights a more widespread problem that should be addressed by training the people involved accordingly and raising their awareness.

Safety recommendation no. 97, 22/09/2016

The FOT should increasingly concern itself with issues relating to human factors and strive to flesh out a concept for training all parties involved regarding teamwork in the driver's cab that takes issues such as verbal and non-verbal communication, the impact of hierarchies, qualifications and experience into consideration.

Implementation status

Partially implemented. The FOT states that, as part of a 'human factors' support mandate, it has been in collaboration with the University of Applied Sciences and Arts Northwestern Switzerland since 2013. In view of the possibility of an official regulation, various types of basic groundwork have been carried out. The issue of 'human factors' would thereby be addressed appropriately and prioritised accordingly. As part of the collaboration with appropriate departments, the FOT will assess the need for action regarding issues such as verbal and non-verbal communication, the impact of hierarchies, qualifications and experience and, if necessary, appropriately introduce the findings to the railway companies (e.g. via development courses for examination experts). Additionally, the FOT will examine how the issue, particularly the training concepts, can be better integrated into its monitoring activity.

Safety deficit

During the investigation, the cause of the accident was identified to include the following factor: the kind of teamwork in the driver's cab, which gave the impression of mutual control and thereby made it impossible to recognise the error in a timely manner.

The vocal reporting of signals as well as other safety-relevant information makes it possible to individually and mutually check observations or actions. Safety is reduced or even prevented if the roles with regards to the announcements in the driver's cab, as they currently exist, are not clearly defined or if not all parties are aware of them.

Safety recommendation no. 98, 22/09/2016

The FOT should analyse the guidelines on signal reporting with regards to their safety relevance and implementation, with a special focus on whether the relevant actions are covered explicitly.

Implementation status

Partially implemented. The FOT states that this safety recommendation is being implemented and clarifies the procedure as follows: as a first step, the guidelines on signal reporting were evaluated. Regulation FDV R 300.13, clause 3.2.4 dictates signal reporting, whereas for the responsibilities thereof the guideline in R 300.13, clause 2.1.1 applies. Whether it is – with a view to ensuring safety – more expedient for the trainee train driver to report the signals to the assigned train driver or vice versa has to be assessed dependent on the trainee train driver's level of training and the visibility conditions in the driver's cab. Here, the guideline as per R 300.1, clause 2.1.7 applies, stipulating that the parties have to agree on the precise course of action. In addition, the railway operating companies have to design their training concept on the basis of their specific operations and are responsible for this. Following the event in Rafz, SBB P has already amended the corresponding clause in their operating regulations. Possible findings resulting from the measures formulated in safety recommendation no. 97 or from the safety monitoring activities are taken into account in the further development of official stipulations. Eliciting and analysing events such as signalling incidents is part of the SMS's risk management processes, and the FOT checks that the companies have implemented the processes as part of the FOT's monitoring activities.

Safety deficit

During the investigation, the cause of the accident was identified to include the following factor: the existing safety equipment could not prevent the accident because it contained no departure prevention for departing or turning trains.

The current change-in-use process leads to an assessment of the need for departure prevention for newly arising risk situations. However, it is to be expected that other similar situations, such as in the present case, can be found on the Swiss railway network. These cases are not recognised because the change-in-use process is not applied to past changes in use.

Safety recommendation no. 99, 22/09/2016

The FOT should endeavour to ensure that all situations, even those which already existed before the introduction of the change-in-use process, are assessed to determine whether departure prevention is required and to be supplemented.

Implementation status

Partially implemented. The FOT states that this safety recommendation is being implemented and clarifies that during the SBB's changeover to ETCS L1LS, since 2012, every situation with the respective current use was being assessed on the need for departure prevention. The criteria for which are defined in SBB regulation I-20027, version 4-0. The other infrastructure operators have, in part, individual regulations for assessing whether departure prevention is required or rely on the regulation defined by the SBB. When changing the use, the need for departure prevention is assessed once again. In addition, the change management has to be pointed out in the SMS. The FOT checks that the companies have implemented the processes as part of its monitoring activities.

Safety deficit
During the investigation, the cause of the accident was identified to include the following factor: the existing safety equipment could not prevent the accident because it contained no departure prevention for departing or turning trains.
The automatic train control system cannot be activated for departing or turning trains even if a Euroloop is present.

Safety recommendation no. 100, 22/09/2016
The FOT should ensure, that, as part of the changeover to the ETCS L1LS system, departure prevention that affects all trains is realised by appropriate means.

Implementation status
Partially implemented. The FOT states that this safety recommendation is being implemented and adds that, with regulation I-20027, version 4-0, the SBB has defined when departure prevention has to be constructed. The criteria for the choice of departure prevention variants is also defined. The following variants are possible:

1. Balise
2. Loop
3. Balise and loop combined

Variants 1 'balise' and 2 'loop' have well-known advantages and disadvantages for turning/departing or for stopping trains and those carrying on (such as a different release speeds and balise positioning for trains that are carrying on). To prevent the departure of any train without a track warrant, variant 3 'balise and loop combined' or ETCS L2 is required. With the changeover to ETCS L1LS, the conditions for a later upgrade to ETCS L2 have been created. The other infrastructure operators have, in part, individual regulations for assessing the need for departure prevention or rely on the regulation defined by the SBB. The safety recommendation is being and will be implemented with the changeover to ETCS L2. Considering the risks and the costs, the FOT is of the opinion that prior introduction of departure prevention for all trains would not be proportional.

Safety deficit
During the investigation, the cause of the accident was identified to include the following factor: the ability of the S-Bahn train to accelerate to such an extent that it could no longer be stopped by the train control system before the danger point.

After the driver's cab has been started up, the ATC indicator displays '8888' which refers to the monitoring of the train's possible top speed. This enables a departure with the greatest amount of acceleration possible, irrespective of the signal placement that is to follow. A speed can thereby be reached at which – with a full application of the emergency brakes by the train control system – it is no longer possible to stop the train before the danger point.

Safety recommendation no. 101, 22/09/2016
The FOT should effect that, after the driver's cab has been started up and until information on the infrastructure has been received, the speed is monitored to ensure it is at a level at which it still remains possible to stop the train before the danger point with a full application of the emergency brakes by the train control system.

Implementation status
Partially implemented. The FOT states that this safety recommendation is being implemented. The FOT says it is engaged in conversations with the manufacturer of the ZUB262ct train control system regarding this recommendation. An examination is being carried out as to whether the speed of the train could be limited to 40 km/h after the driver's cab has been started up and until information on the infrastructure has been received. Other ZUB train control systems are no longer being developed further. With the implementation of ETCS L1LS by the end 2017, there will continually be fewer trains running with Euro-ZUB train control systems. With the ECTS L1LS system, the speed is limited to 40 km/h in cases such as this. This safety recommendation has been substantively implemented (not from a technical point of view, but operationally by 'paper cover') by means of the operational measures in regulation I 30111, 6.3, clause 4.1 (SBB/BLS/SOB).

Safety deficit
Amongst other things, the investigation has established the following factors, which contributed to the accident: the different light intensity of the signals which facilitate a mix-up; the presence of poor light conditions, which made it more difficult to see which signals relate to which track.
For the installation of signals, operational criteria such as train headways, the usable length of track, travel times, track clearance, etc. are taken into consideration. Signals should primarily satisfy the needs of human capabilities and meeting operational requirements should be secondary. The layout of the track in Rafz, with a gentle S bend, made it more difficult to see which signal aspects applied to which track. The unusual operating position of the regional train overtaking the S-Bahn train coupled with the light conditions present created a situation for the S-Bahn train that could only be interpreted correctly with an above-average

level of attention. All of this increased the risk of being enticed into departing when a 'Stop' signal was displayed.

Safety recommendation no. 102, 22/09/2016
The FOT should audit the process used by the infrastructure operators for determining and checking signal locations for whether all signals meet the level of visibility, correlation of signal and track as well as perceptible light intensity required by the crew in all light conditions.

Implementation status
Partially implemented. The FOT states that this safety recommendation is being implemented as part of its safety monitoring activities and adds that by issuing advice regarding risk, the process for determining and checking signal locations used by the infrastructure operators as well as the signals' visibility is being incorporated into its work. This measure should clarify the infrastructure processes as well as the operational processes with regard to the location of signals and their perceptibility. The companies demonstrate how the visibility of new or changed signal locations can be assessed for new projects and how human perceptibility is adequately considered in this process. In addition, the train operators' procedures must be assessed with regards to how staff systematically report insufficient visibility of signals and how this is processed by the infrastructure operator. Visibility of the signals will be randomly inspected as part of the 'train driver's operational checks'.

Safety deficit
When writing the work schedule for locomotive staff, the SBB Passenger Service follows an internal working instruction, according to which a period of five minutes is sufficient for a single train driver to turn a type RABe 514 unit with a length of 100 m. If necessary, this time may be shorter.
The STSB found that on one occasion, under time pressure, a period of seven minutes was required to turn a train, and on one occasion without time pressure, ten minutes were required. In both cases, more than five minutes were necessary. The possibility of reducing this is therefore questionable. It also remains questionable, whether the allocated time is still sufficient when a trainee train driver carries out the task.
If the time allocated to carry out tasks is too short, the ensuing time pressure can lead to a susceptibility to error during safety-relevant tasks.

Safety advice no. 1, 22/09/2016
For work scheduling at SBB Passenger Services, the defined time allocations for essential preparatory and finishing work should be evaluated with regards to their safety-related effects and adapted accordingly.

Safety deficit
The vocal announcement of the next stop is regarded as an initial 'vocational gesture' to trigger the departure workflow. For safety reasons, an initial gesture for departure should, however, refer to checking if the relevant signal is open. The commonly used 'vocational gestures' mainly apply to matters that are not immediately safety relevant.

Safety advice no. 2, 22/09/2016
SBB Passenger Services should effect that the initial 'vocational gesture' for departure is reviewed and purged of matters that are not relevant to safety.

Derailment of a freight train in Daillens, 25/04/2015

On Saturday 25th April 2015, at 02:49, the five rearmost wagons of a freight train travelling from Basel to Lausanne-Triage derailed on the line between Éclépens and Vufflens-la-Ville in the vicinity of the municipality of Daillens (canton of Vaud). The train consisted of 22 wagons, of which 14 were laden with hazardous goods.
Several hundred metres before the position where the derailed wagon came to a halt, part of the running gear detached from one of wagon 20's bogies. When passing over a switch shortly before a right-hand bend, the wagon derailed and was pushed out of the rails. Due to the resulting momentum, two wagons in front of wagon 20 as well as the wagon behind it all overturned, and the rearmost wagon's front bogie derailed.
Wagons 18 to 21, all of which were laden with chemicals, rolled over onto their sides. While overturning, wagon 19's tank – which contained 25 tonnes of sulphuric acid – was damaged, and the contents spilled onto the ground next to the track. Due to the pushing effect of the two wagons that followed, wagon 20 rotated by approx. 180° before coming to a stop next to the track. Its tank was damaged and leaked approx. 3,000 litres of caustic soda.
The direct cause of train 60700's derailment in Daillens is the loss of wagon 20's front-left axle bearing housing (axle box).
The loss of this axle box is the result of a long process which began with maintenance work on the aforementioned axle box in August 2011. During this work, the castellated nut's retaining washer which fixes the bearings onto the axle journal, was not secured correctly. The castellated nut gradually loosened itself, which led, bit by bit, to the following damage:

An increase in transverse stress on the axle box's rolling element, the intensification of axle 1's lateral movement and the occurrence of S-shaped pitting on the rolling surface of this axle's wheels, the fatigue and subsequent breaking of the left-hand leaf spring on axle 1.
Ultimately, this damage caused the derailment of wagon 20 in Daillens.

Safety deficit
If a tank wagon overturns during a derailment, the presence of protruding components such as a measuring bar (track assurance) on the edge of the track can lead to damage to the wagon's casing and thereby lead to the spilling of its contents, something that can hold various hazards for both people and the environment. As these measuring bars (track assurances) are no longer relied on today, removing them could seriously reduce this risk.

Safety recommendation no. 93, 22/09/2016
To decrease the risk of damage caused to wagons during a derailment, the STSB recommends that the FOT has protruding measuring bars (track assurances), which are still built into the edge of the track, removed.

Implementation status
Partially implemented. In September 2016, the FOT, together with other parties including the SBB, has made a 'joint declaration' regarding the transportation of chlorine, which should also be effective for the transportation of other hazardous goods. The SBB has committed itself to the task of examining stretches of line used in the transportation of chlorine for obstacles which are not operationally or technically imperative but that increase the likelihood of a leak (breach of the tanker wall) during a derailment. These obstacles are, where reasonable, to be removed. This is to occur on stretches of line assessed for critical risks due to the transportation of chlorine by 2019 and is to occur on remaining stretches of line used in the transportation of chlorine as part of general renewal and renovation works.

Safety deficit
Currently, no regulations or consistent standards define a limit for the dynamic coefficient wheel load checkpoint (RLC). In addition, there is no existing catalogue of any possible irregularities which could form the basis for an appropriate notification.
If a 'hot box' or a 'locked brake' is reported, the cause of the irregularity can be identified very easily. In comparison, as this accident shows, damage to the interior of an axle box may result in vibrations which do not noticeably increase the temperature of the axle box. For a transport company that does not recognise the elements which can underlie such a fault, it is difficult to interpret the fault and instruct appropriate measures. However, through a quick repair on the axle box that is subject to continuous wear, the risk that the bearing is destroyed or the wagon derails when the bearing jams or disengages can be significantly reduced.

Safety recommendation no. 94, 22/09/2016
The STSB recommends that the FOT promotes the use of a system for measuring the dynamic coefficient, compiles a standardised technical basis for defined limits, and also compiles a catalogue of faults, thereby allowing transport companies to arrange appropriate inspection measures for incoming notifications.

Implementation status
Partially implemented. As the system manager, the SBB has developed the foundations for the train control mechanisms and has defined limits for optimal, practice-oriented application. The system is continuously developed further and adjusted. From the FOT's point of view, the train control mechanisms currently deployed in Switzerland are at a high level. However, together with the system manager, the FOT will pursue additional development stages in this area, and discuss the results within the 'network access safety' working group of the railway safety commission (Kommission Sicherheit Eisenbahnen – KOSEB).

Safety deficit
The leaf spring packs are fundamental components of the running gear. They are one of the pieces that guarantee contact between the wheels and the track. When a leaf spring breaks, it creates an imbalance on the relevant axle and, depending on the track layout and load conditions, can lead to a derailment.
The test station values of a leaf spring pack can easily be within the permissible limits even though one or more of the leaf springs exhibit visible notches or small cracks. It is not possible to visually identify damage like this in a pack which consists of eight individual leaf springs arranged on top of each other. During maintenance, it cannot be guaranteed that a leaf spring pack is crack- and notch-free through the inspection of the spring strength alone, even though having no cracks or notches is a prerequisite for preventing a leaf spring pack from breaking.

Safety recommendation no. 95, 22/09/2016
The STSB recommends that the FOT adapts the technical specifications for the inspection of leaf springs as part of maintenance work, so that an additional inspection, besides checking the spring strength, is stipulated that enables possible notches and fine cracks to be detected in the individual leaf springs.

Implementation status

Partially implemented. The FOT states that responsibility for the continued development of maintenance regulations lies with the Entity in Charge of Maintenance (ECM). The FOT will consequently send an information letter to the ECM, which reports a potential safety deficit and at the same time requests that they continue to develop the maintenance regulations while taking into consideration pertinent events as well as their own experiences and investigations.

Safety deficit

The wheelsets are of critical importance to the safety of the rolling stock.

The current certification system is guided by economic factors which often come at the cost of safety. As the present case shows, the certifying body did not carry out the entire audit at the yearly maintenance audits, but for the section on workshop work, instead fell back on the technical assessment that had been carried out by a body, which in its structure was governed and represented by the wagon owner. Even if this practice is in accordance with the rules, it raises the question, whether the impartiality of the certifying body is ensured.

Safety recommendation no. 96, 22/09/2016

The STSB recommends that the FOT amends the ECM regulations with regards to the certification of the bodies commissioned to carry out maintenance so that certifications and audits of the workshops responsible for maintenance (ECM system's function 'd') can no longer be delegated to third-party organisations, but instead fall under the responsibility of the national regulators.

Implementation status

Partially implemented. The FOT states that EU regulation 445/2011 (ECM regulation) describes the current state of the technology with regards to the certification of those responsible for maintenance work and that the regulation was introduced throughout Europe and within the domain of OTIF. The revision of the ECM regulation was under way and should be completed in 2018. Suggestions for the amendment of the ECM regulation are put forward in the appropriate committees and also by FOT employees.

Over the course of 2017, the FOT will examine the current extent of monitoring the certifying bodies' audits, taking the results into consideration.

Shunting accident in Landquart, 30/04/2015

On 30th April 2015 at 08:10 in Landquart, a shunting operation with tank wagons was manoeuvred from the station to the industrial and railway siding facility towards the tank terminal. An incorrectly set switch on the railway siding was overlooked, which led to a side-on collision between the foremost tank wagon and one of the goods wagons positioned at the loading bay.

Safety deficit

It is difficult to see the setting of a switch, which is embedded into tarred or concreted roads.

Safety recommendation no. 106, 04/11/2016

The FOT should take measures to make it easier to identify the setting of a switch embedded into the ground.

Implementation status

Not implemented. The FOT deems the technical and operational scope and its regulations in the official guidelines to be appropriate and therefore refrains from tightening the official guidelines pertaining to the identification of switches embedded into the ground. As part of its operational control of railway sidings, the FOT will discuss the situation and possible measures with the infrastructure operators.

Safety deficit

If rolling vehicles are moved at a speed that is greater than that at which the foreman shunter can lead on foot, time pressure is created that facilitates misinterpretations. The ongoing setting of switches in non-centralised works in front of a rolling shunting operation increases the level of time pressure for individuals with the joint task of being foreman shunter and switchman, and thus facilitates misinterpretations.

Safety recommendation no. 107, 04/11/2016

The FOT should examine the interaction between the processes for route preparation, clearance and speeds in the areas of non-centralised switches, and adapt it where necessary.

Implementation status

Partially implemented. The FOT is of the view that the regulations for the processes and maximum speeds for shunting operations in non-centralised areas or railway sidings create the foundations for consistently safe operation. As part of supervision in the operational phase, the FOT would examine the implementation of the guidelines for shunting operations in non-centralised areas. In addition, the FOT would carry out a study on the influence of human factors over the observation of regulations, the results of which would be integrated into the continued development of official guidelines for the construction and operation of railway installations. The current view concerning human factors in the area of regulations would also be inspected in this context. New findings may lead to the amendment of the regulations.

Accident involving a person in Riedholz, 23/09/2015

On the morning of 23rd September 2015, shortly after 06:00, on the line between Flumenthal and Riedholz a game keeper searching for dead game was hit by a train travelling in the direction of Solothurn and hurled into the air. The game keeper was fatally injured.

Safety deficit

The game keeper was in the track area whilst doing his job, without having received sound training about the hazards that are prevalent there and without carrying high-vis equipment. A directive, such as that which exists for the retrieval of roadkill on motorways, does not exist for railways. It can be assumed that game keepers and wardens from every canton often enter the tracks without the necessary training about proper conduct in that area.

Safety recommendation no. 104, 18/10/2016

The FOT should ensure that the cantons train game keepers and wardens about proper conduct on and around tracks and ensure the use of high-vis equipment.

Implementation status

Not implemented. The FOT discussed safety recommendation no. 104 with the Swiss accident insurance institution (SUVA). In accordance with the regulation for the prevention of accidents and occupational illnesses (VUV), article 3, and in accordance with industry solutions no. 48 and 49 of the Federal Coordination Commission for Occupational Safety (FCOS), it is the obligation of the employer to train their employees regarding accident prevention and equip them with the appropriate safety equipment. The FOT had no legal authority over the cantons and cannot ensure implementation of safety recommendation no. 104.

Derailment of a passenger train in Les Brenets, 26/07/2016

On Monday 26th July 2016, at 07:22, a train, consisting of railcar BDe 4/4 no. 5, travelling from Le Locle to Les Brenets derailed on an open stretch of the line due to a fracture on the foremost axle. The axle fractured having travelled an extremely low total distance of 31,519 km.

Safety deficit

The axles are dimensioned for an indefinite lifespan. The occurrence of a fatigue fracture indicates a fault in construction. With this axle, the drive shaft's keyway extended into the radius between the axle and the body of the wheel. The sharp edges of the keyway allowed cracks to occur in the axle very quickly because of the notch effect, which ultimately led to the axle fracture. In the short-term, there is a high potential risk of axle fractures.

Safety recommendation no. 105, 07/10/2016,

The STSB recommends that the FOT has axles with non-compliant keyways replaced.

Implementation status

Implemented. The FOT requested in a letter that the rail transport companies replace non-compliant axles, request approval with provision of a stress test should an anomalous axle be used and guarantee operational safety through monitoring procedures until non-compliant axles have been replaced.

5.4 Inland navigation

Fire in the auxiliary engine room on board the steamboat Uri, 27/12/2014

On 27th December 2014, the steamboat 'Uri' was running a tour of Lake Lucerne without a scheduled stop from Lucerne. When passing in the vicinity of Kastanienbaum, a fire was detected in the auxiliary engine room. The boat was thereafter sailed to the landing in Hergiswil, where it was evacuated and the fire was extinguished by the fire service. No one was injured.

Safety deficit

The fire is probably the result of a damaged stranded wire cable that ran too tightly to the generator's terminal board. When using a cable supply without strain relief, the cross section can become too small due to fracturing of the cable strands and thus no longer be sufficient for the power being conducted. As a result, overheating and arcing are possible causes of the fire.

Safety recommendation no. 90, 05/02/2016

The FOT should ensure that during the assembly of electrical components on craft no impermissible forces can occur at terminal connections.

Implementation status

Partially implemented. The FOT states that the installation of electrical devices on-board boats falls under the supervision of the Federal Inspectorate for Heavy Current Installations (ESTI) and not the FOT, and that the safety recommendation made therefore falls within the scope of ESTI. The FOT has, however, made ESTI aware of safety recommendation no. 90.

6 Analysis

6.1 Aviation

As in the previous years' annual reports, statistical data from past years has also been analysed for this annual report. However, the statistical methodology for this annual report has been slightly adapted. This is due to a pool of data that is now larger being available which makes it possible to look back over a longer period of time (2007 to 2016). The methodology used is described in annex 5. Definitions of the terms used can also be found in annex 5.

Analysis has been carried out for the following three aircraft categories:

- Motorised aircraft with a maximum take-off mass of up to 5,700 kg (including motor gliders and touring motor gliders in powered flight);
- Gliders (including motor gliders and touring motor gliders when gliding);
- Helicopters.

Furthermore, analysis was carried out where the accidents involving the three aircraft categories were examined jointly and were not separated into the three categories referred to above.

The reasons for potential improvements or deteriorations in safety in the various sectors of Swiss civil aviation cannot, however, be derived from this statistical data due to the small number of accidents and incidents. As air traffic movements are partially collected in different ways for the different aircraft categories, it is not necessarily possible to compare the safety of the three aircraft categories that were analysed on the basis of the data that follows. For similar reasons, any comparison with figures from other countries should be undertaken with caution. Definitions and delimitations may be different in other countries.

6.1.1 Motorised aircraft with a maximum take-off mass of up to 5,700 kg

Analysis of the accident statistics using the methods described and the definitions given in annex 5 produces the following results for the category of motorised aircraft with a maximum take-off mass of up to 5,700 kg (including motor gliders and touring motor gliders in powered flight);

- Absolute number of accidents in 2016: 1 accident.
- The decrease in the anticipated number of accidents is estimated to be 1.89% per year. However, this is not significantly different from zero.
- For the accident rate, the decrease in the probability is estimated to be 0.94% per year. This figure is also not significantly different from zero.

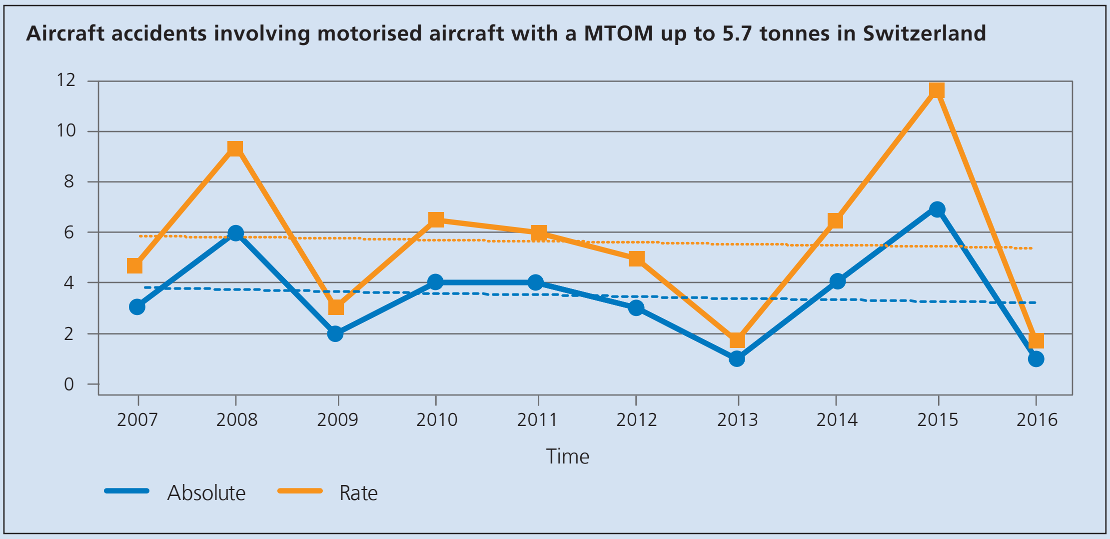
The number of accidents per year is shown as a round dot; the accident rate per year is shown as a square. To provide a better overview, the data points have been connected using corresponding lines. The line with long dashes shows the anticipated number of accidents; the line with short dashes shows the anticipated accident rate.

6.1.2 Gliders

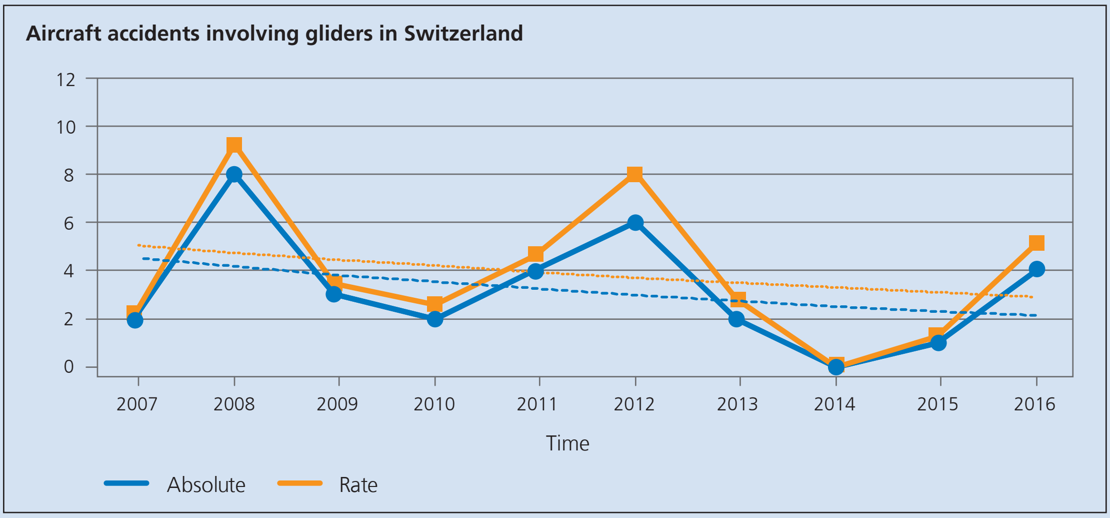
Analysis of the accident statistics using the methods described and the definitions given in annex 5 produces the following results for the glider aircraft category (including motor gliders and touring motor gliders when gliding);

- Absolute number of accidents in 2016: 4 accidents.
- The decrease in the anticipated number of accidents is estimated to be 8.09% per year. However, this is not significantly different from zero.
- For the accident rate, the decrease in the probability is estimated to be 5.98% per year. This figure is also not significantly different from zero.

Accidents per 1 million aircraft movements (accident rate)



Accidents per 1 million aircraft movements (accident rate)



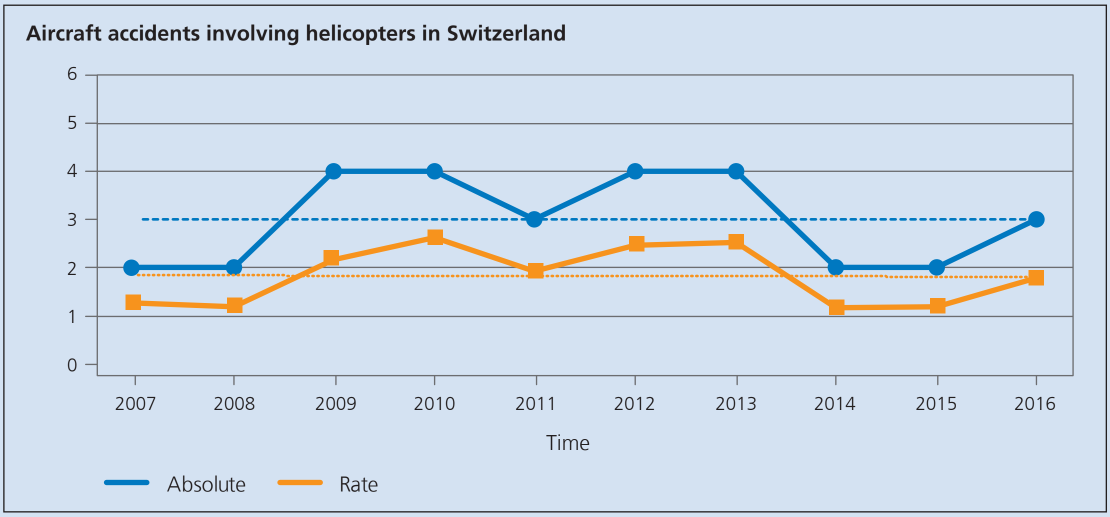
The number of accidents per year is shown as a round dot; the accident rate per year is shown as a square. To provide a better overview, the data points have been connected using corresponding lines. The line with long dashes shows the anticipated number of accidents; the line with short dashes shows the anticipated accident rate.

6.1.3 Helicopters

Following analysis of the accident statistics using the methods described and the definitions given in annex 5, the following statements can be made for the helicopter aircraft category:

– Absolute number of accidents in 2016: 3 accidents.

Accidents per 1 million aircraft movements (accident rate)



– No change to the anticipated figure can be determined (0.00%)
– For the accident rate, the decrease in the probability is estimated to be 0.19% per year. This figure is not significantly different from zero.

The number of accidents per year is shown as a round dot; the accident rate per year is shown as a square. To provide a better overview, the data points have been connected using corresponding lines. The line with long dashes shows the anticipated number of accidents; the line with short dashes shows the anticipated accident rate.

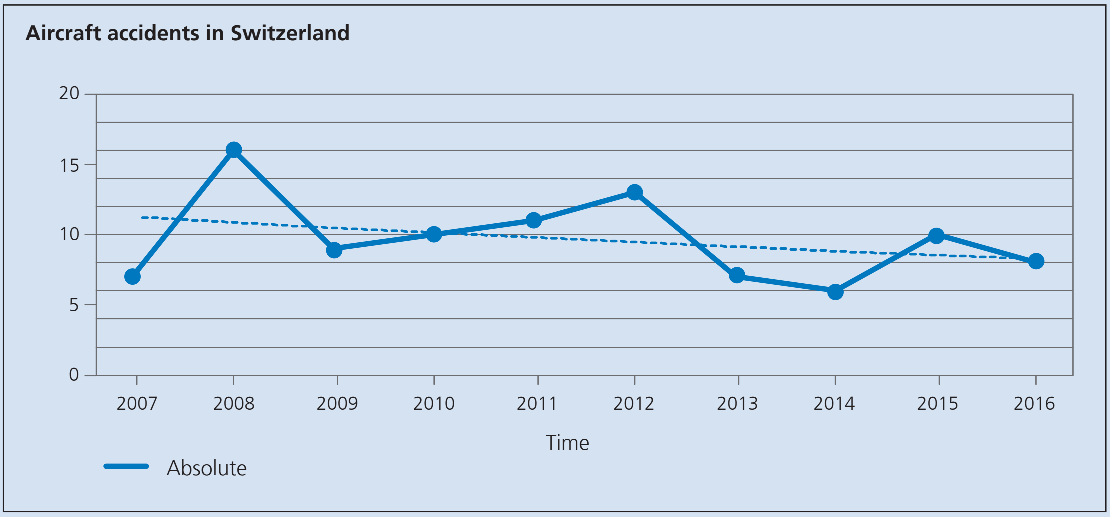
6.1.4 Total for motorised aircraft, gliders and helicopters

Following analysis of the accident statistics using the methods described and the definitions given in annex 5, the following statements can be made for the consolidated aircraft categories of motorised aircraft with a maximum take-off mass of up to 5,700 kg, gliders and helicopters:

– Absolute number of accidents in 2016: 8 accidents.
– The decrease in the anticipated number of accidents is estimated to be 3.38% per year. However, this is not significantly different from zero.
– For the accident rate, the decrease in the probability is estimated to be 2.56% per year. This figure is also not significantly different from zero.

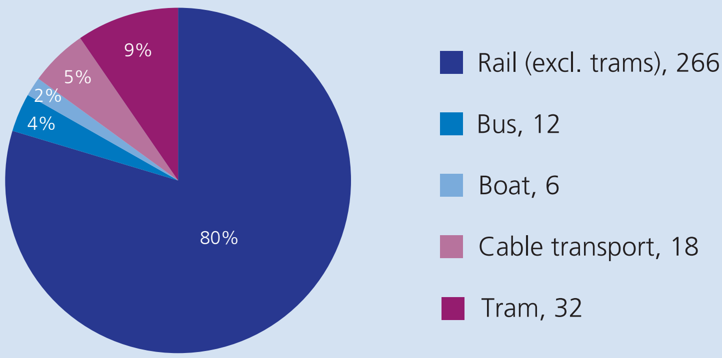
As demonstrated by the above analysis, there is great uncertainty when estimating the anticipated accident figures. This is due to the fact that, with 10 observations, the time series is still very short. For this reason, the STSB takes the view that it is not possible to establish a trend concerning the development of flight safety over the last 10 years for motorised aircraft with a maximum take-off mass of up to 5,700 kg, gliders and helicopters.

Absolute no. of accidents



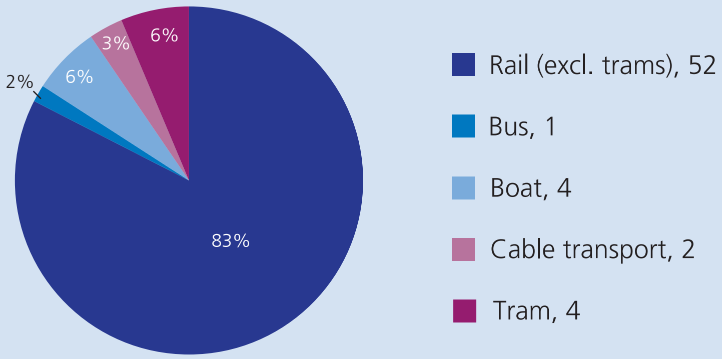
6.2 Rail, bus, boat and cable transport

Distribution of event notifications



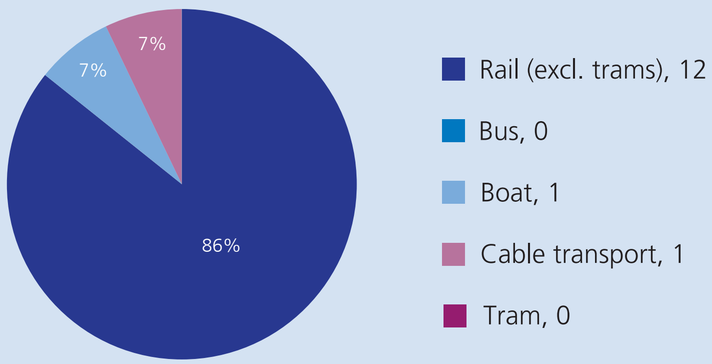
89% of the notifications relate to rail transport (incl. trams). The remaining 36 – 11% of the notifications – relate to the other modes of transport: bus, boat and cable transport.

Distribution of investigations opened



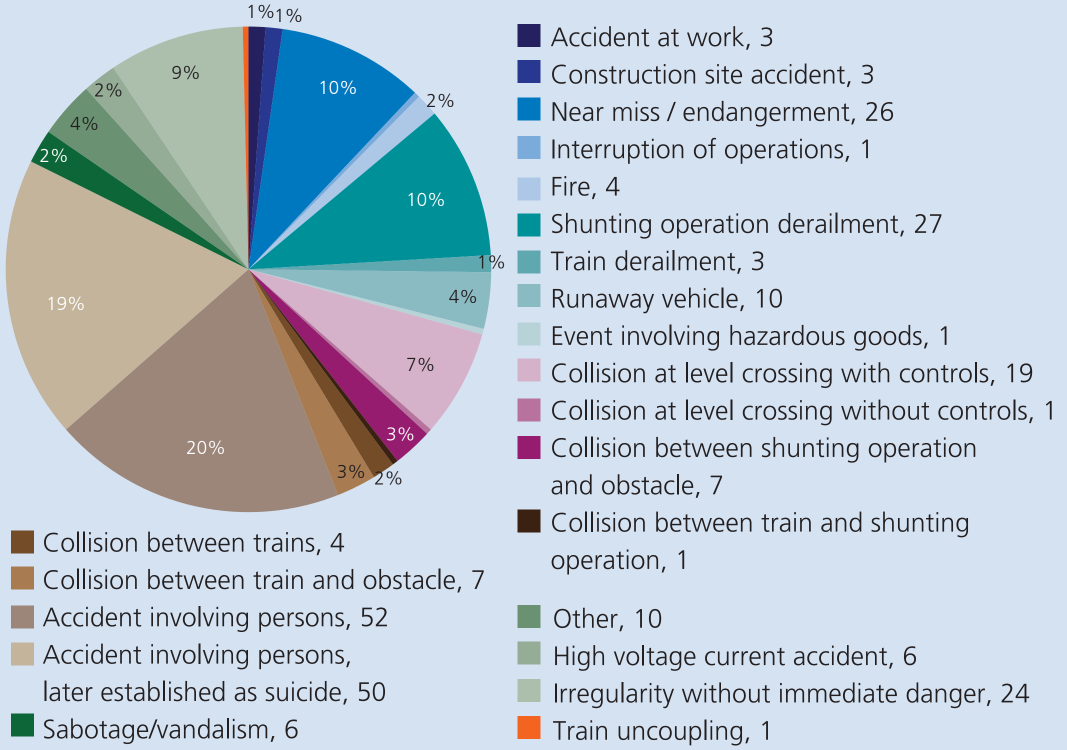
The number of investigations opened is roughly equivalent to the ratio of the number of event notifications.

Distribution of reports published



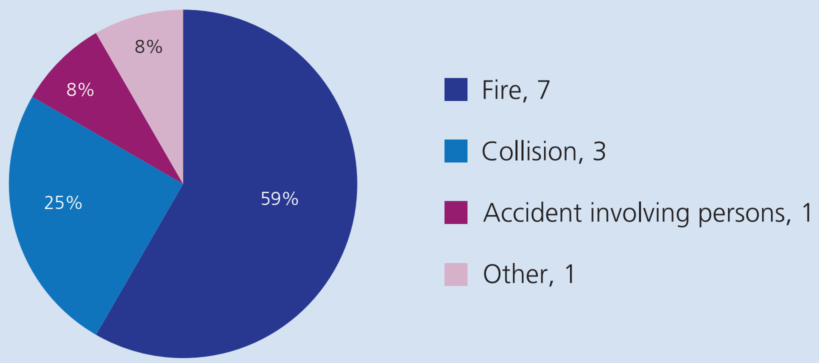
The majority of reports published (incl. summary reports) relate to the Rail Division. The distribution by mode of transport is roughly equivalent to the distribution of event notifications and investigations opened.

Distribution of event types from the event notifications for rail transport (excluding trams)



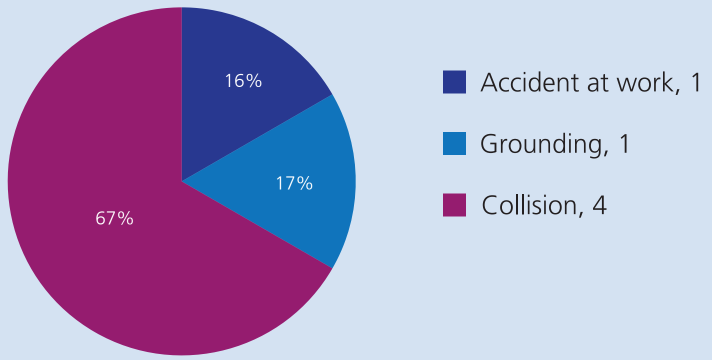
For rail transport (excluding trams), the event types concerning accidents to persons constitute a majority of the 266 event notifications. This is followed by collisions, derailments and near misses / endangerment.

Distribution of event types from the event notifications for buses



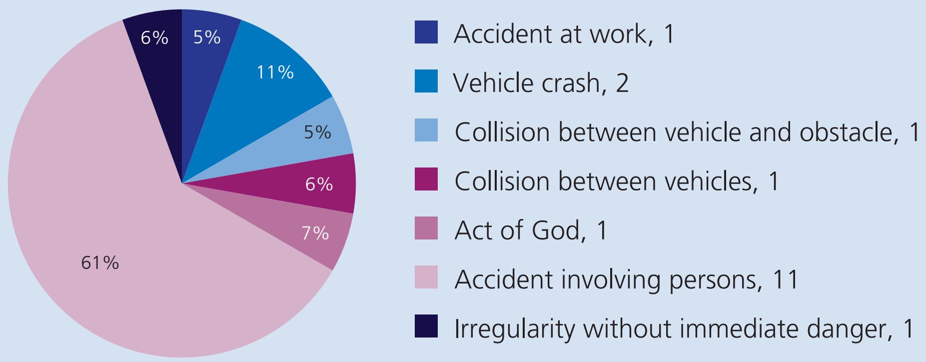
Incidents on public roads, which can be attributed to a violation of road traffic regulations, are not required to be reported to the STSB and are also not investigated. With regard to all event types, fires form the majority of events reported.

Distribution of event types from the event notifications for boats



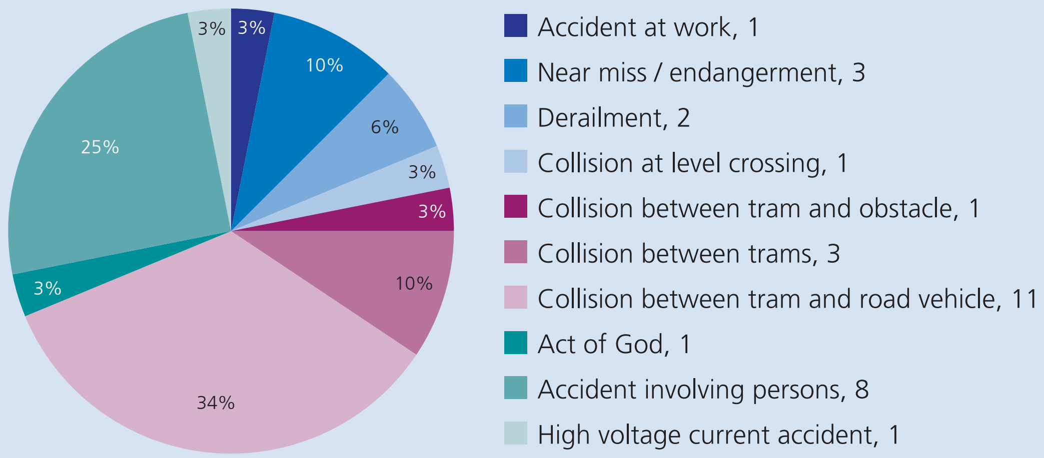
Of the 6 event notifications for boats, 4 collisions were reported. This number is classified as exceptional.

Distribution of event types from the event notifications for cable transport



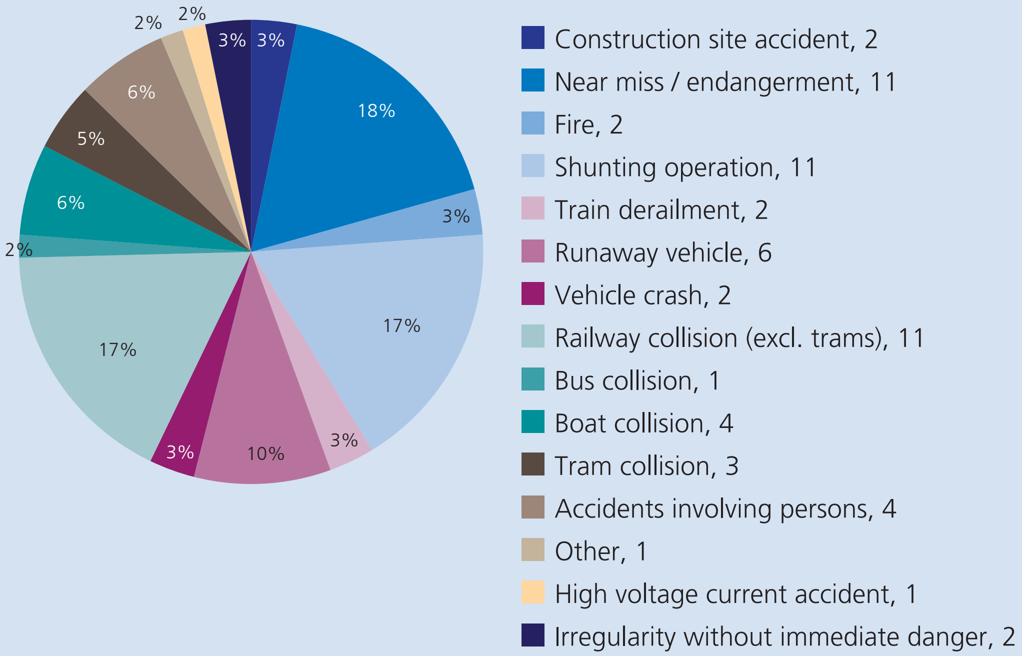
For cable transport, the majority of the event notifications relate to accidents involving persons, which occurred whilst getting into or out of a vehicle. The remaining events that were reported are mainly specific events. The two events in which a vehicle crashed are examined in detail and the causes presented in a final report.

Distribution of event type from the event notifications for trams



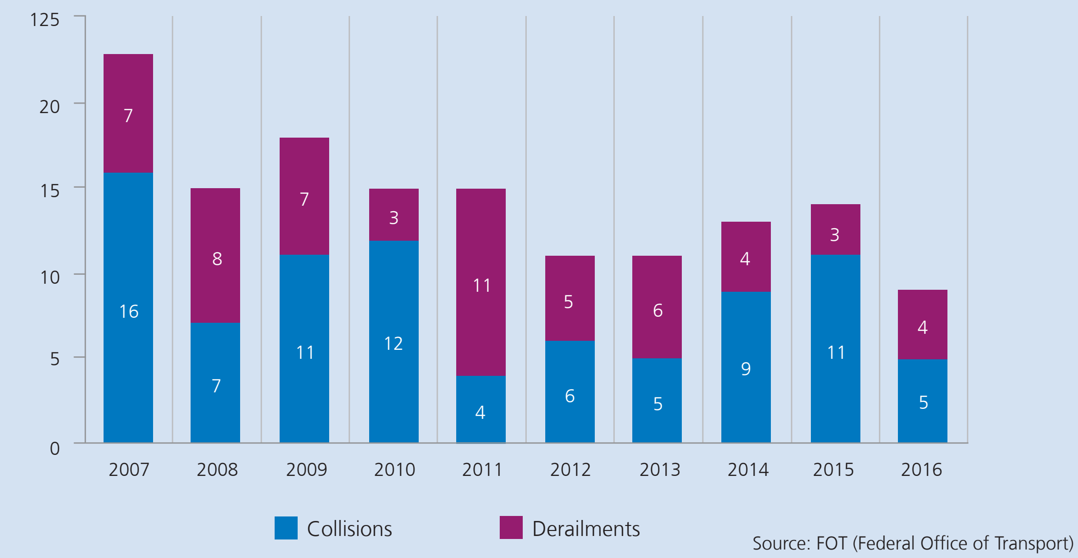
For trams, the majority of the events involve collisions with other road users, whether this was a pedestrian (accident involving persons) or a road vehicle. It should be noted here that incidents on public roads that can be attributed to a violation of road traffic regulations are not required to be reported to the STSB.

Distribution of investigations opened by event type for all modes of transport



The majority of the 63 investigations opened relate to collisions (19), derailments (13) and near misses (11).

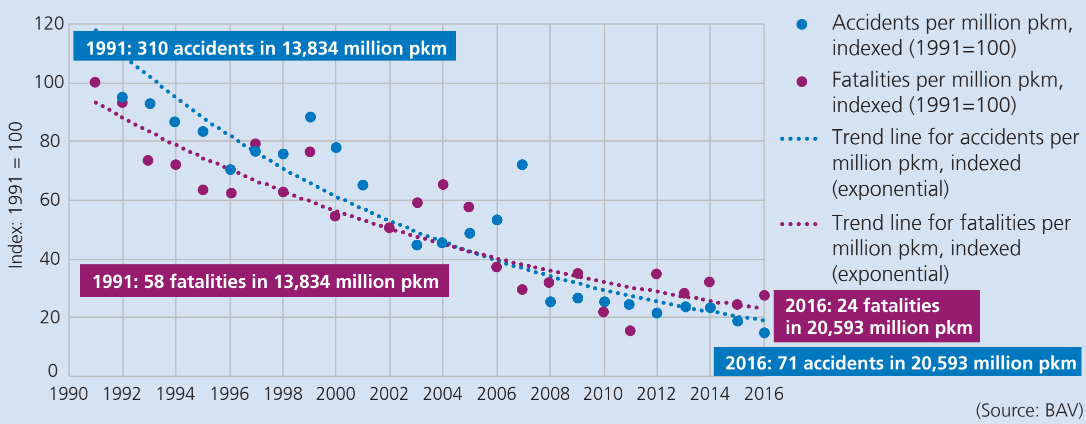
Accidents involving shunting operations



Source: FOT (Federal Office of Transport)

Generally, the number of accidents involving shunting operations has decreased over the last 10 years. Furthermore, the potential for damage in shunting accidents is relatively limited because of the low speeds involved. The potential for measures to be taken is also rather limited.

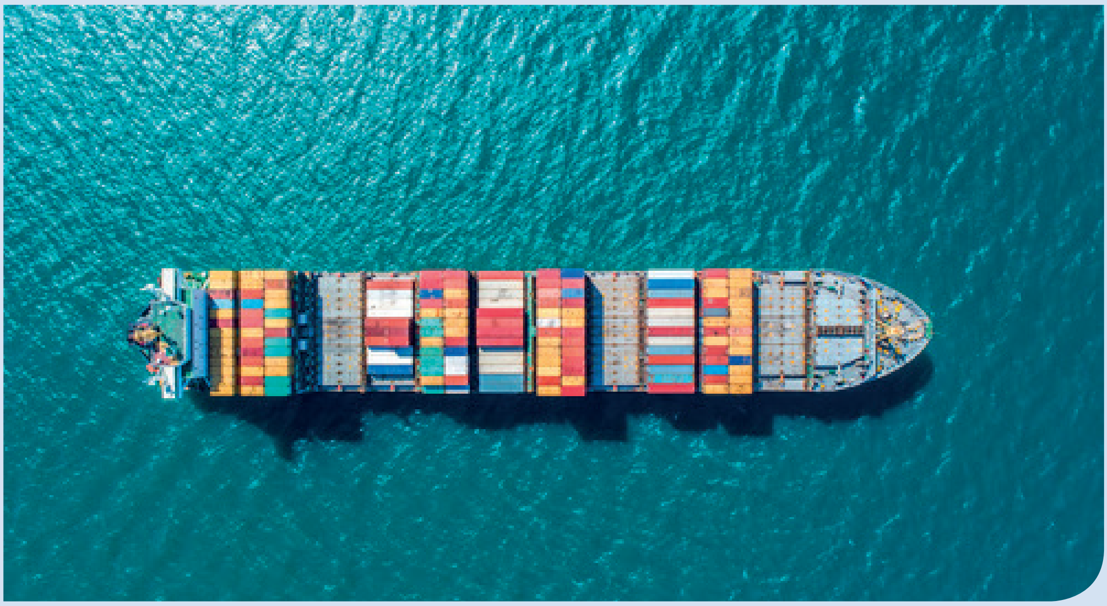
Development of accidents and persons fatally injured in railway accidents



(Source: BAV)

During the past 25 years, the number of railway accidents and persons fatally injured on the railways has decreased by around a quarter. This is the result of the efforts made by all parties in the overall safety infrastructure, including those made by the STSB.

Annex



Annex 1: List of final reports, interim reports and studies published in 2016 by the Swiss Transportation Safety Investigation Board regarding aviation
Annex 2: List of final and interim reports published in 2016 by the Swiss Transportation Safety Investigation Board regarding railway, cable transport and inland navigation
Annex 3: Statistical information on aviation incidents
Annex 4: Statistical data on incidents involving railways, cable transport, buses as well as inland and maritime navigation
Annex 5: Method and conceptual considerations for the analysis of statistical aviation data

Annex 1

List of final reports, interim reports and studies published in 2016 by the Swiss Transportation Safety Investigation Board regarding aviation

Number	Code	Date	Location	Safety recommendation	Safety advice
3	SAR Study	01/01/2016		513, 514, 515, 516, 517	13
2238	HB-DFP / HB-3373	06/06/2013	Auenstein, canton of Aargau	498, 499	
2244	D-ABKB (BER17Z) / G-TAWF (TOM857) / G-EZAU (EZY899B)	26/05/2013	10 NM north-northwest of MOLUS		
2253	HB-WYS	12/07/2013	Gland, canton of Vaud	505	
2254	HB-ZRS	06/06/2013	Zurich Airport, canton of Zurich	528	
2255	T362 / HB-SGK	19/03/2014	1.5 NM east of Bern-Belp Airport, canton of Bern		
2258	HB-XSO	29/06/2013	Approx. 900 m south of Iragna, municipality Lodrino, canton of Ticino		
2260	CS-DRC (NJE424R) / HB-PLY	20/03/2014	Zurich Airport, canton of Zurich		
2261	HB-QOW	06/08/2013	Comba d'Avau, canton of Fribourg		
2262	HB-QOT	08/03/2014	Neyruz-sur-Moudon, canton of Vaud		
2263	HB-PGU	05/06/2014	300 m southwest of Grenchen Regional Airport, canton of Solothurn		
2264	HB-IYY	24/03/2013	Near the LUSAR waypoint, 50 NM northwest of Geneva Airport, canton of Geneva		
2265	HB-ZMO	01/07/2013	Erstfeld, canton of Uri		
2266	HB-ZKF	29/08/2014	Eisten, canton of Valais		
2267	HB-ZLJ	13/07/2013	Wichtrach, canton of Bern	502, 503	
2268	HB-PIJ	26/04/2014	Locarno Airport, canton of Ticino		
2270	HB-ZNH / J-3089	12/02/2015	4 NM southeast of Meiringen Military Airport, canton of Bern		
2271	HB-ZLG / HB-ZMU	01/07/2015	7 km southwest of St Moritz, canton of Grisons		
2272	HB-CBZ	13/12/2014	Beromünster Airport, canton of Lucerne	(497)*)	4
2273	HB-PLC	30/05/2015	Grenchen Regional Airport, canton of Solothurn		
2274	HB-PMR	13/08/2015	Ecuvillens Airport, canton of Fribourg		
2275	HB-RXC	20/12/2012	Rüthi, canton of St Gallen	506, 507	
2277	HB-2483	03/08/2015	Approx. 600 m southeast of Bex Airfield		
2278	OE-LVL (AUA582W) / TC-JGV (THY1QM)	31/03/2014	Geneva Airport, canton of Geneva	508	
2286	HB-SRB	07/04/2015	Riggisberg, canton of Bern		5
2287	HB-WAL	05/07/2014	Grenchen Regional Airport, canton of Solothurn	523	6, 7
2288	HB-2088 / HB-ZRR	20/07/2015	1 NM southwest of Samedan Airport, canton of Grisons	509, 510	8, 9
2293	HB-IOC	09/03/2014	Geneva Airport, canton of Geneva		
ZB	HB-WAR	13/12/2015	Locarno Airport, canton of Ticino	511	10

*) The figures in parentheses mean that the respective safety recommendation had already been published earlier, together with the interim report concerning the case.

Annex 2

List of final and interim reports published in 2016 by the Swiss Transportation Safety Investigation Board regarding railway, cable transport and inland navigation

Number	Operation category	Type of accident	Date	Location	Safety recommendation	Safety advice
2014050901	Rail	Collision at level crossing with controls	29/02/2016	Sattel		
2014061103	Rail	Derailment shunting operation	15/12/2016	Ebikon	(72)*)	
2014072302	Rail	Injured person	19/07/2016	Visp		
2014100901	Rail	Accident at work	13/05/2016	Cornaux		
2014122701	Boat	Fire	08/02/2016	Hergiswil	90	
2014122901	Rail	Collision shunting operation involving an obstacle	29/03/2016	Solothurn	91, 92	
2015011701	Rail	Near miss / endangerment	31/03/2016	Aigle		
2015012001	Rail	Near miss / endangerment	04/10/2016	Glovelier		
2015021201	Cable transport	Collision of vehicles	08/11/2016	Torgon		
2015022001	Rail	Collision between trains	26/09/2016	Rafz	97, 98, 99, 100, 101, 102	1, 2
2015042501	Rail	Train derailment	26/09/2016	Daillens	(86)*), (87)*), 93, 94, 95, 96	
2015043001	Rail	Derailment shunting operation	03/11/2016	Landquart	106, 107	
2015092301	Rail	Injured person	21/10/2016	Riedholz	104	
2016072601_ZB	Rail	Train derailment	26/07/2016	Les Brenets	105	

*) The figures in parentheses mean that the respective safety recommendation had already been published earlier, together with the interim report concerning the case.

Annex 3

Statistical information on aviation incidents

Contents

1. Preliminary remarks

The following annual statistics contain all accidents and serious incidents investigated involving civil-registered Swiss aircraft in Switzerland and abroad, and involving foreign-registered aircraft in Switzerland.

Accidents involving parachuters, hang gliders, kites, paragliders, tethered balloons, unmanned balloons and model aircraft are not subject to investigation.

2. Definitions

Some significant terms used in air accident investigation are explained below:

Incident

An event associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time it comes to rest at the end of the flight and the primary propulsion system is shut down, 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 the aircraft's 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 has sustained 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 a single engine (including its cowlings or accessories), to propellers, wingtips, antennas, probes, vanes, tyres, brakes, wheels, fairings, panels, landing gear doors, windscreens, the aircraft skin (such as small dents or puncture holes), or minor damage to the main rotor blades, tail rotor blades, landing gear, and those resulting from hail or bird strike (including holes in the radome); or

c) the aircraft is missing or is completely inaccessible.

Serious injury

An injury which is sustained by a person in an accident and which involves one of the following:

a) Hospitalisation for more than 48 hours, commencing within seven days from the date the injury was received;
b) A fracture of any bone (except simple fractures of fingers, toes, or nose);
c) Lacerations which cause severe haemorrhage, nerve, muscle or tendon damage;
d) Injury to any internal organ;
e) Second- or third-degree burns or any burns affecting more than 5% of the body surface;
f) Verified exposure to infectious substances or harmful radiation.

Fatal injury

An injury which is sustained by a person in an accident and which results in his or her death within 30 days of the date of the accident;

Large aircraft

An aircraft which has a maximum take-off mass (MTOM) of at least 5,700 kg, is classified in airworthiness category Standard, 'transport' subcategory or has more than ten seats for passengers and crew.

Country of registration

The country where the aircraft is registered with the national aviation authority.

Country of manufacture

The country or countries that have certified the airworthiness of the prototype (type).

Country of the operator

The country in which the operator's principal place of business or permanent residence is located.

3. Tables and diagrams

3.1 Air accidents and serious incidents involving Swiss-registered aircraft

Year	Number of registered aircraft 1)	Flight hours 1)	Flight personnel licences 1)	Number of accidents investigated	Number of accidents with summary procedure	Total number of accidents	Number of serious incidents (incl. airproxes)	Airproxes investigated 2)	Total number of accidents and serious incidents	Number of fatalities
2005	3,841	768,643	15,501	22	37	59	12	9	71	15
2006	3,822	715,572	15,368	27	31	58	10	7	68	10
2007	3,813	766,557	15,076	23	20	43	4	6	47	12
2008	3,765	784,548	14,691	28	19	47	5	6	52	11
2009	3,685	842,017	14,973	26	17	43	4	3	47	5
2010	3,705	793,592	15,313	21	16	37	8	4	45	8
2011	3,709	873,548	12,855,3)	21	24	46	13	8	59	13
2012	3,657	875,708	12,840	22	20	42	23	10	65	22
2013	3,620	933,752	11,871	28	16	44	20	11	64	15
2014	3,556	919,987	11,563	18	28	46	13	5	59	8
2015	3,494	865,404	11,536	29	24	53	22	4	75	12
2016	**3,414**	**849,373**	**11,563**	**21**	**16**	**37**	**46**	**16**	**83**	**5**

1) Source: Federal Office of Civil Aviation

2) Incl. airproxes involving foreign-registered aircraft

3) Due to the revision of the law on aviation, provisional licences are no longer issued effective from 01/04/2011

3.1.1 Air accidents and serious incidents involving Swiss-registered aircraft exceeding 5,700 kg MTOM

Year	Number of registered aircraft [1]	Flight hours [1]	Number of accidents investigated	Number of accidents with summary procedure	Total number of accidents	Number of serious incidents (incl. airproxes)	Airproxes investigated[2]	Total number of accidents and serious incidents	Number of fatalities
2005	241	445,228	0	0	0	12	9	12	0
2006	248	434,050	1	0	1	8	7	9	0
2007	260	393,368	3	0	3	0	5	3	1
2008	285	385,686	1	0	1	3	5	4	0
2009	293	394,055	0	0	0	4	3	4	0
2010	303	419,323	0	0	0	6	3	6	0
2011	299	458,225	0	0	0	9	8	9	0
2012	294	475,786	0	0	0	11	7	11	0
2013	290	540,826	1	0	1	11	8	12	0
2014	284	483,673	1	0	1	7	3	8	0
2015	284	466,086	1	0	1	11	1	12	0
2016	**279**	**471,650**	**0**	**0**	**0**	**17**	**9**	**17**	**0**

[1] Source: Federal Office of Civil Aviation

[2] Incl. airproxes involving foreign-registered aircraft

3.1.2 Air accidents and serious incidents involving Swiss-registered aircraft up to 5,700 kg MTOM

Year	Number of registered aircraft[1)]	Flight hours[1)]	Number of accidents investigated	Number of accidents with summary procedure	Total number of accidents	Number of serious incidents (incl. airproxes)	Airproxes investigated[2)]	Total number of accidents and serious incidents	Number of fatalities
2005	3,600	323,415	22	37	59	0	0	59	15
2006	3,574	281,522	26	31	57	2	0	59	10
2007	3,553	373,189	20	20	40	4	1	44	11
2008	3,480	398,862	27	19	46	2	1	48	11
2009	3,392	447,962	26	17	43	0	0	43	5
2010	3,402	374,269	21	16	37	2	1	39	8
2011	3,410	415,323	22	24	46	3	0	49	13
2012	3,363	399,922	22	20	42	12	3	54	22
2013	3,330	392,926	27	16	43	9	3	52	15
2014	3,272	436,314	17	28	45	6	2	51	8
2015	3,210	399,318	28	24	52	11	3	63	12
2016	**3,145**	**377,723**	**21**	**16**	**37**	**29**	**7**	**66**	**5**

[1)] Source: Federal Office of Civil Aviation

[2)] Incl. airproxes involving foreign-registered aircraft

3.1.3 Diagram showing air accidents and serious incidents involving Swiss-registered aircraft

3.2 Summary of accident data for the reporting period 2015/2016

3.2.1 Accidents and serious incidents with and without injured persons involving Swiss-registered aircraft in Switzerland and abroad, and foreign-registered aircraft in Switzerland

	Accidents and serious incidents involving Swiss-registered aircraft						Accidents and serious incidents involving Swiss-registered aircraft						Accidents and serious incidents involving foreign-registered aircraft					
	domestic						abroad						in Switzerland					
	Total		of which with injured persons		of which without injured persons		Total		of which with injured persons		of which without injured persons		Total		of which with injured persons		of which without injured persons	
	2016	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015
Total	**64**	64	**7**	8	**57**	56	**19**	11	**4**	3	**15**	8	**23**	11	**1**	2	**22**	8
Aircraft with MTOM of up to 2,250 kg	**22**	37	**1**	5	**21**	32	**9**	4	**3**	1	**6**	3	**3**	6	**0**	2	**3**	3
Aircraft with MTOM of 2,250–5,700 kg	**3**	0	**0**	0	**3**	0	**0**	0	**0**	0	**0**	0	**2**	0	**0**	0	**2**	0
Aircraft with MTOM exceeding 5,700 kg	**9**	7	**0**	0	**9**	7	**8**	5	**0**	0	**8**	5	**15**	5	**0**	0	**15**	5
Helicopters	**17**	12	**3**	2	**14**	10	**1**	0	**1**	0	**0**	0	**0**	0	**0**	0	**0**	0
Motor gliders and gliders	**11**	7	**3**	1	**8**	6	**1**	2	**0**	2	**1**	0	**2**	0	**1**	0	**1**	0
Balloons and airships	**0**	1	**0**	0	**0**	1	**0**	0	**0**	0	**0**	0	**1**	0	**0**	0	**1**	0
Ultralight aircraft	**2**	–	**0**	–	**2**	–	**0**	–	**0**	–	**0**	–	**0**	–	**0**	–	**0**	–

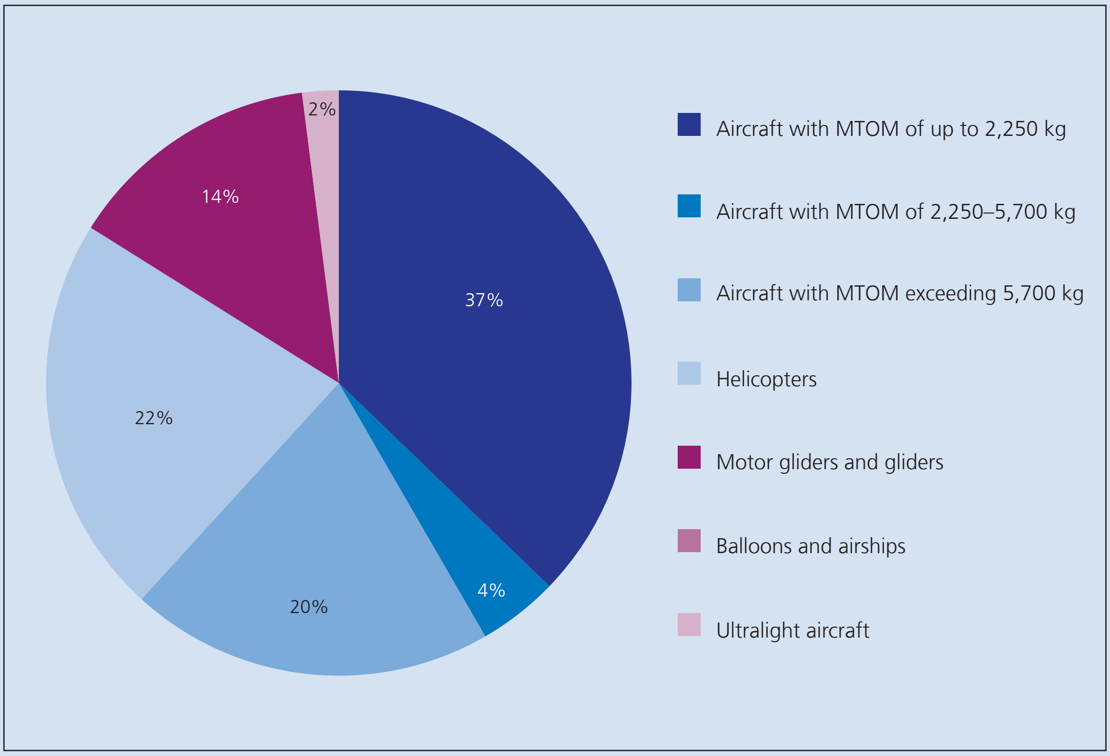
3.2.2 Accidents and serious incidents involving Swiss-registered aircraft

	Number of registered aircraft [1] (01/01/2017)		Total number of accidents / serious incidents	
	2016	2015	**2016**	2015
Aircraft with MTOM of up to 2,250 kg	**1,382**	1,397	**24**	41
Aircraft with MTOM of 2,250–5,700 kg	**162**	169	**3**	0
Aircraft with MTOM exceeding 5,700 kg	**279**	284	**11**	12
Helicopters	**337**	326	**17**	12
Motor gliders and gliders	**907**	949	**11**	9
Balloons and airships	**347**	**369**	**0**	**1**
Ultralight aircraft [2]	**–**	–	**2**	–
Total	**3,414**	3,494	**68**	59

[1] Source: Federal Office of Civil Aviation
[2] The number of ultralight aircraft is not collated separately; in 2015, accidents and serious incidents involving ultralight aircraft have not been collated separately.

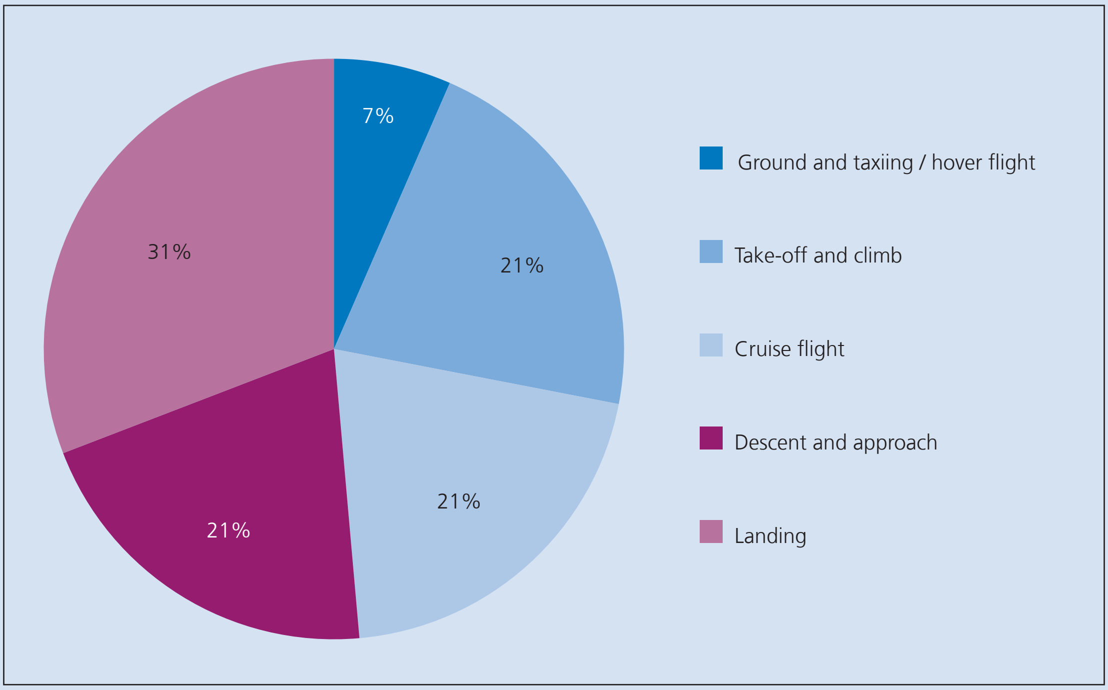
3.2.3 Accidents and serious incidents by aircraft type involving Swiss-registered aircraft

	2016	2015
Aircraft with MTOM of up to 2,250 kg	**37%**	55%
Aircraft with MTOM of 2,250–5,700 kg	**4%**	0%
Aircraft with MTOM exceeding 5,700 kg	**20%**	16%
Helicopters	**22%**	16%
Motor gliders and gliders	**14%**	12%
Balloons and airships	**–**	1%
Ultralight aircraft	**2%**	–



3.2.4 Flight phase (accidents and serious incidents involving Swiss-registered aircraft in Switzerland and abroad, and foreign-registered aircraft in Switzerland)

	Ground and taxiing / hover flight		Take-off and climb		Cruise flight		Descent and approach		Landing		Total	
	2016	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015
Aircraft with MTOM of up to 2,250 kg	**3**	6	**6**	8	**5**	8	**5**	1	**15**	18	**34**	41
Aircraft with MTOM of 2,250–5,700 kg	**0**	0	**2**	0	**0**	0	**1**	0	**2**	0	**5**	0
Aircraft with MTOM exceeding 5,700 kg	**3**	2	**9**	1	**10**	7	**10**	1	**1**	1	**33**	12
Helicopters	**1**	0	**2**	3	**3**	2	**4**	2	**8**	5	**18**	12
Motor gliders and gliders	**0**	0	**4**	3	**3**	4	**1**	0	**6**	2	**14**	9
Balloons and airships	**0**	0	**0**	0	**1**	0	**0**	0	**0**	1	**1**	1
Ultralight aircraft	**0**	–	**0**	–	**0**	–	**1**	–	**1**	–	**2**	–
Total	**7**	8	**23**	15	**22**	21	**22**	4	**33**	27	**107**	75



3.2.5 Persons injured in accidents

	Accidents and serious incidents involving Swiss-registered aircraft in Switzerland															
	Total		Aircraft with MTOM of up to 2,250 kg		Aircraft with MTOM of 2,250–5,700 kg		Aircraft with MTOM exceeding 5,700 kg		Helicop-ters		Motor gliders and gliders		Balloons and airships		Ultra-light aircraft	
	2016	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015
Accidents / serious incidents	**64**	64	**22**	37	**3**	0	**9**	7	**17**	12	**11**	7	**0**	1	**2**	–
Fatalities	**3**	7	**1**	5	**0**	0	**0**	0	**0**	1	**2**	1	**0**	0	**0**	–
Crew	**2**	6	**0**	4	**0**	0	**0**	0	**0**	1	**2**	1	**0**	0	**0**	–
Passengers	**1**	1	**1**	1	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	–
Third parties	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	–
Persons seriously injured	**6**	7	**2**	4	**0**	0	**0**	0	**3**	3	**1**	0	**0**	0	**0**	–
Crew	**3**	4	**1**	2	**0**	0	**0**	0	**1**	2	**1**	0	**0**	0	**0**	–
Passengers	**1**	3	**1**	2	**0**	0	**0**	0	**0**	1	**0**	0	**0**	0	**0**	–
Third parties	**2**	0	**0**	0	**0**	0	**0**	0	**2**	0	**0**	0	**0**	0	**0**	–

	Accidents and serious incidents involving Swiss-registered aircraft abroad															
	Total		Aircraft with MTOM of up to 2,250 kg		Aircraft with MTOM of 2,250–5,700 kg		Aircraft with MTOM exceeding 5,700 kg		Helicop-ters		Motor gliders and gliders		Balloons and airships		Ultra-light aircraft	
	2016	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015
Accidents / serious incidents	**19**	11	**9**	4	**0**	0	**8**	5	**1**	0	**1**	2	**0**	0	**0**	-
Fatalities	**2**	5	**2**	2	**0**	0	**0**	0	**0**	0	**0**	3	**0**	0	**0**	-
Crew	**2**	4	**2**	1	**0**	0	**0**	0	**0**	0	**0**	3	**0**	0	**0**	-
Passengers	**0**	1	**0**	1	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	-
Third parties	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	-
Persons seriously injured	**3**	0	**1**	0	**0**	0	**0**	0	**2**	0	**0**	0	**0**	0	**0**	-
Crew	**1**	0	**1**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	-
Passengers	**2**	0	**0**	0	**0**	0	**0**	0	**2**	0	**0**	0	**0**	0	**0**	-
Third parties	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	-

	Accidents and serious incidents involving foreign-registered aircraft in Switzerland															
	Total		Aircraft with MTOM of up to 2,250 kg		Aircraft with MTOM of 2,250–5,700 kg		Aircraft with MTOM exceeding 5,700 kg		Helicop-ters		Motor gliders and gliders		Balloons and airships		Ultra-light aircraft	
	2016	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015	**2016**	2015
Accidents / serious incidents	**23**	11	**3**	6	**2**	0	**15**	5	**0**	0	**2**	0	**1**	0	**0**	0
Fatalities	**2**	1	**0**	1	**0**	0	**0**	0	**0**	0	**2**	0	**0**	0	**0**	0
Crew	**2**	1	**0**	1	**0**	0	**0**	0	**0**	0	**2**	0	**0**	0	**0**	0
Passengers	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
Third parties	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
Persons seriously injured	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
Crew	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
Passengers	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
Third parties	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0

Annex 4

Statistical data on incidents involving railways, cable transport, buses as well as inland and maritime navigation

Contents

1. Definitions

Fatal injury
An injury to a person which results in his or her death within 30 days of the date of an event

Serious injury
An injury to a person which requires hospitalisation for more than 24 hours

Minor injury
An injury to a person which requires out-patient medical treatment

Considerable material damage
Material damage which is a direct result of an event and exceeds the value of 180,000 CHF

Accident
An event which results in a fatal or serious injury of a person, considerable material damage or which results in an accident as defined in the Major Accidents Ordinance (MAO) of 27 February 1991

Serious incident
An incident which would nearly have resulted in an accident and the occurrence of the incident would not have been prevented by any possible automatic safety precautions designated to do so

Major disruption
A malfunction which interrupts the operation of a line for at least six hours

Event involving hazardous goods
An event which endangers people or the environment when loading, transporting, shunting or unloading hazardous goods during transport-related handling

2. Tables

2.1 Injuries to persons and accidents at work reported

	2013			2014			2015			2016		
Number of notifications	379			382			296			334		
Investigations opened	37			27			87			59		
Total no. of injuries to persons, rail (excl. cable transport)	**51**			**60**			**56**			**60**		
Accident victims	**†**	**S**	**L**	**†**	**S**	**L**	**†**	**S**	**L**	**†**	**S**	**L**
in trains/trams	–	–	–	–	1	2	–	–	22	–	1	1
when boarding/leaving	–	–	6	1	8	2	–	3	2	–	3	5
at stations	9	9	4	11	11	14	11	11	3	17	7	3
outside of stations	13	10	5	4	7	4	10	8	8	9	7	3
other	–	–	–	1	3	1	–	–	–	–	–	–
Suicides or attempted suicides* reported to the STSB	**81***			**60***			**47***			**50***		
Accidents at work	**16**			**15**			**15**			**9**		

Key:

† = Fatalities

S = Severe casualties

L = Minor injuries

*) Suicides included in our statistics were initially reported to the STSB as accidents involving persons.

2.2 Reported collisions and derailments

	2013			2014			2015			2016		
Total no. of collisions	**81**			**73**			**47**			**55**		
train-train / tram-tram	6 / 7			7 / 5			2 / 4			5 / 3		
involving working equipment (excavator, crane, …)	4			8			2			1		
involving buffers	2			7			2			1		
involving parked wagons	7			3			12			6		
involving road vehicles	14			13			12			15		
involving miscellaneous	7			6			–			4		
Total no. of collisions at level crossings	**34**			**26**			**12**			**20**		
Injured persons	**†**	**S**	**L**	**†**	**S**	**L**	**†**	**S**	**L**	**†**	**S**	**L**
at level crossings with controls	4	9	6	–	9	4	1	4	2	0	7	17
at level crossings without controls	2	3	15	3	7	6	–	–	–	–	–	–
Total no. of derailments	**31**			**37**			**40**			**32**		
passenger train journeys	3			6			7			2		
freight train journeys	1			2			6			1		
shunting operation	19			21			22			23		
track maintenance trains	6			5			–			4		
tram trains	2			3			5			2		

Key:

† = Fatalities

S = Severe casualties

L = Minor injuries

2.3 Near misses, shunting accidents and fires reported

	2013	2014	2015	2016
Near misses / endangerment	**47**	**53**	**30**	**29**
Shunting accidents*)	**11**	**13**	**11**	**8**
Total no. of fires	**17**	**9**	**12**	**11**
rail carriages	12	4	3	4
scheduled buses	5	4	9	7
cable transport	–	–	–	–
boats	–	1	–	–
Other	**38**	**57**	**28**	**25**
sabotage/vandalism	6	7	6	6
accidents involving hazardous goods	5	3	2	1
high-voltage accidents	9	14	7	7
miscellaneous	18	33	13	11

*) without derailments

2.4 Incidents involving inland navigation and cable transport

	2013			2014			2015			2016		
Total no. of boats	**3**			**2**			**3**			**6**		
Total no. of cable transport accidents involving people	**4**			**2**			**5**			**11**		
Persons injured	**†**	**S**	**L**	**†**	**S**	**L**	**†**	**S**	**L**	**†**	**S**	**L**
cable cars	–	–	–	–	–	–	–	1	–	–	–	2
chairlifts	1	–	2	–	–	2	–	–	4	1	5	3
drag lifts	–	–	–	–	–	–	–	–	–	–	–	–
Other cable transport incidents (excl. accidents at work)	**1**			**2**			**1**			**6**		
cabin/chair crash	–			–			–			2		
cable derailments	–			1			1			–		
cable failures	–			–			–			–		
miscellaneous	1			1			–			4		

2.5 Maritime navigation results

	2016
Notifications	**8**
Accidents	**3**

Key:

† = Fatalities

S = Severe casualties

L = Minor injuries

Annex 5

Method and conceptual considerations for the analysis of statistical aviation data

Measures and their component parts

Absolute and relative numbers of accidents
Alongside the absolute numbers of accidents, the relative numbers of accidents – accident rates – have been collected and compared in the accident statistics. This means that whenever the data has allowed it, not only has the number of accidents that occurred been looked at, but also to the number of accidents that took place per 1 million air traffic movements. The absolute numbers of accidents, as well as the relative numbers of accidents (i.e. accident rates) each refer to a particular year and a particular aircraft category or to the total of the three defined aircraft categories.

The advantage of accident rates is that they allow comparisons over a longer time period to be made more easily, even if the exposure[1] changes over this time period. As exposure generally fluctuates to a lesser extent than the number of accidents, the advantage of a rate as a measure has a lesser effect for a period of just a few years.

For accident rates, it is important only to include accidents in the rate, whose corresponding exposure is also included. For example, the take-off and landing of a flight from Friedrichshafen (GER), via Switzerland to Grenoble (FRA), is not included in FOCA's air traffic movement statistics. If this aircraft were to have an accident in Switzerland, this accident must also not be included in this analysis. This is because FOCA's air traffic movement statistics are included as a component part of the measure of accident statistics. Account is taken of this situation in the present accident statistics. A similar situation arises for flights from Switzerland to countries abroad or from abroad to Switzerland: accidents that take place during flights from Switzerland to countries abroad or from abroad to Switzerland can potentially occur in foreign territory. In such cases, the STSB is not always notified of the accident. As a result, the STSB is not aware of certain accidents for flights of this type and therefore they cannot be counted by the STSB; in order to be consistent, the corresponding exposure must not be included in the measure. The present accident statistics take account of this situation, too.

Accident
For an aviation event to be classified as an accident for the purpose of the present statistics, the STSB must be aware of the event. As soon the STSB is aware of the event, the event is reviewed to see if it meets the criteria for an accident, according to article 2 of (EU) regulation no. 996/2010[2]. In the present analysis, once again only those events classified as an accident are included, where at least one person is seriously or fatally injured and where the event was not caused deliberately. The definitions of serious and fatal injuries can also be found in article 2 of (EU) regulation no. 996/2010.

The reason for only including serious or fatal injuries in the accident statistics is due to the fact that the number of unreported accidents without serious or fatally injured persons is assessed as not insignificant. If all accidents – or perhaps even the serious incidents – were to be included in the statistics, the figures being looked at would be higher and it would be easier to make statistical statements, however,

[1] Here, exposure is equivalent to the number of air traffic movements

[2] (EU) regulation no. 996/2010 of the European Parliament and of the Council of 20th October 2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing directive 94/56/EC.

the statements would more likely describe the reporting system and reporting culture, rather than safety.

Air traffic movement
The air traffic movements are used for quantification of the exposure for the accident statistics. Figures for air traffic movements are provided by FOCA. FOCA collects these figures using forms that have been completed and submitted by the majority of aerodromes and heliports since 2007. Take-offs and landings are normally considered to be air traffic movements, meaning that a flight from A to B results in two air traffic movements. However, the term is not precisely defined by FOCA. The following types of air traffic movements are not recorded in FOCA's data collection:

– Movements on certain military airfields;
– Movements on open terrain, for example, off-airport landings of gliders or landings and take-offs of helicopters on open terrain during work flights;
– Take-offs and landings abroad, even when the flight passes over Swiss territory.

Movements at Basel/Mulhouse/Freiburg Airport are recorded by FOCA, but are not included in the STSB's analysis. This airport is not on Swiss territory. As a consequence of this, accidents that occur at this airport, or in the French area surrounding this airport, are neither reported to the STSB, nor investigated by the STSB.

Aircraft category
Analysis has been carried out for the following three aircraft categories:

– Motorised aircraft with a maximum take-off mass of up to 5,700 kg (including motor gliders and touring motor gliders in powered flight);
– Gliders (including motor gliders and touring motor gliders when gliding);
– Helicopters.

Furthermore, analysis has been carried out where the accidents involving the three aircraft categories were examined jointly and were not separated into the three categories ('total').

For motorised aircraft with a maximum take-off mass exceeding 5,700 kg (in particular for commercial aircraft) as well as for airships and balloons, no statistics are produced due to sample sizes being too small.

Statistical methods
The number of accidents U_t in the year $t = 2007,\dots,2016$ is a discrete random parameter range. In this case, the standard model is given by the Poisson distribution function.

$$U_t \sim Poisson(\lambda_t).$$

Here, parameter λ_t is the anticipated number of accidents in the year t, i.e. $E[U_t] = \lambda_t$. The number of accidents over time is modelled with a Poisson regression, i.e.

$$\log(\lambda_t) = \beta_0 + \beta_1 \cdot t.$$

The temporal development of the anticipated number of accidents can be read from the β_1 parameter. In practice, the number of accidents changes from one year to the next by coefficient $\exp(\beta_1)$. If β_1 is negative, the anticipated number of accidents decreases over time, otherwise, it increases. β_0, β_1 coefficients are estimated using the maximum likelihood method within the generalised linear model framework. It is therefore also possible to state if parameter β_1 is significantly different from zero, i.e. whether a significant change in flight safety has occurred. It is also possible to state a 95% confidence interval for the anticipated number of accidents, which reflects the uncertainty in the estimation. In order to determine whether an exceptionally high or an exceptionally low number of accidents have occurred in a year, the Pearson residuals r_t can be determined:

$$r_t = \frac{u_t - \hat{\lambda}_t}{\sqrt{\hat{\lambda}}}$$

The r_t values indicate (approximated) how many standard deviations away from the anticipated figure a number of accidents is. In statistics, $|r_t| > 2$ is usually described as significant. The binomial model is used to estimate the accident rate, on the following assumption

$$U_t \sim Bin(n_t, p_t).$$

In this case, U_t remains the accident rate in year t. In addition, n_t is the population size, that is the number of flight movements in year t. Parameter p_t is the accident rate at the t, point in time, or the likelihood that an accident will result from an air traffic movement. The accident rate over time is modelled using binomial regression.

$$\log\left(\frac{p_t}{1-p_t}\right) = \beta_0 + \beta_1 \cdot t$$

Once more, the estimation is made using the maximum likelihood method within the generalised linear model framework. From parameter β_1 the development of the accident rate over time can be deduced. In practice, probability $p_t/(1-p_t)$ is multiplied from one year to the next by coefficient $\exp(\beta_1)$. Once again it is possible to make statements concerning the significance of this change, as well as to state a 95% confidence level for the accident rate. It should be noted that to aid readability, the representation of the accident rate has, in each case, been extrapolated to 1 million air traffic movements. In order to assess whether the accident rate in a year is exceptionally high or low, the Pearson residuals r_t can again be used. In the binomial model, they are defined as follows:

$$r_t = \frac{u_t - n_t \hat{p}_t}{\sqrt{n_t \hat{p}_t (1-\hat{p}_t)}}$$

The same statements apply as for the Poisson model for the accident rate: the r_t values indicate (approximated) how many standard deviations away from the anticipated figure the accident rate is in a year. In statistics, $|r_t| > 2$ is usually described as significant.

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