Swiss Transportation Safety Investigation Board STSB
Annual Report 2019

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Swiss Transportation Safety Investigation Board STSB

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1 Editorial

The work of the STSB in 2019 was marked by numerous accident investigations which attracted a great deal of interest amongst the public and specialists alike. In aviation, the central focus was the investigation into the causes of the "Tante Ju" ("Aunt Ju") crash of 4 August 2018. Safety deficits had been identified in an interim report at the end of 2018 and immediate measures recommended, leading in the reporting year to far-reaching measures by the supervisory authority.

On the railways, extensive investigations were pending into the derailments of passenger trains at Lucerne (22 March 2017), Basel (29 November 2017) and Basel Badischer Bahnhof (17 February 2019). These investigations were completed with safety recommendations in their final reports. The investigation into the accident in which a train manager became trapped in the door of a passenger coach and was fatally injured rapidly resulted in recommendations for immediate measures. In all these cases, the supervisory authority and railway companies took quick action to remedy the safety deficits by means of with measures they regarded as appropriate.

The general public expects a high standard of safety in public transport and aviation. We achieve this when each party involved takes its responsibilities in its particular role as seriously as possible. The interaction between roles, in other words the cooperation, interfaces and communication between these parties, must function as optimally as possible. A "safety network" of this form, consisting of all the parties involved, offers the best prospects for preventing similar accidents and their associated human suffering in future.

When an accident happens, there is no time for a discussion of principles. We will therefore never tire of explaining the role of the STSB in this safety network. The sole purpose of the STSB as an independent organisation is prevention. Questions of blame and liability are left to the courts and fall outside the remit of STSB investigations. Our results provide lessons to be learned from the events by the parties involved so that they can take the necessary measures. It is then the responsibility of the supervisory authorities or transport companies to implement the recommendations, and of their supervisory organisations – not the STSB – to monitor whether these roles are being fulfilled. The STSB itself does not have any supervisory function, but as an independent body in the safety network it can provide the necessary scientific basis for operational, technical, organisational and human safety issues.

Pieter Zeilstra
President of the extra-parliamentary board

2 Management Summary

A total of 1849 incidents were reported to the STSB in 2019. The figure of 1566 for aviation was another peak. Although the increase was only ten reports up on 2018, this is still 24 % more than the average for the period from 2015 to 2017, and 40 % more than in 2014. For public transport, 280 incidents were reported, which represents the lowest figure for the past five years. Three of the reported incidents related to maritime navigation. Analysis of these reports led to 79 investigations being opened, 64 for aviation and 15 for public transport.

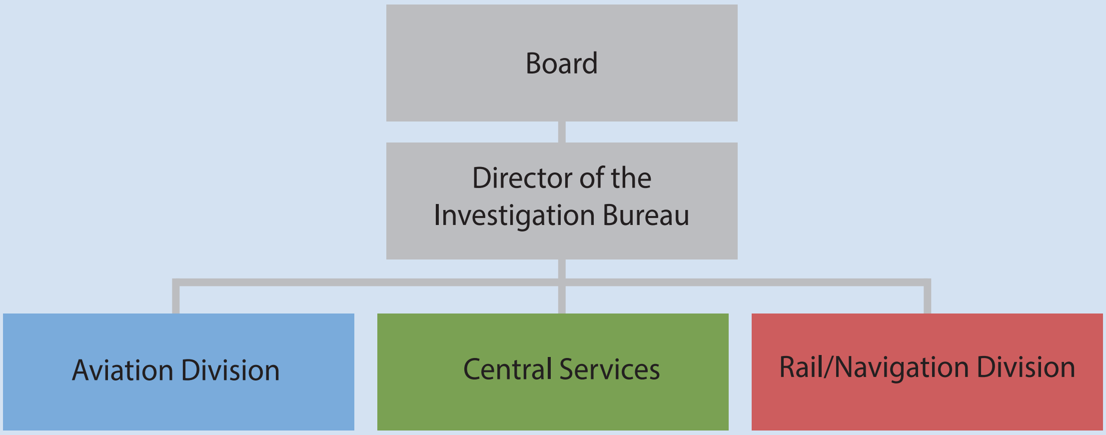
The Investigation Bureau completed a total of 94 investigations into accidents and serious incidents, including 72 incidents where the preventive potential justified a summary investigation. In the course of its investigations, the STSB issued a total of 20 safety recommendations and 10 items of safety advice during 2019.

In relation to aviation the main thrust was the continuance of the investigation into the accident involving a Junkers 52 that occurred in August 2018. As well as a smaller number of accidents and serious incidents compared to previous years in aviation generally, a number of engine explosions occurred in the new Airbus A220 aircraft registered in Switzerland. These incidents took place outside Switzerland and were therefore investigated by other safety investigation boards. The aviation division provided intensive support to these investigations in order to contribute to a lasting solution for the problem as rapidly as possible. In 2019 the first two accidents involving commercial drones were investigated, and in both cases major safety deficits of these aircraft were addressed by appropriate safety recommendations. The first accident involving an electrically-powered aircraft in Switzerland attracted considerable international interest, as this environmentally-friendly technology is regarded as future-oriented and is encouraged in many neighbouring countries. As a consequence, the aviation division is sharing its initial findings on this accident in close cooperation with other authorities, and is thus able to contribute to an increase in safety.

The rail/navigation division completed four major and largescale investigations into derailments, namely those at Lucerne (22 March 2017), Bern (29 March 2017), Basel (29 November 2017) and Basel Badischer Bahnhof (17 February 2019). In the case of Lucerne and Basel, extensive simulations were performed in order to reconstruct the course of events in the derailments and identify the major factors. Safety recommendations for eliminating wheel-rail deficits were issued in the final reports. The investigation of a near-miss between an intercity train (S-Bahn) and a shunting locomotive at St. Margrethen (16 September 2016) identified and described deficits in the disruption management between different players in the railway sector. One of the causes of the fatal accident involving a train manager at Baden (4 August 2019) was a major fault in the door system anti-trap mechanism and the door feedback in the driver's cab. An interim report with recommendations to eliminate these deficits was rapidly issued to the FOT.

3 Organisation

The STSB is an extra-parliamentary committee established under Articles 57a–57g of the Swiss Government and Administration Organisation Act (GAOA) SR 172.010). It investigates incidents in aviation, public transport and maritime navigation as laid down in the Swiss Ordinance on the Safety Investigation of Transport Incidents (OSITI, SR 742.161). The investigations consist of an independent examination of the technical, operational and human circumstances and causes that led to the event, and their sole purpose is to improve safety in transport, in other words to prevent similar incidents in the future. The reports are intended for experts in the respective fields and to the interested general public, and are explicitly not intended for criminal prosecution and administrative authorities.



The members of the Swiss Transportation Safety Investigation Board are appointed by the Swiss Federal Council. Administratively, the STSB is part of the General Secretariat of the Federal Department of the Environment, Transport, Energy and Communications (GS-DETEC).

3.1 Personnel

In the rail/navigation division, one technical investigator left the STSB during the reporting year to take on a new career challenge. This departure was compensated by the appointment of a new technical investigator with effect from October 2019.

An important prerequisite for the quality of incident investigations is the competence of the investigators. It is important that their knowledge covers not only changes in the legal framework or developments in operational and technical areas, but also topics such as occupational safety at accident sites and the psychological processing of stressful situations. In 2019, investigators and parttime investigators employed at accident scenes attended a basic or refresher course in psychological emergency care. Basic training in occupational safety and a refresher course were also provided for working at accident sites.

As with all previous years, employees from both the aviation and railways/ships divisions took part in several specific staff and operational exercises on accidents. Staff from the Investigation Bureau have given lectures at various training and prevention events (police forces, fire brigades, emergency services at airports). The international network was also cultivated through participation in several meetings and professional development courses.

3.2 Finances

In the year under review, the Swiss Transportation Safety Investigation Board had a budget of almost CHF 7.8 million at its disposal. The investigation of the major accident involving the Junkers Ju 52 on 4 August 2018 at Piz Segnas also led to a considerable increase in the demand for resources in 2019. SUST had additional funds of CHF 2.8 million at its disposal, which had been approved by the parliament.

Of the total of CHF 10.6 million, a little over CHF 8.7 million was actually required by the end of the year under review. The technical investigator's workload which increased in July 2018 and the appointment of the Director of the Investigation Bureau in August 2018 led to an overrun of the personnel budget by 14.4 %. In contrast, material and operating expenses were CHF 2.27 million less than budgeted. Some of the services rendered in connection with the Ju 52 accident in the year under review could not be completed as planned in the year under review due to the complexity of the matter. The services provided will be booked in 2020.In addition, in 2019, as in 2018, other work had to be postponed due to the major accident, which led to lower expenditure on the normal budget.

As is also customary in other countries, the work of the Swiss Transportation Safety Investigation Board represents a basic service provided by the state to improve safety. This work is therefore almost exclusively publicly funded. For example, all STSB products, in particular the final reports of investigations, are provided free of charge on the Internet. 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 CHF 32,375 in 2019, which was the STSB's only regular external source of income.

3.3 Performance targets

On 1 January 2017, the new management model for the federal administration (NFB) was introduced; it is designed to strengthen administration management at all levels and to increase transparency and control of services. The STSB has also introduced the NFB and defined the following operational projects, guidelines and performance targets for 2019:

Projects and initiatives

- examining the potential for accelerating the investigation process;
- reducing the number of old investigations which have not yet been completed;
- provisional draft of the revision of the Ordinance on the Safety Investigation of Transport Incidents (OSITI) for interdepartmental consultation.

Possible optimisations of the investigation processes were identified and the technical investigators were made aware of the need to speed up and optimise investigations. The reduction in the number of pending investigations has been included in the annual objectives of the Investigation Bureau since 2018, so the project has therefore been implemented.

These actions are bearing their first fruits. An increasing number of summary investigations are being carried out, in which extensive investigations are conducted on a consistent "need-to-know v. nice-to-know" basis. Due to their large number, it will take several years to reduce the pending investigations. During the reduction phase, these pending cases will have a negative effect on the measurement criteria for the "Rapid Completion of Safety Investigations" performance target, as can be seen from the figures for recording the performance targets in the reporting year. A slight improvement was achieved compared to 2018, but performance is still well under the set targets. The implementation has therefore not yet had its full effect.

The revision of the OSITI had to be postponed due to other priorities, which turned out to involve considerably more work than expected. However, the necessary amendments to the Ordinance necessitated by the adoption of the technical-operational pillars of the 4th Railway Package were introduced as part of the amendment of the Railways Act (EGB). The revision of the OSITI will be continued in 2020 as a priority project.

Performance targets

Targets and indicators	2018 ACTUAL	2019 TARGET	2019 ACTUAL	2020 PLAN
Conformity assessment: The internal guidelines and procedures are adapted to the current international guidelines				
Annual conformity assessment procedure in aviation according to International Civil Aviation Organisation (ICAO) Annex 13, EU Regulation No. 996/2010 (yes/no)	yes	yes	yes	yes
Rapid completion of safety investigations: By applying adequate measures, the STSB ensures that incident investigations are completed in a timely manner and in compliance with the law.				
Investigations into serious incidents and accidents involving aircraft with a take-off mass of more than 5700 kg completed within 12 months (%, minimum)	11	80	6	80
Investigations into serious incidents and accidents involving railways, boats and buses with a federal licence completed within 12 months (%, minimum)	20	75	29	80
Investigations into serious incidents and accidents involving aircraft with a take-off mass of more than 5700 kg completed within 18 months (%, minimum)	17	80	0	80
Summary investigations into serious incidents and accidents involving aircraft completed within 6 months (%, minimum)	30	80	27	80
Summary investigations into serious incidents and accidents involving railways, boats and buses completed within 6 months (%, minimum)	31	80	71	80

The targets were partially achieved. There were major deviations in the following areas:
Rapid completion of safety investigations: the values achieved in 2019 are well below the target values and are in some cases lower than those of 2018. In many cases, the time required to carry out investigations and prepare reports was longer than the set time limit and the STSB's internal requirements. The reason was other urgent work in aviation which had higher priority than the completion of ongoing investigations:

- The major accident involving the Ju 52 on 4 August 2018 tied up a significant proportion of resources in 2019 as well as 2018.
- The number of event notifications in 2019 was higher than average (and has accordingly tied up more resources for preliminary enquiries. Unless these are carried out without delay, data and information relevant to the investigation cannot be secured.
- With resources remaining the same, pending cases have accumulated as a result of the sharp increase in the number of aviation events notified in recent years. Reducing these older pending cases has led to delays in preparing reports on more recent incidents.

In the railways and ships sector, the resources available during nearly half of the year were below the target value due to personnel changes. The period required to train new investigators to be productive is comparatively long, as this competence is in short supply in the labour market.

In 2018, in light of the preventive effect of safety investigations, i. e. publishing the findings of investigations as soon as possible, the Board decided that completion of investigations within the meaning of Article 52 of the Ordinance on the Safety Investigation of Transport Incidents (OSITI) should not mean the completion of the actual investigation work but the approval of the respective report. The results for the measurement criteria for 2019, as for 2018, were calculated according to this guideline, in contrast to the results for 2017 and 2016. The annual values for the measurement criteria are therefore only comparable to a limited extent. As a result of the tightening of the financial reporting requirements, many studies already in the "prepare report" phase did not meet these requirements, which is another reason for the comparatively significant deviations from the values for the years before 2018.

Although the target of completing safety investigations rapidly was not achieved, the STSB's performance in 2019, taking into account the major accident involving the Ju 52, is comparable to that of previous years, (see table below).

Year	Number of notifications	Opened investigations	Completed investigations			Ongoing investigations
			total:	with final report:	with summary report:	
2019	1849	79	94	22	72	194
2018	1860	131	102	33	69	207
2017	1635	111	128	57	71	161
2016	1561	159	97	40	57	221
2015	1556	173	64	51	13	n/a

Measures adopted: In 2017, the Board conducted an audit of the STSB Investigation Bureau, during which it identified requirements and options for action. On this basis, it established organisational, structural, personnel and procedural measures, which were implemented during 2018. The effectiveness of these measures can be seen, among other things, in the higher number of closed investigations compared to those opened in 2017 and 2019.

4 Investigations and results

4.1 Overview of investigations of the entire Investigation Bureau

During 2019 a total of 1849 incidents, i. e. accidents and other dangerous events, were reported to the STSB. This figure is eleven less than in 2018. Whereas the total of 280 reports for public transport was the lowest for the past five years, the number of reports relating to aviation increased, although only by a figure of ten. However, this still represents 24 % more than the average for the period from 2015 to 2017, and 40 % more than in 2014. Three reports concerned maritime navigation. Safety investigations were opened in 79 cases, i. e. slightly more than 4 % of the reports.

The Investigation Bureau as a whole completed 94 investigations into accidents and serious incidents. These included 72 summary investigations whose preventive potential warranted a summary investigation. 21 final reports (see Annexes 1 and 2) and 44 summary reports were published in the year under review. As part of its investigations, the STSB issued a total of 20 safety recommendations and 10 items of safety advice during 2018. At the end of the year, 194 investigations were still in progress.

In aviation, 77 investigations concerning incidents were completed in the reporting year. 13 final reports (see Annex 1), 2 interim reports and 35 summary reports were published in the same year. With regard to aviation, 10 safety recommendations and 7 items of safety advice were issued. At the end of the year, 162 investigations were in progress.

In the reporting year, for the 5 modes of transport (railways, cableways, buses, inland and maritime navigation), 17 investigations were completed and 8 final reports, 1 interim report and 9 summary reports were published. In 2018, a total of 8 safety recommendations and 10 items of safety advice were issued in final reports. At the end of the year, 32 investigations were in progress concerning railways, cableways, buses and inland and maritime navigation, including a study on natural hazards.

4.2 Overview by mode of transport

Aviation

In 2019, 1556 notifications of aviation incidents were received, which were assessed in accordance with the law. Here, additional technical aids were often used to assess the level of danger, in particular with airproxes (aircraft proximities). Based on these preliminary enquiries, a total of 23 investigations into accidents and 41 investigations into serious incidents were opened. These included 13 airproxes with a high or considerable risk of collision. An extensive investigation was opened for 19 incidents, whilst the initial investigation findings suggested a summary investigation for 45 events.

In the reporting year, there were 23 accidents involving aircraft registered in Switzerland. 5 people suffered fatal injuries.

Since 2011, the number of reported incidents has steadily increased, to a provisional maximum of 1566 in 2019 (diagram 1). In contrast to 2018, when the number of investigations opened reached its peak of 119, in 2019 the number of investigations opened, 64, was considerably lower (diagram 2).

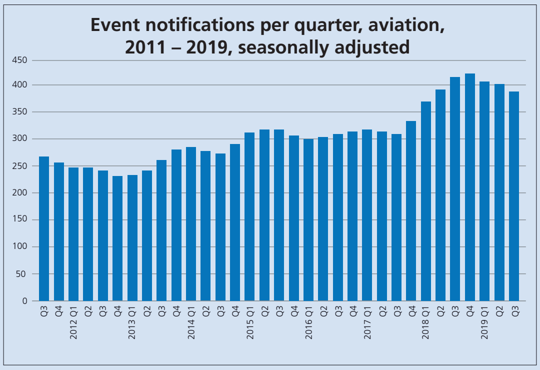


Diagram 1: Number of incidents reported per quarter and relevant to the aviation sector between 2011 and 2019. Seasonal effects were adjusted by means of a moving average.

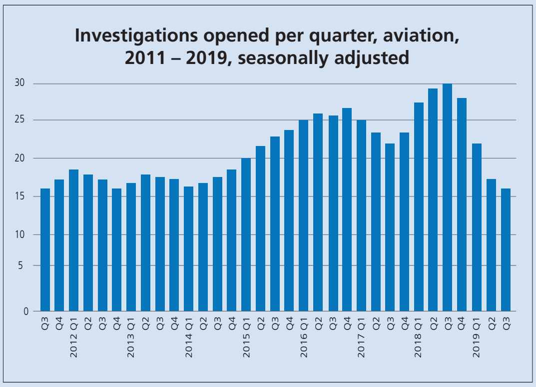


Diagram 2: Number of investigations opened per quarter in aviation due to reported incidents. Seasonal effects were adjusted by means of a moving average.

Public transport and maritime navigation

In the year under review, the number of incidents reported in the public transport and maritime navigation sector was 283. The figure of 280 reported incidents in public transport is the lowest value since 2006. In contrast to the aviation sector, no seasonal pattern in the number of reported incidents can be identified in public transport. In maritime navigation, only a few incidents are recorded per year (2019: three).

These have no impact on the statistics for total notifications.

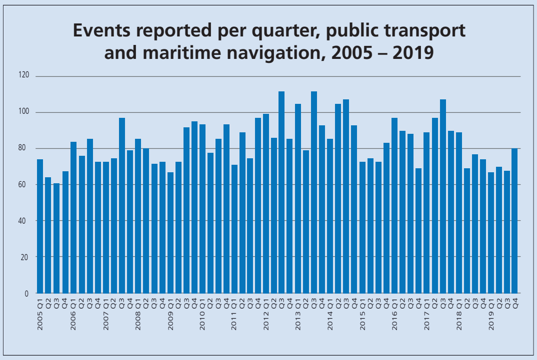


Diagram 3: Number of incidents reported per quarter and relevant to public transport, 2005–2019.

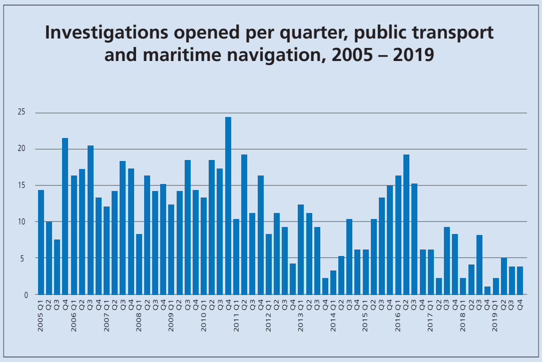


Diagram 4: Number of investigations opened per quarter in public transport and maritime navigation due to reported incidents.

The time series for opened investigations (diagram 4) shows no clear patterns either, except that the number of opened investigations has tended to decrease since 2005. For railways, the development of the international legal basis has resulted in a complex landscape of responsibilities involving numerous players. The investigation of operational and organisational processes is becoming more demanding and entailing significantly more work. The figures for the individual modes of transport are shown below.

Railways

In 2019, 255 events relevant to safety on the railways were reported, 24 of which concerned trams. In 28 cases, an investigator attended the scene. An investigation was opened in 14 cases. No investigations were opened into 14 reports of shunting incidents, as the causes were judged to be similar to deficits in a final report[1] with safety recommendation 109.

The more significant events include, in chronological order, an industrial accident on 5 February at Airolo, in which one worker was fatally injured and another was severely injured, the derailment of an ICE on 17 February at Basel Badischer Bahnhof, the derailment of a construction train on 25 May at Busswil, a fatal accident during a photo stop at Exergillod on 22 June, a frontal collision between a goods train and a shunting movement on 11 July at Zurich Herdern, a fatal accident involving a train manager on 4 August at Baden, a gondola crash from a cableway on 20 October at Rickenbach (SZ), and a derailment of goods wagons on 4 November at Bonaduz.

In the events reported to the STSB, 20 passengers sustained minor injuries, 2 were seriously injured and one suffered fatal injuries. Four railway company employees were fatally injured, 5 were seriously injured and 22 sustained minor injuries. In the railways sector (incl. trams), another 28 people were fatally injured, 26 were seriously injured and 12 sustained minor injuries. As in recent years, the most common cause of reported accidents involving people is careless behaviour by individuals crossing the tracks in a manner that is not permitted or otherwise entering the clearance zone of

[1] Final report of a collision between a pushed shunting movement and parked vehicles in Zurich marshalling yard (ZH) on 18 September 2015, no.: 2015091801

trains. Transport and infrastructure companies cannot usually directly influence such incidents.

Cableways

Twelve reports concerned cableways. A technical investigator attended in the following two cases: on 5 June an industrial accident took place during splicing work on a cable, and on 20 October a gondola crashed at a support tower due to a sudden severe gust of wind. An investigation was initiated in the case of the crash.

One passenger was slightly injured in the events reported. One cablecar company employee was fatally injured in the course of splicing work on a cable, while four employees of cablecar companies sustained serious injuries, and three employees sustained minor injuries. Apart from passengers and employees, no other persons sustained injuries. The most frequent incidents were those caused by environmental influences (wind, avalanches, subsidence).

Buses

Nine incidents concerning buses were reported to the STSB. None of the cases justified attendance by an investigator, or the opening of an investigation.

Nine passengers sustained minor injuries in the reported events. One bus company employee sustained minor injuries, and one other person sustained minor injuries in addition to the passengers and employees. Six of the nine events related to fires in which nobody was hurt, and the injuries to persons resulted from buses colliding with other road users or with a house wall.

Inland navigation

In 2019, the STSB was alerted on four occasions. One case concerned a collision with a jetty, while in a second case, a fire broke out on a passenger vessel in the course of maintenance work. In two other cases, the STSB was not the competent body for an investigation and so no investigation was opened. No one was injured.

Maritime navigation

During 2019, two incidents involving maritime navigation ships sailing under the Swiss flag were reported to the STSB. In one case, a control problem arose affecting the main engine of a cargo ship. The second report concerned a multi-purpose cargo ship which lost its cargo in heavy seas. An analysis showed that in both cases, it was not appropriate to open an investigation from the point of view of preventing further incidents. In addition, a collision between a Swiss river cruise vessel and a chemicals tanker on a Dutch inland waterway was reported to the STSB. This accident was investigated by the Dutch transportation safety investigation board.

5 Safety recommendations and advices

5.1 General

In the first half of the last century, accidents in the transport sector were usually investigated by the respective 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 prevailed over the course of recent decades: in most countries, in addition to the supervisory authority, an independent, staterun safety investigation body also exists, which is expected to impartially clarify the reasons for an accident or a serious incident. Because of the separation of powers, the investigation body does not itself mandate measures to improve safety but proposes such measures 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), whose mission is to provide uniform and binding rules on aviation safety in the European aviation sector on behalf of the member states. Since then, the EASA has increasingly exercised its authority, particularly in the areas of technology, flight operations, air traffic control and aerodromes and airports. Here, 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 (FOCA), depending on the area of competence.

Regulation by the EU is becoming increasingly important in the area of railways. In particular, this concerns technical interoperability in international transport. The EU Safety Directive (2004/49/EC), which is listed in the Annex to the Land Transport Agreement between Switzerland and the EU, sets only general standards, but also stipulates that each state must have an independent safety investigation body. However, full safety supervisory authority over the railways continues to reside with the national supervisory authorities for safety. Therefore, all safety recommendations in the area of railways are addressed to the Federal Office of Transport (FOT), in accordance with article 48, paragraph 1 of the Ordinance on the Safety Investigation of Transport Incidents of 17 December 2014 (OSITI). The OSITI implements the EU Safety Directive (2004/49/EC) into equivalent Swiss law. However, the EU revised the Safety Directive completely in 2016. Under this, enforcement responsibilities will now be assumed by the European Union Agency for Railways (ERA), in particular in relation to approvals and licences. After the adoption of this Directive as part of the revision of the Railways Act (RA, SR742.101), certain recommendations by the STSB in relation to railways will no doubt in future be addressed to the EU authorities.

Safety objectives and requirements for cableway installations and their operation are regulated by the EU Cableways Regulation (EU) 2016/424 dated 9 March 2016. Supervision and enforcement are exclusively within the remit of the national supervisory authorities, in the case of federally licensed cableways within the remit of the FOT. STSB recommendations are therefore addressed to this authority.

Regulations applying to licensed inland navigation in Switzerland are primarily national regulations. Consequently, recommendations from the STSB are addressed to the FOT as the national supervisory authority for safety.

With regard to maritime navigation, the European Union established the European Maritime Safety Agency (EMSA) in 2002. Its mission is to reduce the risk of accidents at sea, the pollution of the seas through maritime navigation and the loss of human life at sea. The 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 (SMNO) as the national supervisory authority.

Having received a safety recommendation, the supervisory authority informs the STSB of the measures taken which arise from the safety recommendations. If no measures have been taken, the supervisory authority justifies its decision. The measures taken by supervisory authorities in relation to safety recommendations are classified as follows:

- **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.

Following the introduction of the OSITI, the STSB started to issue safety advice in addition to the safety recommendations, as and when required. 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 stipulations from this authority or its supervisory activity. However, occasionally safety deficits also become apparent as part of an investigation that cannot be eliminated by amending rules or regulations or by direct supervisory activity, but rather by changing or improving risk awareness. In these 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 items of safety advice issued by the STSB in interim or final reports during 2019 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. Each safety recommendation is followed by the implementation status as at mid-February 2020. The current implementation status of safety recommendations and further details can be found on the website of the Swiss Transportation Safety Investigation Board.

5.2 Aviation

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

On 13 December 2015, a pilot took off from Locarno Airport in an MCR-ULC aircraft for a towing flight. A few seconds after take-off he noticed that the aircraft engine had begun to run roughly and at the same time some of the automatic circuit breakers tripped. A few seconds later the aircraft engine cut out at a height of approximately 20 m above ground. The pilot was able to make an emergency landing with the tug, in which it suffered damage. The glider under tow was able to release and land safely.

Safety deficit

The fuel supply in the MCR-ULC aircraft type with a Rotax 914 engine is provided by two electrical fuel pumps. Failure of both fuel pumps, one reason for which can be a total power supply failure, results in an engine shutdown. The voltage regulator that rectifies and controls the generator alternating current output requires a constant input voltage from the battery in order to operate. In the event of a battery failure, the voltage regulator automatically switches off in order to avoid internal damage and severe fluctuations in its output voltage, which would cause damage to other electrical systems. Consequently, the power supply units in the electrical system of the MCR-ULC, consisting of a generator with a voltage regulator and battery, do not have a redundant design.

Disconnection of the battery from the onboard electrical system, e.g. as a result of a short-circuit, a break in the ground cabling, failure of the main relay or simply by switching off the main switch, results in the failure of both fuel pumps followed by an engine shutdown due to lack of fuel. A comparison with other aircraft types registered in Switzerland fitted with a type 914 Rotax engine showed that the power supply system is designed in the same way as the MCR-ULC. The risk of engine failure in these aircraft types due to the absence of redundancy in the power supply is therefore the same.

Safety recommendation no. 511, 14/07/2016[2]

The European Aviation Safety Agency – EASA and the Federal Office of Civil Aviation (FOCA) should ensure by appropriate measures that the electrical system of aircraft powered by Rotax type 914 engines is equipped with a redundant power supply for the two electrical fuel pumps.

[2] Already published in the interim report on 14 July 2016

Implementation status

Not implemented. The FOCA sees no need for action and the EASA is examining the situation together with the engine manufacturer. In a final reply, the EASA stated that it had analysed the maintenance records of the aircraft types it had certified fitted with type 914 Rotax engines in order to identify any further existing problems regarding airworthiness. The information examined did not show any indications of engine shutdowns due to the failure of the two fuel pumps.

For aircraft which will be certified in future under the certification specifications for Light Sport Aircraft (LSA), the EASA will draw up a special condition under which a redundant power supply of this nature is mandatory – although the LSA certification specification does not contain such a requirement.

Safety deficit

The fuel supply in the MCR-ULC with the Rotax 914 engine is ensured by two electrical fuel pumps. In the event of failure of the generator or regulator rectifier, the fuel pumps can run for a maximum of another 30 minutes with a fully-charged battery before they fail and the motor shuts down as a result. It is therefore important for a warning lamp to light up if the generator or regulator rectifier fails.

Safety recommendation no. 533, 18/09/2019

The European Aviation Safety Agency (EASA) and the Federal Office of Civil Aviation (FOCA) should ensure by appropriate measures that the operators and owners of aircraft with a type 914 Rotax engine are informed of the safety deficit described here and that the electrical system in their aircraft does not have any defects.

Implementation status

Partially implemented. In a comment on 19 November 2019, the EASA stated that under Annex 1 of EU Regulation 2018/1139, it is not responsible for the aircraft category to which the aircraft involved in this accident belonged. Consequently, it is outside the competence of the EASA to take measures that ensure early detection of the deficit.

Furthermore, as part of the maintenance of aircraft with a type 914 Rotax engine that do fall within the competence of the EASA, not a single case is known in which the engine cut out as a result of the failure of both electrical pumps. For these reasons, the EASA is of the view that no further measures are necessary in this regard.

The FOCA is fundamentally in agreement with this safety recommendation and has started a corresponding information campaign on the subject.

Safety deficit

The fuel supply in the MCR-ULC aircraft type with a Rotax 914 engine is provided by two electrical fuel pumps. Failure of both fuel pumps, one reason for which can be a total power supply failure, results in an engine shutdown. The voltage regulator that rectifies and controls the generator alternating current output requires a constant input voltage from the battery in order to operate. In the event of a battery failure, the voltage regulator automatically switches off in order to prevent internal damage and severe fluctuations in its output voltage, which would cause damage to other electrical systems. Consequently, the power supply units in the electrical system of the MCR-ULC, consisting of a generator with a voltage regulator and battery, do not have a redundant design. Disconnection of the battery from the onboard electrical system, e.g. as a result of a short-circuit, a break in the ground cabling, failure of the main relay or simply by switching off the main switch, results in the failure of both fuel pumps followed by an engine shutdown due to lack of fuel. A comparison with other aircraft types registered in Switzerland fitted with a type 914 Rotax engine showed that the power supply system is designed in the same way as the MCR-ULC. The risk of engine failure in these aircraft types due to the absence of redundancy in the power supply is therefore the same.

Safety recommendation no. 534, 18/09/2019

The European Aviation Safety Agency (EASA) and the Federal Office of Civil Aviation (FOCA) should ensure by appropriate measures that a failure of the regulator/rectifier or generator and a discharge of the battery can be detected early.

Implementation status

Not implemented. In a comment on 19 November 2019, the EASA stated that according to Annex 1 of EU Regulation 2018/1139, it is not responsible for the aircraft category to which the aircraft involved in this accident belonged. Consequently, it is outside the competence of the EASA to take measures that ensure early detection of the defect. Furthermore, as part of the maintenance of aircraft with a type 914 Rotax engine that fall within the competence of the EASA, not a single case is known in which the engine cut out as a result of the failure of both electrical pumps. For these reasons, the EASA is of the view that no further measures are necessary in this matter.

The FOCA agrees with the safety recommendation in part. Direct implementation by the FOCA is not possible, however. Responsibility for the design of the Rotax 914 lies purely with the EASA.

Safety deficit

The fuel supply in the MCR-ULC with the Rotax 914 engine is ensured by two electrical fuel pumps. In the event of failure of the generator or regulator rectifier, the fuel pumps can run for a maximum of another 30 minutes with a fully-charged battery before they fail and the motor shuts

down as a result. For this reason it is important that that the battery is fully charged before each flight.
The procedures described in the Aircraft Flight Manual (AFM) of the MCR-ULC which are carried out on the ground before the flight do not include any check on the state of charge of the battery. Nor are the possible effects of taking off with a battery less than fully charged accurately described.

Safety advice no. 10, 18/09/2019

Topic: Operation with a less than fully charged battery

Target group: Operators and owners of aircraft that rely on electrical systems essential for the continuation of flight.

Steps must be taken to ensure that the crew are informed of the possible effects of taking off with a less than fully charged battery, and that appropriate procedures for checking the state of charge of the battery are described in the AFM.

Accident involving a glider, Tschuggentälli (municipality of Davos), 14/10/2017

The glider collided with the ground while executing a 360° turn to the right probably during controlled flight. The glider was destroyed on impact and the pilot was fatally injured.

Safety deficit

The recording of the flight path of the aircraft involved in the accident provided a valuable basis for the accident analysis and thus for prevention. Since flight recorders are not mandatory for gliders, data from glider computers and the collision warning system Flarm are often used for reconstructing the flight path for safety investigations. Several cases are known in which either the storage media of the devices was destroyed in the course of the accident or the data were only partially recorded due to an interruption in the power supply. Due to the incomplete data recording on the glider computer, the present case is one in which it was not possible to determine how the accident occurred.

Safety advice no. 19, 21/02/2019

Topic: Crash-proof flight path recording in glider computers and collision warning systems

Target group: Manufacturers of glider computers and collision warning systems

The manufacturers of glider computers and collision warning systems should modify the design and construction of their equipment so that the data of the flight path recording are recorded in a storage medium until the time of an accident and can still be read out afterwards.

Airprox between a business jet and a light aircraft north-west of the airport at St. Gallen-Altenrhein, 24/10/2016

The serious incident occurred because the air traffic controller at the airport cleared a business jet for take-off simultaneously with the flight of a light aircraft through the control zone because he incorrectly assessed the development of the situation. This resulted in an airprox between the two aircraft.

Safety deficit

The investigation of this incident indicated that imprecise position information using the term "abeam" makes it difficult for air traffic controllers and other airspace users to gain an accurate overview of the traffic situation. Deviating from an agreed flight path without consulting air traffic control can make dangerous situations more likely.

Safety recommendation no. 543, 03/01/2019

The Federal Office of Civil Aviation (FOCA) should take the necessary measures in conjunction with the Skyguide air navigation services company to ensure that at regional airports, an acoustic warning is given in addition to the visual warning display by the ground-based Short Term Conflict Alert (STCA) so as to improve the situational awareness of the air traffic controller.

Implementation status

Not implemented. The FOCA fears that the recommended introduction of an acoustic warning could be a distraction and lead to uncertainty on the part of the air traffic controller in question. Both the FOCA and Skyguide base this view on the false alarms that obviously occur, and alarms that relate to conflict situations outside the area of responsibility of the air traffic controller. Skyguide was therefore commissioned by the FOCA to check whether the high number of STCA warnings within and directly around the CTR of all regional airports could be limited. The objective within the meaning of the STSB safety recommendation should be to increase awareness of potential conflicts without creating a disproportionate distraction. However, Skyguide was unable to set up targeted filtering, so that the FOCA abandoned implementation of the safety recommendation. Skyguide proposed treating the findings of this incident as a case study in a refresher training course for all air traffic controllers at regional airports and making their employees aware of the subject. The FOCA agreed to this course of action and commissioned Skyguide to implement it in the soonest possible training cycle.

Safety deficit

The investigation of this incident indicated that imprecise position information using the term "abeam" makes it difficult for air traffic controllers and other airspace users to gain an accurate overview of the traffic situation. Deviating from an agreed flight path without consulting air traffic control can make dangerous situations more likely.

Safety advice no. 20, 03/01/2019

Topic: Cooperation with air traffic control, meaningful exchange of information

Target group: Pilots of aircraft operating under visual flight rules

Crews are reminded that precise position information including altitude represents important information that allows other airspace users and air traffic control to gain an overview of the traffic situation. There should be no departure from agreed or notified flight paths without consulting air traffic control or informing other airspace users, since other crews and air traffic control rely on these flight paths.

Safety deficit

The investigation of this incident has once again highlighted the fact that some aircrew still have false expectations regarding the services provided by air traffic control. Some pilots, for example, incorrectly assume that air traffic control separates IFR from VFR traffic in class D airspace.

Safety advice no. 21, 03/01/2019

Topic: Awareness of the services provided by air traffic control.

Target group: Pilots of aircraft operating under visual and instrument flight rules

Aircrews must be aware that in Class D airspace they are themselves responsible for maintaining safe distances between VFR flights, and between VFR and IFR flights.

The FOCA has indicated that it shares the view of the STSB that false expectations exist amongst pilots in particular regarding VFR/IFR separation in Class D airspace. A "Stay Safe" awareness campaign already exists for Class E airspace. The FOCA will examine extending this campaign to cover Class D airspace.

Collision between two aircraft in formation flight, Mollis, 26/05/2016

During a practice flight for an air display, two aircraft collided after leaving the formation because of a misunderstanding regarding the division of responsibilities for collision avoidance.

Safety deficit

The investigation recognised the inadequacy of the training for this division of responsibilities as a contributory factor.

Safety recommendation no. 545, 20/06/2019

The Federal Office of Civil Aviation (FOCA) should take appropriate measures to ensure that pilots who obtain an exemption allowing them to fly below the minimum altitude with a licence for formation flight in an air display are adequately trained for their respective position in the formation and in particular know the responsibilities of that position.

Implementation status

Implemented. In a letter dated 09 September 2019 the FOCA announced that the FMA Flyers display organisers had announced and immediately implemented a modification to their training shortly after the accident. Contrary to the original practice of all the pilots flying in different positions and formations being flown with aircraft of greatly different performance and power ranges, new fixed teams with fixed positions were designated and formation flying with different aircraft was abandoned completely.

FOCA inspections in 2017, 2018 and 2019 confirmed the implementation of, and compliance with, the newly-defined procedure.

Furthermore, the requirements in the FS I 001D guideline as last amended on 06 March 2019 correspond to the prevention objective of the safety recommendation.

Safety deficit

The present case indicated that formation flying planning which is not sufficiently detailed, particularly regarding the flight paths and establishing visual contact with all the aircraft taking part, and the procedures in the event of an unexpected loss of visual contact, can result in misunderstandings with a high risk.

Safety advice no. 23, 20/06/2019

Topic: Formation flying planning

Target group: Pilots of aircraft engaged in formation flying

Aircrews are reminded that detailed planning and a comprehensive briefing with all the pilots taking part are extremely important for safe formation flying. The complexity of the manoeuvres should be planned to match the experience of the pilots taking part and the aircraft used, taking into account their specific performance characteristics and visual contact. All pilots must be aware of their responsibilities and the procedures in the event of unclear situations during the flight.

Airprox between a glider and a business jet south-west of Amriswil, 15/10/2017

An airprox between a glider and a twinengined business jet on its approach path to St. Gallen-Altenrhein airport under instrument flight rules took place south-west of Amriswil at an altitude of some 5000 ft above mean sea level.

Safety deficit

Approach and take-off paths under instrument flight rules (IFR) at St. Gallen-Altenrhein airport extend beyond the control zone (CTR) and the terminal control area (TMA), through long distances in Class E airspace. Aircraft flying under visual flight rules (VFR) in this airspace are not obliged either to have transponders or to maintain radio contact with the corresponding air traffic control center. Air traffic control may therefore be completely unaware of VFR traffic, which can only be discovered by the IFR flight crew establishing visual contact (see and avoid).

Safety advice no. 24, 05/09/2019

Topic: Use of transponders and contacting air traffic control in the terminal area of regional airports under instrument flight rules
Target group: Aero-Club of Switzerland (AeCS) and all airspace users

The Aero-Club of Switzerland should make its members aware that increased IRF traffic must be expected in Class E airspace adjacent to control zones (CTR) and terminal control areas (TMA) at regional airports, such as St. Gallen-Alterhein. Keeping the transponder permanently switched on and making contact with air traffic control at the airport to give one's own position and altitude currently represent the only possibility for aircraft operating under IFR to detect an aircraft operating under VFR, apart from the "see and avoid" principle.

Collision of a powered aircraft with obstacles while taxiing, Sion, 15/11/2017

After taxiing from the runway in the Grely sector with his landing lights switched on, the pilot of a single-engined light aircraft turned into the "Route des Aviateurs" public highway instead of the Sierra taxiway. The aircraft then collided with a fence post and shortly afterwards with a road traffic sign, and was slightly damaged as a result. The pilot was uninjured.

Safety deficit

The lighting situation on the taxiways at Sion Airport (LSGS) in the Grely sector has contributed more than once to pilots taxiing on to the "Route des Aviateurs" public highway instead of the taxiway which runs parallel to it. The aircraft then collided with a road traffic sign and was damaged.

Safety recommendation no. 547, 21/08/2019

The Federal Office of Civil Aviation (FOCA) should take measures in conjunction with the airport operator to improve the lighting situation at night on the taxiways in the Grely sector.

Implementation status

Not implemented. The intention of the FOCA, which planned concrete measures with the airport operator after examining the situation, seems plausible and appropriate. However, no time frame was defined for implementing these measures and at the moment no measures have been taken that would improve the lighting situation at night on the taxiways in the Grely sector, for which reason this safety reco principle.

Near miss involving a fire-fighting vehicle and an airliner, Zurich, 10/01/2018

After a deployment on a runway, an airport fire-fighting vehicle approached a transverse active runway in a dangerous manner, where a scheduled airliner was in the process of taking off.

Safety deficit

Only a few firefighter deployments take place on the runway system of Zurich Airport (LSZH) every year, for which reason the more junior firefighters have little experience of such activities. Regular driver training is carried out primarily on the taxiway and roadway system, but no driving exercises take place on the runway system due to the dense air traffic. Driver training on the runways is an essential precondition for the fire-fighting crews to be able to carry out their work safely and without endangering air traffic in an emergency situation.

Safety advice no. 27, 03/12/2019

Topic: State of training of firefighting crews
Target group: Airport operator and fire brigade at Zurich Airport

The operator of Zurich Airport should take measures in conjunction with air traffic control and the airport fire brigade to ensure that firefighting crews receive regular training in driving on the runway system.

Safety deficit

The crew of an airport fire-fighting vehicle did not pay sufficient attention to their location on the runway system while driving because they were distracted by tasks and conversations of lesser priority, resulting in a dangerous near miss with an aircraft on take-off. There is no requirement for the crew of an airport fire-fighting vehicle to refrain from irrelevant work and conversations during exercises. Rules of a similar nature, known as a sterile flight deck, apply to flight crew on the flight deck of passenger airliners.

Safety advice no. 28, 03/12/2019

Topic: Rules within vehicle crews when taxiing on the runway system

Target group: Zurich Airport fire brigade

The Zurich Airport fire brigade should take appropriate measures to ensure that when driving on the runway system, firefighting vehicle crews direct their attention to their route and their orientation, and refrain from irrelevant tasks and conversations.

Accident involving a glider, Amlikon, 18/07/2018

A self-launching glider with a retractable power unit stalled shortly after take-off during its self-launch, impacted the ground hard and suffered minor damage. One of the occupants sustained a fractured vertebrae as a result of the impact.

Safety deficit

The mandatory dual-control training flights for a self-launch licence can be carried out on a touring motor glider (TMG). Modern touring motor gliders are little different in operation to powered aircraft, whereas the difference to self-launching gliders with a retractable power unit is considerable. The take-off procedure for a self-launching glider and the associated risks necessitate special type-specific training. These risks include, for example, the extremely abrupt change in attitude in the event of engine failure, when the aircraft tends to pitch upwards suddenly, or a landing approach with the propeller extended without a functioning engine. Consequently, it is not sufficient for dual-control flights to be carried out solely on a touring motor glider.

Safety recommendation no. 555, 03/12/2019

The European Aviation Safety Agency – EASA should take appropriate measures to ensure that the training for self-launching with gliders with a retractable power unit is modified to take account of the type-specific risks.

Implementation status

Awaiting response.

Interim report, accident involving a drone, Irchel, 09/05/2019

Approximately two minutes after take-off at the University of Zurich, Irchel, the drone flight termination system tripped automatically and initiated an emergency landing.

Safety deficit

After deployment of the parachute, the canopy suspension line ruptured and the drone fell unchecked to the ground in the wood and was destroyed.

Safety recommendation no. 553, 20/06/2019

The Federal Office of Civil Aviation (FOCA) should take appropriate measures to ensure that the fastening of the emergency parachute to the drone can withstand the possible loads.

Implementation status

Implemented. By letter of 19 September 2019, the FOCA announced that the original fastening of the parachute represented a single failure that had been overlooked by both the manufacturer and the FOCA in the design review. A service bulletin (SB) was issued stipulating abrasion protection and

a redundant second line for the parachute to be fitted to all drones.
Due to the measures taken, the STSB regards the present safety recommendation as implemented.

Safety deficit
The acoustic warning signal after the emergency parachute had deployed was not heard by persons near the crash site.

Safety recommendation no. 554, 20/06/2019
The Federal Office of Civil Aviation (FOCA) should take appropriate measures to ensure that the acoustic warning signal when an emergency landing is initiated can be heard by third parties on the ground.

Implementation status
Partially implemented. As the FOCA announced by letter of 19 September 2019, the concept of the acoustic warning signal in the event of an emergency parachute landing was to warn any persons in the vicinity of or under the drone about to land by parachute. This is an additional safety measure to the parachute itself and was never intended as a warning to persons in the event of a "free fall". The manufacturer decided on its own initiative to increase the loudness of the acoustic signal. The arguments of the FOCA are therefore not completely logical, since a targeted warning of third parties on the ground in the event of an emergency landing is ultimately a question of loudness and not of speed of descent. In view of the manufacturer's and drone operator's own initiative, the safety recommendation is regarded as partially implemented.

5.3 Railways

Collision between a train and a road coach on a controlled level crossing at Interlaken Ost, 20/05/2016

On 20 May 2016 at approximately 20:00, the ICE 371 passenger train collided with a coach at the "Beau Rivage" controlled barrier level crossing at Interlaken Ost. Two passengers in the coach were severely injured, and a further fifteen sustained minor injuries. The front of the ICE was slightly damaged by the collision, while the rear of the coach was severely damaged. One level crossing barrier was also damaged.
The collision of an ICE train with a coach at the "Beau Rivage" controlled barrier level crossing at Interlaken was due to an individual error on the part of the coach driver. The fact that the driver did not take the opportunity of leaving the danger area by breaking through the barrier was a contributory factor.

Safety deficit
The FOT renovation programme implemented technical measures to modify level crossings to meet statutory requirements and thus make them safer. However, it has been found that the number of accidents at controlled level crossings is increasing. As the present case, similar cases and the FOT monitoring of level crossing accidents shows, in almost all cases accidents are caused by errors on the part of the road user.

Safety recommendation no. 138, 11/06/2019
In order to increase safety at level crossings, the STSB has advised the Federal Roads Office (FEDRO) in conjunction with the Fund for Road Safety (FRS) [Fonds für Verkehrssicherheit (FVS)] and the Federal Office of Transport (FOT) to identify and implement appropriate measures to make road users more aware of the dangers at level crossings. Particular emphasis was to be placed on road user education and pedestrian behaviour.

Implementation status
Partially implemented. The FEDRO reported that before any agreement had been reached, the FOT had taken up the matter proactively and launched the "Happy End" campaign together with the SBB and other organisations.
This dealt among other things with the (correct) behaviour at level crossings as proposed in safety recommendation 138. The correct behaviour has also been taught for some time in driving schools, so this knowledge will continue to be disseminated. Consequently, no further action is planned by either FEDRO or FVS.

Near miss between a city train (S-Bahn) and a shunting locomotive at St. Margrethen, 16/09/2016

On 16 September 2016 at 16:38 a near miss occurred between a city train (S-Bahn) and a shunting locomotive at St. Margrethen. A shunting locomotive travelling from St. Margrethen to Au SG remained briefly at a standstill in Au station due to a fault. This prevented a city train

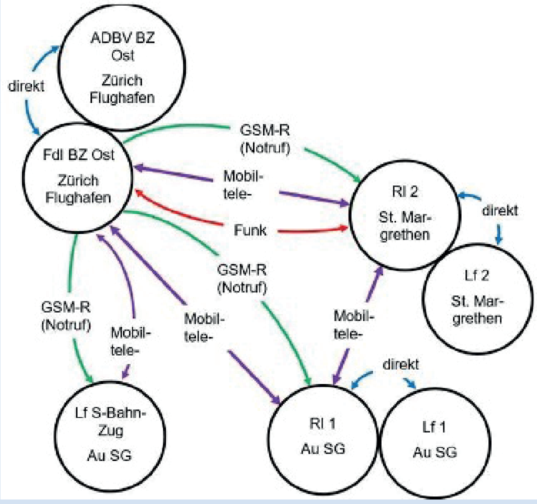
(S-Bahn), which was travelling in the opposite direction to St. Margrethen, from continuing its journey and the train had to wait at Au SG station before continuing its journey.

As a remedial measure, the faulty shunting locomotive was pushed into Au SG station with the aid of a second shunting locomotive stationed at St. Margrethen, whose movement from St. Margrethen to Au should have been carried out as a shunting movement along the line. In the meantime, the fault in the stranded shunting locomotive was rectified, whereupon it continued its journey. The city train (S-Bahn) was then given the all-clear to continue to St. Margrethen. Shortly before St. Margrethen the driver of the city train (S-Bahn) saw a shunting locomotive standing on his line and carried out emergency braking, stopping just short of the shunting locomotive.

Lack of clarity and misunderstandings between the two shunting teams and the dispatcher in resolving the disruption to operations resulted in the shunting locomotive travelling along the line beyond the shunting limit, which was prohibited, while the city train (S-Bahn) travelled along the same line in compliance with the signals, almost causing a collision.

The following contributed to the course of events:

- Partial hesitation in handing over and accepting managerial responsibility respectively for the movement between young inexperienced employees in charge and older, more experienced colleagues with lesser authorisations or competences;
- The handling of safety-relevant aspects by the parties involved, who accepted uncertainties and a lack of clarity without actively determining the facts;
- The lack of awareness by the parties involved that they were caught between two sets of duties: the duty on the one hand to follow procedures, and on the other to question instructions, which required them to use their own judgement and perceptions constantly, and act accordingly. The duty to follow instructions was given too much weight by the parties involved. Even persons exceeding their competences were tolerated.
- The parties involved were too intensely focused on remedying the disruption to normal operation as quickly as possible in order to minimise any effects on (passenger) traffic and their other duties, and gave too much priority to the time factor in the conflict between ensuring safety and time pressure.
- The parties involved had different levels of knowledge of the situation and how to resolve it but were unaware of this, since there were no means of common simultaneous communication available.
- With the advance information from shunting supervisor 1 and the instructions passed on before the movement, shunting supervisor 2 mistakenly thought himself entitled to carry out the shunting movement on the line when the signals transmitted the movement authority.
- Confusion regarding the phone number of a called party, which was not clarified by the party called in error.
- The plan laid down in advance for resolving disruption was not cancelled clearly enough for all the parties involved before normal operation was restored.



Safety deficit

Shunting supervisor 1 implicitly assumed the lead to resolve the disruption. The dispatcher did not ask any further questions as to what the best solution might be. Shunting supervisor 2 overestimated his abilities and engine driver 2 did not intervene. Shunting supervisor 2 was not sure about the destination of the movement but then made an unreliable assumption because the dispatcher seemed impatient. Even the driver of the city train (S-Bahn) created additional disruption with an unplanned enquiry into the status of the disruption resolution measures. These were all understandable reactions in themselves in which all the parties involved pursued the totally legitimate objective of clearing the line as quickly as possible. The trend for people to have stress response, an unconsidered readiness to take risks and a lack of communication between the parties involved were also major factors. This resulted in chains of errors which in the present case were not broken. Incidents are hardly ever caused by a single error by a single person. In most cases accidents result from a chain of errors by a number of parties involved. Consequently, incidents can be prevented if the parties involved are in a position to interrupt the chain of errors. The abilities to recognise errors and interrupt chains of errors can and must be practised. A core precondition is empowering employees to speak openly about events which disturb or could potentially distract them. Targeted training and practice of these abilities for persons with safety-relevant activities has not to date been a systematic part of the training in public transport.

Safety recommendation no. 145, 27/08/2019
The Federal Office of Transport (FOT) should lay down mandatory requirements for persons with safety-relevant duties so that their initial training and periodic professional development covers ways of thinking and behaving when dealing with disruption, similar to the position in aviation with TRM training.

Implementation status
Partially implemented. The FOT is of the view that the STSB recommendation is met by the existing rules (Regulation (EU) 762/2018 and FDV). The FOT does not see any need to issue additional mandatory regulations for initial training and professional development.

Safety deficit
In order to gain time, the schedule for shunting movements on the line was communicated before it was due to be executed. A shunting movement was then initiated within the station. The early receipt of the movement authority led to incorrect expectations. The existing rules, whereby items are communicated subject to a receipt and recorded individually on a form, does not lead to all the parties involved having the same level of information, and does not protect against different states of knowledge amongst the parties involved. Communicating items early should be avoided so as not to give rise to any incorrect expectations. A common information status reduces potential misunderstandings considerably.

Safety recommendation no. 146, 27/08/2019
The Federal Office of Transport (FOT) should examine whether the procedure, whereby items are communicated subject to a receipt and forms are filled in, meets the objective of an unambiguous unequivocal agreement between the parties involved which meets both the time requirements and the safety aspects at all times and does not entail additional safety risks of its own. This examination should take account in particular of the possible means of communications available today.

Implementation status
Implemented. The FOT is of the view that with the adoption of the requirement that "The orders are to be passed on to the body carrying them out as rapidly as practicable" in accordance with TSI OPE in the FDV 2020 (R 300.3, Section, 6.2.1) , the recommendation has been met and the time of passing on an item should be as early as possible.

Derailment of a Eurocity train at Lucerne, 22/03/2017

On 22 March 2017 at 13:57 two mid-train carriages of a Eurocity train derailed when departing from Lucerne station, so that when the train came to rest one of the carriages was leaning at an angle against an overhead line support. Seven train passengers sustained minor injuries. There was considerable damage to the infrastructure and the carriages. Lucerne station had to be closed to all normal-gauge rail traffic for four days for the infrastructure repairs.
The derailment of a Eurocity train on 22 March 2017 at a set of points at Lucerne was due to the wheel flange mounting the top surface of the switch rail.
The interaction of different factors resulted in the wheel flange tip running on the top edge of the switch rail at a critical area: The wear shape of the wheel flange resulted in the wheel flange tip moving closer to the switch rail tip. Since the gap at the switch rail was greater than the known values, the switch rail tip was also near to the critical area at the wheel flange tip. The absence of a lubricant film between the wheel flange face and the rail flank led to an increase of friction coefficient, and together with an increased lateral force caused by the fault at the transverse springs of the first bogie to derail, an increased wheel lift occurred while the bogie was travelling. All these factors contributed to the wheel flange tip becoming positioned in such a way that the wheel could rise up on to the top of the switch rail. In addition, the wheel flange tip was somewhat flatter due to rolling, which made rising up on to the switch rail without any counterforce easier.

Safety deficit
The function dimension q_{Wz} at the switch rail tip is checked by means of static measurements with a form gauge, and it can be deduced from this in accordance with the general rules of engineering that the gap dimension q_ε does not exceed an acceptable value. As part of the investigation it was recognised that with dynamic measuring, the gap dimension q_ε can turn out to be larger than previously assumed. Under dynamic loading a geometric contact situation arises in which even a wheel profile with no wear can mount the switch rail and derail. This happens when the gap between the stock rail and switch rail is too large.

Safety recommendation no. 139, 16/07/2019
The Federal Office of Transport (FOT) should examine measures and specifications for the gap between stock rails and

switch rail and ensure that the gap dimension q_ε remains restricted under a running train so that a critical situation for derailment does not arise.

Implementation status
Awaiting response.

Safety deficit
Measurements and various simulations showed that the friction between the wheel flange face and rail flank can reach values of up to 0.6. This results in significant lifting of the wheel when travelling through a curve, which in turn can – and did – lead to a critical condition for derailment in track geometries which impose high dynamic stresses, as exist in some tracks across points in Switzerland. The practice of lubricating the rail flanks via the wheel flange lubrication of traction units or power cars does not ensure lubrication in critical track geometries.
The technical specifications for interoperability (TSI) treats the high-stress track geometries in the Swiss rail network as of secondary importance. Trains are therefore increasingly less able to make an adequate contribution to lubricating the rail flank. To date it is assumed that trains must also be operated as derailment-proof under dry conditions. A friction coefficient of 0.4 is generally assumed. Various investigations of derailments in Switzerland and other countries have shown, however, that under dry conditions without lubrication of the rail flank or wheel flange this coefficient can be exceeded until a derailment-critical situation arises.

Safety recommendation no. 140, 16/07/2019
The Federal Office of Transport (FOT) should examine measures and specifications to ensure that lubrication of the rail flank is ensured at all times in areas with high dynamic stress track geometries.

Implementation status
Awaiting response.

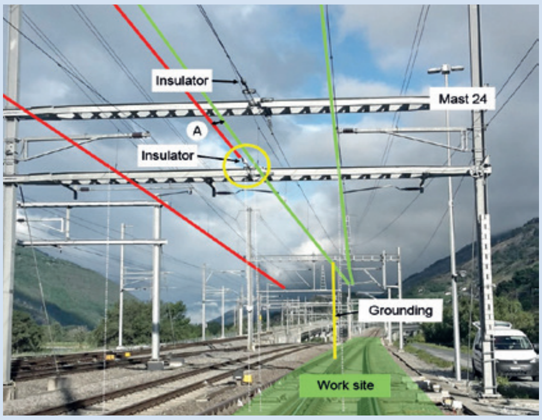
Accident involving high-voltage current during maintenance work at Visp, 25/07/2017

On 25 July 2017 at 01:30, an accident involving high-voltage current occurred during maintenance work on the overhead line at Visp. The accident occurred as a contact line fitter was trying to replace an insulator of the contact line in accordance with his job order. Contrary to what he thought, the contact line was live. An arc flash occurred when a tool was brought into the proximity of the contact line, severely injuring the fitter. The accident was due to the arc flash that occurred during work on the contact line because a contact line in the work area was live.
Contributing factors to the accident were:

- The "5+5 safety rules when dealing with electricity" were not fully or consistently obeyed.
- The risk assessment was generalised and not appropriate for the specific task in hand.
- The safety plan did not include any information or measures regarding a live contact wire section at the work site.
- The job order was not clear and contained maintenance measures that were not feasible.
- No site inspection was carried out in the preparatory phase.
- Employees were not briefed at the work site before carrying out the work.
- The overhead lines were not grounded on all sides of the work site.

Other factors:

- The sign of the "electrical separation (with parallel circuit)" symbol did not contribute to recognising the hazard.
- The T-shirt made of synthetic material could have exacerbated any burns on the upper body.



Safety deficit
The present case shows that the work preparations including documentation, handover, briefing and check did not ensure safe working conditions at the work site. The required documents contained errors and were not matched to each other. There was no briefing or inspection on site. The cases at Rivaz (VD), no. 2018030601, and La Conversion (VD), no. 2018032301, also revealed safety deficits in relation to the preparation for the work.

Safety recommendation no. 144, 03/09/2019
The Federal Office of Transport (FOT) should continue its audits and checks/operational inspections, with the focus on safety at the workplace, and examine additional findings and measures of the infrastructure manager in relation to effectiveness and sustainability. The focus should be placed on the following aspects in particular:

- checking the previous processes such as: risk analysis, safety plan, construction work regulations, job order and documentation, and the job handover and instructions to the employee doing the work, and inspecting the work site.
- organisation of training and professional development courses for employees on the work preparation process and monitoring them regularly for quality assurance purposes.

Implementation status

Partially implemented. The FOT is continuing its audits and operational inspections, checking the effectiveness and sustainability of measures taken as part of safety monitoring, and will amend and augment the test instruction "Operational checks on electrical equipment" as regards work on or near electrical equipment by 31 July 2020.

Derailment of an ICE at Basel, 29/11/2017

On 29 November 2017 at 16:59 three mid-train carriages of an ICE train derailed when arriving at Basel SBB station. Nobody was injured. There was considerable damage to the infrastructure and the carriages.
The derailment of the ICE 75 when arriving at Basel SBB station at the curved double-slip points 317 is due to the fact that as a result of the large gap dimension caused by the stock rail tilting away at the switch rail, the first left wheel of carriage 9 ran on to the top edge of the switch rail some 50 cm after its tip, lost its guidance from the rail and derailed after two metres. The investigation showed that the inadequate lubrication of the rail running edges and switch rails can contribute to the risk considerably.

Safety deficit

Measurements and various simulations showed that the friction coefficient between the wheel flange face and rail flank can reach values of up to 0.6. This results in significant lifting of the wheel when travelling around a curve, which in turn can – and did – lead to a critical condition for derailment in track geometries which impose high dynamic stresses, as exist in some tracks across points in Switzerland. The practice of lubricating the rail flanks via the wheel flange lubrication of traction units or self-propelled vehicle does not ensure lubrication in critical track geometries.
The technical specifications for interoperability (TSI) treats the high-stress track geometries in the Swiss rail network as of secondary importance. Vehicles are therefore increasingly less able to make an adequate contribution to lubricating the rail flank. At the moment it is assumed that vehicles must also be operated as derailment-proof under dry conditions. A friction coefficient value of 0.4 is generally assumed. Various investigations of derailments in Switzerland and other countries have shown, however, that under dry conditions without lubrication of the rail flank or wheel flange this value can be exceeded until a derailment-critical situation arises.

Safety recommendation no. 140, 03/09/2019

The Federal Office of Transport (FOT) should examine measures and specifications to ensure that lubrication of the rail flank is ensured at all times in areas with high dynamic stress track geometries.

Implementation status

Awaiting response.

Safety deficit

The new switch rails were installed in the unfinished condition. There was no grease film on the switch rail contact surface. No initial manual lubrication of the switch rail took place.

Safety advice no. 21, 03/09/2019

Target group: Infrastructure operators
After a new switch rail has been installed, an initial quantity of lubricant should be applied to the rail manually until the wheel flanges have spread a sufficiently large grease film over the switch rail.

Derailment of an ICE at Basel Badischer Bahnhof, 17/02/2019

On 17 February 2019 at 20:47 an ICE train passed over a set of points when departing from Basel Badischer Bahnhof. The front power car and the first bogie of the first carriage continued travelling along the right-hand track after the points, while the rear bogie and the rest of the train were switched to the left track. This derailed the rear bogie. The first carriage was dragged diagonally along across both tracks until the train came to a standstill approximately 20 metres in front of a tunnel wall between the two tracks. One person suffered a hand injury when attempting to stop the train with the emergency door release.

The derailment of an ICE train when leaving Basel Badischer Bahnhof was caused by the inadvertent inadmissible emergency cancellation of its route track and the subsequent setting of another route track, which resulted in a points set being switched under the train while it was moving.

Safety deficit

The interlocking at Basel Badischer Bahnhof on Swiss territory has the weakness, compared to Swiss signal boxes, that after an emergency cancellation of a route track there is nothing to prevent the next immediate route block being selected. There is no requirement for this interlocking in Germany.

The competence for laying down requirements for interlocking design rests with the German Federal Railway Authority (FRA), which under an international treaty is responsible for the safety equipment at Basel Badischer Bahnhof. The STSB cannot issue any safety recommendations to the German Federal Railway Authority.

Safety recommendation no. 143, 03/09/2019

The Federal Office of Transport (FOT) should bring the report and the safety advice it contains to the notice of the German Federal Railways Authority (FRA) and ask the latter for its comments on the measures envisaged.

Implementation status

Partially implemented. By letter of 05 November 2019 from the FOT, the infrastructure operator Deutsche Eisenbahn-Infrastruktur in der Schweiz (DICH) [German Rail Infrastructure Operator in Switzerland – GIOS] and SBB Infrastructure were requested to comment on safety advice items nos. 19 and 20 in the STSB final report 2019021701. Copies of the letters were sent to the German Federal Railway Authority (FRA) in Bonn for their information. The FRA was not asked to comment.

Safety deficit

After an emergency cancellation of one route track, another route could be quickly set up by changing the points of the previously-cancelled route track. There was no need to wait for the expiry of a blocking period or carry out a second operator control action before this resetting of this route track. Interlocking exists which also contains route blocks which after an emergency cancellation are automatically switched back to a preferred default setting. This has already led to similar incidents in Germany.

It gives unambiguous instructions from DB Netz AG to the dispatcher regarding the circumstances under which a train route track can be given an emergency clearance. The mechanism of this instruction is intended to ensure that automatic selection of route blocks or inputting a new route does not entail any risks. There are no other dependent factors regarding the conditions under which route blocks can be reselected after the emergency cancellation of a route. The safeguarding against the risk after an emergency cancellation for a route rests solely on a written instruction for the dispatcher, which must be obeyed before the emergency cancellation.

If emergency and evasive actions are also allowed from a 10-digit numerical keypad, this is known in Switzerland as "computer control operation". Control operations of this type are to be regarded in Switzerland as remote-control operations and consequently all have an emergency clearance time delay.

Safety advice no. 19, 03/09/2019

Target group: Infrastructure operators

The infrastructure operators should examine the conditions under which route blocks of the cancelled train route can be used immediately after an emergency cancellation of the route, and take appropriate measures as necessary.

Safety deficit

Responsibility for operations on the line between Basel Badischer Bahnhof and Gellert is split between two interlocking depending on the direction of travel. Switching between the German and Swiss GSM-R radio networks does not always coincide with the jurisdictions.

In this case, the dispatcher at Basel Badischer Bahnhof was unable to contact a train in his area which had to be brought to a halt as quickly as possible.

Safety advice no. 20, 03/09/2019

Target group: SBB-I and GIOS

SBB-I and GIOS should examine whether the current locations for radio switching on the line between Basel Badischer Bahnhof and Basel SBB or Basel RB respectively are appropriate, and effect changes if necessary.

Interim report, fatal industrial accident involving a train manager at Baden, 04.08.2019

On Sunday 04 August 2019 at 00:10 the train manager of the Interregio train IR 1893 was trapped in a door as the doors were closing, and was dragged along as the train was departing from Baden station, sustaining fatal injuries as a result. The train was departing from Platform 2 at Baden station. After passengers had alighted and boarded, the train manager instructed the train driver by text message to move off and activated the UIC door closing command for the train at no. 4 door set of the fifth-last carriage, using a square wrench. The doors where the command is given remain open so that door closing can be monitored. These doors then have to be closed by the train manager by pressing a separate button. The train manager was trapped in no. 4 door set during the closing action.

Safety deficit
The pneumatic anti-trap system must be switched off for technical reasons shortly before the closing action.
The reliability of the switching point of the "Doors 98 % closed" sensor that deactivates the pneumatic anti-trap system is not guaranteed, which means that the protective anti-trap function can no longer be guaranteed before the 98 % doors-closed position, contrary to its specification.

Safety recommendation no. 141, 20/08/2019
The STSB recommends that the Federal Office of Transport (FOT) asks vehicle keeper to replace the current system for deactivating the anti-trap protection on the EW IV by a reliable system.

Implementation status
Implemented. On 22 August 2019, the FOT ordered that safety recommendation no. 141 must be implemented. The FOT also ordered that the SBB arrange for the organisation of train maintenance and activities to be examined.

Safety deficit
Persons or objects trapped in doors must be detected with a high degree of reliability. The current system of the EW IV with a pair of door limit switches connected in parallel does not meet this requirement. The doors can be displayed as closed to the train driver even though they are not fully closed, resulting in uncertainty on the part of train driver, and can lead to accidents.

Safety recommendation no. 142, 20/08/2019
The STSB recommends that the Federal Office of Transport (FOT) ask train operators to have the door limit switch system of EW IV to be modified so that the red indicator lamps display the correct door status to the engine driver.

Implementation status
Implemented. On 22 August 2019, the FOT ordered that safety recommendation no. 142 must be implemented. The FOT also ordered that the SBB arrange for train maintenance organisation and activities to be examined by an external body.

5.4 Cableways, buses, inland and maritime navigation

In the year under review, no reports with safety recommendations were published for cableways, buses or inland or maritime navigation

6 Analysis

6.1 Aviation

The following Chapters 6.1.1 to 6.1.4 illustrate the trend over time in the absolute number of aircraft accidents and the accident rates of various aircraft categories between 2007 and 2019. Accident rates are calculated by standardising the absolute number of accidents by the respective annual number of aircraft movements. The number of aircraft movements for the years 2007 to 2018 were recorded by the Federal Office of Civil Aviation (FOCA) and made available. The flight movement figures for the year 2019 were extrapolated using a statistical model.
The following three aircraft categories have been analysed:
– Aeroplanes with a maximum take-off mass of up to 5700 kg (including motor gliders and touring motor gliders in powered flight);
– Gliders (including motor gliders and touring motor gliders when gliding);
– Helicopters.
In addition, an analysis was carried out that considered the accidents in the three aircraft categories as a whole.

As some of the aircraft movements for the various aircraft categories are collected in different ways, it is virtually impossible to compare the different categories. Caution should also be exercised when comparing figures from other countries, as other definitions and delimitations have been used in some cases.

Causes of tendencies or trends for more or fewer accidents or higher or lower accident rates in the time series cannot be derived from the available data and their analysis.

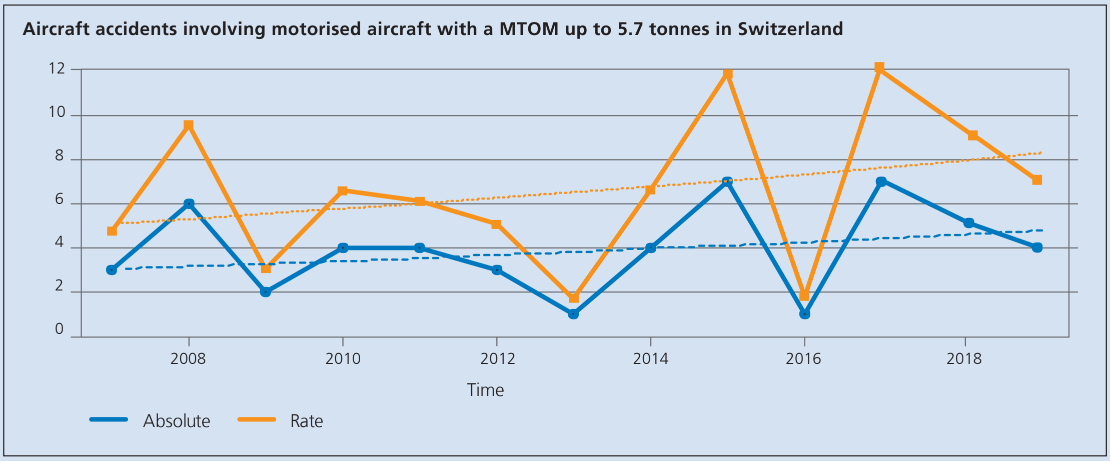
What is common to all categories is that the absolute number of accidents can vary from year to year. The respective time series for accident rates run almost identical to those for absolute values. Models for trend calculations, or regression calculations, are usually based on the assumption that a time series comprises systematic and random components. For time series with small absolute values, as is the case here, the random component can outweigh the significance calculations. In other words, the influence of an existing systematic component on changes in the time series is marginal and the random component dominates the change. For these reasons, the statistical tests on presumed decreases or increases (trends) in the time series are only significant in one case.

6.1.1 Motorised aircraft with a maximum take-off mass of up to 5700 kg

In 2019, 4 aircraft accidents were recorded in this category. Over the entire time series, the absolute accident figures range between 1 and 7. Three of the four highest values were recorded in the last five years. For this reason, each trend model shows a slight increase in the number of accidents and the accident rate. The results of the statistical analysis show an estimated increase in the anticipated value of +2.7 % per year for the number of accidents and +4.0 % for the accident rate. In both cases, however, the value is not significantly different from zero (p = 0.477 or p = 0.292).

The number of accidents per year is shown as a blue dot; the accident rate per year is shown as a yellow square. For better legibility, the data points have been connected using corresponding lines. The blue dotted line shows the anticipated number of accidents; the yellow dotted line shows the anticipated accident rate.

Accidents (Absolute) / Accidents per 1 million aircraft movements (Rate)

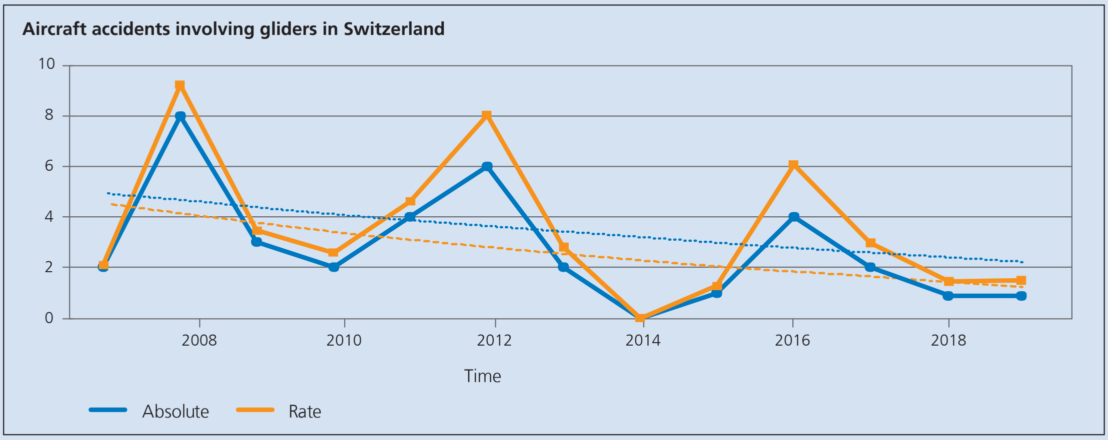


6.1.2 Gliders

One accident in this category was reported in 2019, which alongside identical figures for 2015 and 2018, is the second-lowest figure since 2007. Over the entire time period, the absolute number of accidents has varied from zero to eight. All four lowest values were recorded in the last six years, with the result that the trend models show a slight drop in the number of accidents and the accident rate. The results of the statistical analysis show an estimated increase in the anticipated value of -9.9 % per year for the number of accidents and -7.1 % for the accident rate – in other words, a decrease. The value for the accident rate is not significantly different from zero ($p = 0.113$), as in the earlier years. This value for the number of accidents, however, is significantly different from zero ($p = 0.025$) for the first time. This means that the clear trend of decreasing figures is also statistically significant for the first time.

The number of accidents per year is shown as a blue dot; the accident rate per year is shown as a yellow square. For better legibility, the data points have been connected using corresponding lines. The blue dotted line shows the anticipated number of accidents; the yellow dotted line shows the anticipated accident rate.

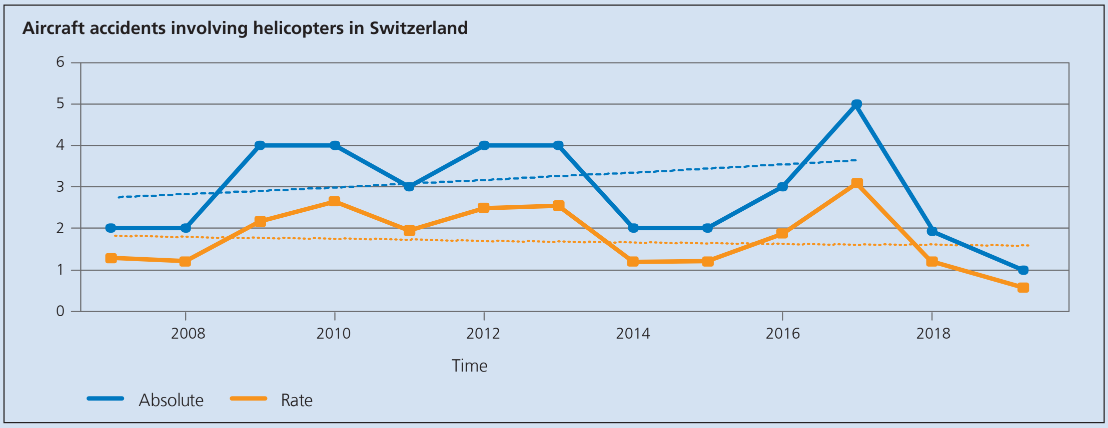
Accidents (Absolute) / Accidents per 100 000 aircraft movements (Rate)



6.1.3 Helicopters

One accident was recorded in this category in 2019, which is the lowest value recorded in this observation period. Over the entire time period, the absolute number of accidents varied between one and five. It should be noted that another helicopter accident that took place in 2019 (24 August 2019, HB-YKJ) is not included in the above statistic because aircraft movements of self-built aircraft are not included in the number of aircraft movements covered by this statistic. The annual fluctuations are fairly small compared to the two categories illustrated above and range around an apparent average of three. The trend models consequently only show

Accidents (Absolute) / Accidents per 100 000 aircraft movements (Rate)



a marginal decrease. The results of the statistical analysis show an estimated change in the anticipated value of -1.7 % per year for the absolute number of accidents and -1.8 % for the accident rate – in other words, a decrease. In both cases, however, the value is not significantly different from zero (p = 0.697 or p = 0.673).

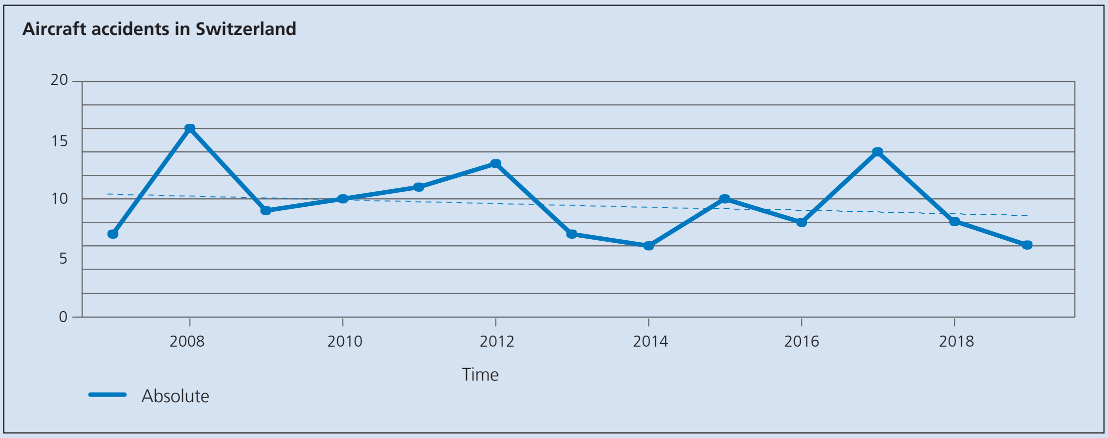
The number of accidents per year is shown as a blue dot; the accident rate per year is shown as a yellow square. For better legibility, the data points have been connected using corresponding lines. The blue dotted line shows the anticipated number of accidents; the yellow dotted line shows the anticipated accident rate.

6.1.4 Total for motorised aircraft, gliders and helicopters

Taking all three categories together, 6 aircraft accidents were recorded in 2019. Over the entire time series, the absolute number of accidents ranged between 6 and 16. For the sum of aircraft accidents across all three categories, the generalized linear regression model shows a slight decrease in the number of accidents. The results of the statistical analysis show an estimated change in the anticipated number of accidents of -2.3 % per year i. e. a decrease. However, this figure is not significantly different from zero (p = 0. 327). Due to the above-mentioned differences in calculating aircraft movements for the individual categories, only the absolute number of accidents is taken into account here.

The number of accidents per year is shown as a blue dot. For better legibility, the data points have been connected using corresponding lines. The blue dotted line shows the anticipated number of accidents.

Absolute no. of accidents



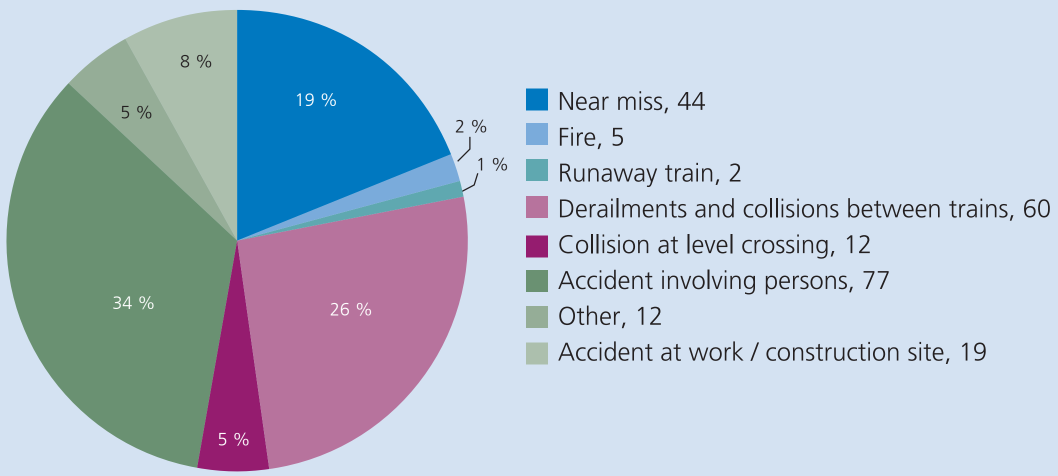
6.2 Railways, cableways, buses, inland and maritime navigation

Distribution of event notifications, investigations opened and reports published

Modes of transport	Notifications		Investigations		Final reports		Summary reports	
	Number	%	Number	%	Number	%	Number	%
Railways	231	81.6 %	14	93 %	8	100 %	8	89 %
Trams	24	8.5 %	0	0 %	0	0 %	0	0 %
Cableways	12	4.3 %	1	7 %	0	0 %	0	0 %
Buses	9	3.2 %	0	0 %	0	0 %	0	0 %
Inland navigation	4	1.4 %	0	0 %	0	0 %	1	11 %
Maritime navigation	3	1.1 %	0	0 %	0	0 %	0	0 %

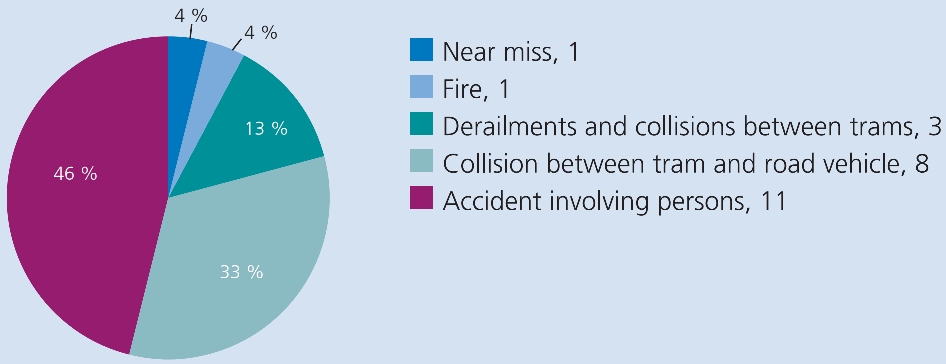
The proportion of notifications relating to railways (incl. trams) was 90 %. The remaining 28 – i. e. 10 % of notifications – relate to the other modes of transport: buses and cableways, as well as inland and maritime navigation. In the year under review, 14 investigations were opened into railways and 1 into cableways. The majority of reports published (incl. summary reports) relate to railways. 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 railways (excluding trams)



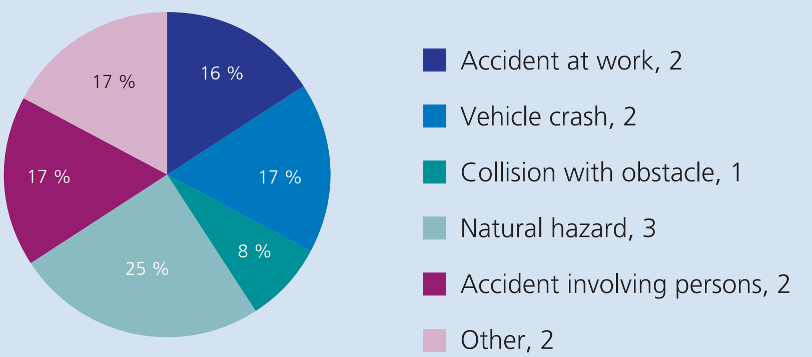
The number of event notifications for railways (excluding trams) requiring clarification was 231. The vast majori-ty were accidents involving persons, with 31 cases subsequently proving to be suicide.

Distribution of event type from the event notifications for trams



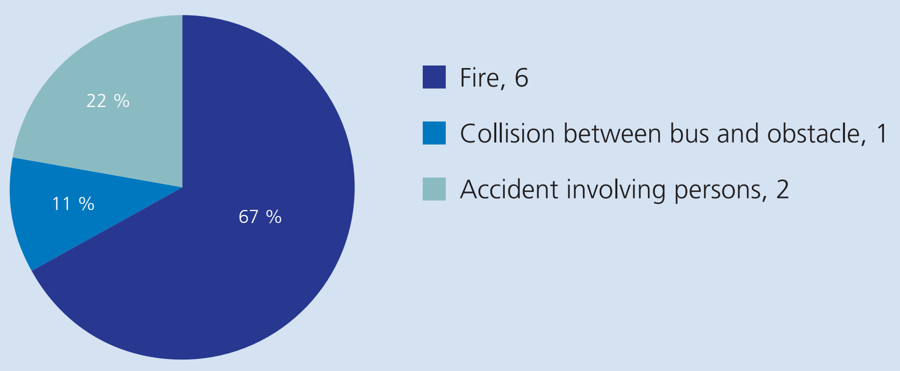
For trams, the majority of the events involved collisions with other road users, whether this was a pedestrian (accident involving persons) or a road vehicle. It should be noted that incidents on public roads that can be attributed to a violation of road traffic regulations are not required to be reported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

Distribution of event type from the event notifications for cableways



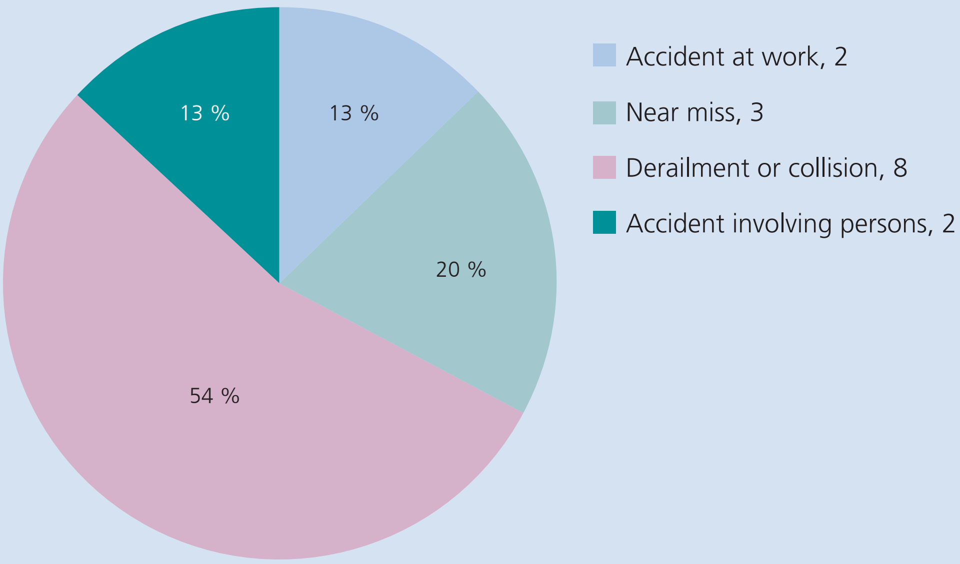
The majority of the 12 incident reports relating to cableways concerned incidents where environmental influences (wind, avalanche, subsidence) were the cause and in 2 cases led to gondola crashes. 2 industrial accidents resulted in one fatally injured and one seriously injured employee.

Distribution of event type from the event notifications for buses



Incidents on public roads that 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 formed the majority of events reported.

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



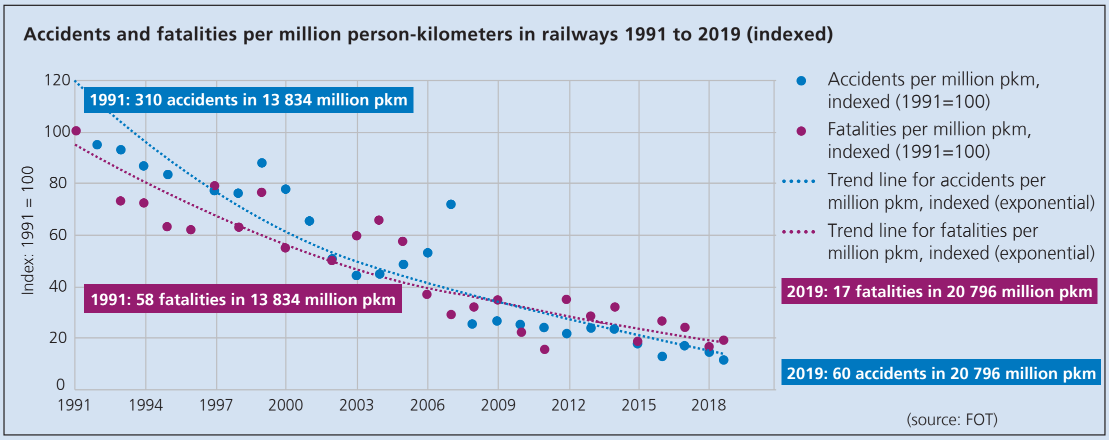
The majority of the 15 investigations opened relate to derailments (3) and collisions (4), followed by near-misses (3) in which no damage occurred, and four industrial and personnel accidents in which persons sustained injuries.

Development of accidents as well as fatally and seriously injured persons in public transport

Modes of transport	Accidents							Fatalities							Seriously injured persons						
	2013	2014	2015	2016	2017	2018	**2019**	2013	2014	2015	2016	2017	2018	**2019**	2013	2014	2015	2016	2017	2018	**2019**
Railways	107	107	83	71	84	73	60	23	27	16	22	21	16	17	65	68	43	22	41	25	23
Trams	54	49	35	36	35	37	71	4	6	5	3	2	7	3	45	37	28	30	50	29	64
Cableways	4	8	10	6	5	6	8	1	3	2	1	0	0	1	3	5	9	6	5	6	9
Buses	39	37	49	42	42	65	70	2	4	5	4	7	5	4	34	39	44	37	39	62	65
Inland navigation	1	3	1	1	1	1	3	0	0	0	0	0	0	0	1	0	0	2	0	0	0
All modes of transport	**205**	**204**	**178**	**156**	**167**	**182**	**212**	**30**	**40**	**28**	**30**	**30**	**28**	**25**	**148**	**149**	**124**	**97**	**135**	**122**	**161**

Over the past 7 years, the number of accidents and fatally and seriously injured persons has shown a decreasing trend. Trams and buses, however, have seen increases in the number of accidents and the number of severely injured persons (source: FOT table). The table shown here contains deviations for some data compared to the table published in the 2018 annual report. The reason for this is subsequent corrections based on additional information regarding the incidents (e. g. suicide findings) received by the FOT after publication of the 2018 annual report.

Development of accidents and fatally injured persons on railways



During the past 28 years, the number of railway accidents and persons fatally injured on the railways has decreased by around one fifth. This is the result of the efforts made by all parties in the overall safety network, including those made by the STSB (source of diagram: FOT).

Annexes

Annex 1: List of the number of notifications, the opened, ongoing and completed investigations and the final reports, interim reports and studies published regarding aviation

Annex 2: List of the number of notifications, opened, ongoing and completed investigations and the final reports, interim reports and studies published regarding public transport and maritime navigation

Annex 3: Statistical information on aviation incidents

Annex 4: Aviation data for statistical analysis (chapter 6) and methods and conceptual considerations used

Annex 1

List of the number of notifications, the opened, ongoing and completed investigations and the final reports, interim reports and studies published regarding aviation

Notifications, opened, ongoing and completed investigations

Aviation						
Year	Number of notifications	Opened investigations	Completed investigations			Ongoing investigations
			total:	with final report:	with summary report:	
2019	1566	64	76	14	62	162
2018	1556	119	83	23[3]	53	156
2017	1259	86	93	30	48	111
2016	1219	92	58	28[4]	31	142
2015	1260	86	33	33	n/a	n/a

Published final reports, interim reports and studies

Number	Registration	Date of incident	Location	Safety recom-mendation	Safety advice
2360	HB-2384	18/07/2018	Amlikon airport (LSPA)	555	
2353	HB-ZKF	16/05/2018	Approximately 600 m north of Raron heliport (LSER)		
2358	HB-IJU	10/01/2018	Zurich airport (LSZH)		27, 28
2351	HB-CQZ	15/11/2017	Sion airport (LSGS)	547	
2350	CS-DLB / HB-3442	15/10/2017	Southwest of Amriswil		24
2338	HB-3359	14/10/2017	Tschuggentälli / Davos		19
2339	HB-PER	04/08/2017	Diavolezza		
2346	HB-1714 / HB-EZX	27/05/2017	Mollis airport (LSMF)		
2352	HB-ZFM / hang glider	28/12/2016	Oberdiessbach		
2343	CS-DXQ / HB-UCM	24/10/2016	3.3 NM north-west of St. Gallen-Altenrhein airport (LSZR)	543	20, 21
2347	D-KVEB	14/09/2016	Côte de Châtel		
2349	T7-FUN / HB-RBG	26/05/2016	Mollis airport (LSMF)	545	23

[3] Includes an interim report
[4] Includes an interim report

Number	Registration	Date of incident	Location	Safety recom-mendation	Safety advice
2313	HB-WAR	13/12/2015	Locarno airport (LSZL)	511, 533, 534	10
ZB	SUI-9903	09/05/2019	Zurich	553, 554	
Status report	HB-HOT	04/08/2018	Piz Segnas		

Published summary reports

Registration	Date of incident	Location	Brief description of incident
HB-3411	21/09/2019	Bern airport (LSZB)	Flight control partially locked
HB-ZNZ	12/03/2019	Bissone	Church tower damaged
N75WU / HB-CDU	27/02/2019	Approximately 3 NM south-west of Willisau radio beacon f(WIL)	Airprox
SUI-9909	25/01/2019	Approximately 500 m north-east of Landiwiese, Lake Zurich	Drone accident
HB-CQW / HB-PES	12/12/2018	Julier pass	Airprox
HB-ODC	08/11/2018	Croix-de-Coeur	Landing incident
F-JSQG	25/10/2018	La Croix de Coeur (LSYQ)	Autogyro take-off accident
HB-KAU	04/10/2018	Grenchen airport (LSZG)	Near miss with a drone
F-JDMN	03/10/2018	Sion (LSGS)	Take-off with tow bar
D-ELOH	30/09/2018	Bad Ragaz airport (LSZE)	Collision on the ground
HB-ZRT / HB-CIE	29/09/2018	Above the former military airfield at Interlaken	Near miss
HB-OUS	26/09/2018	Grenchen airport (LSZG)	Nose-over due to propeller wash from another aircraft
HB-3204	23/09/2018	Ecuvillens airport (LSGE)	Undercarriage not extended during landing
HB-JBA / D-KUHN	18/09/2018	Zurich airport (LSZH), 16 NM north-west	Airprox
HB-RAG	01/09/2018	Thun airport (LSZW)	Severe engine vibration after take-off
N525L	17/08/2018	Kloten VOR	Partial loss of control
HB-TSA	16/08/2018	Lucerne-Beromünster airport (LSZO)	Undercarriage broken off during take-off
HB-KMF	17/07/2018	Fricktal Schupfart airport (LSZI)	Runway excursion on landing
HB-POX	12/07/2018	Hausen a.A. airport (LSZN)	Loss of control on landing, collision with obstacle

Registration	Date of incident	Location	Brief description of incident
HB-KFH	07/07/2018	Schaffhausen airport (LSPF)	Runway excursion on landing
N15YB / HB-3438	30/06/2018	Solothurn region at 6000 ft AMSL	Airprox
HB-RBG	29/06/2018	Birrfeld airport (LSZF)	Overturned after landing
HB-SGT	04/06/2018	Wangen-Lachen airport (LSPV)	Runway excursion on take-off
HB-ZYZ	25/05/2018	Verzasca valley (dam)	Collision with drone
HB-YFR	19/05/2018	Sion airport (LSGS)	Undercarriage retracted on ground
HB-3051	05/05/2018	Bad Ragaz airport (LSZE)	Collision with vehicle on landing
HB-VYS / HB-KLE	01/05/2018	Grenchen airport (LSZG)	Airprox
HB-CCN	07/04/2018	Buttwil	Airprox
ES-PHR	28/10/2017	Geneva airport (LSGG)	Undercarriage damaged
HB-KDM	25/08/2017	Grenchen airport (LSZG)	Collision with obstacle while taxiing
HB-1999	14/04/2017	Rhäzüns	Collision with obstacle on off-field landing
HB-KOW	22/07/2017	Sion airport (LSGS)	Collision with obstacle while taxiing
HB-2360	14/08/2016	Vouvry	Off-field landing by motor glider because the engine could not be restarted
G-EZTY	03/08/2016	Basel-Mulhouse Airport (LFSB)	Smoke in cockpit and passenger cabin
HB-LUL	16/07/2011	Oberhallau	Deliberate collision with obstacle

Annex 2

List of the number of notifications, opened, ongoing and completed investigations and the final reports, interim reports and studies published regarding public transport and maritime navigation

Notifications, opened, ongoing and completed investigations

Public transport and maritime navigation						
Year	Number of notifications	Opened investigations	Completed investigations			Ongoing investigations
			total:	with final report:	with summary report:	
2019	283	15	15	8	7	35
2018	304	14	32	14[5]	17	33
2017	376	25	38	27	12	50
2016	332	64	39	14[6]	26	79
2015	296	87	31	20[7]	13	n/a

Published final reports and interim reports

Number	Mode of transport	Type of accident	Date	Location	Safety recom- mendation	Safety advice
2016042601	Railways	Frontal collision	26/04/2016	Corcapolo		
2016052001	Railways	Collision at an attended level crossing	20/05/2016	Interlaken Ost	138	
2016091601	Railways	Near miss / endangerment	16/09/2019	St. Mar- grethen	145, 146	
2017032201	Railways	Derailment	22/03/2017	Lucerne	139, 140	
2017032902	Railways	Derailment	29/03/2017	Bern		
2017072501	Railways	Accident involving high-voltage current	25/07/2017	Visp	144	
2017112902	Railways	Derailment of train or tram	29/11/2017	Basel	(140)*	21
2019021701	Railways	Derailment of train or tram	17/02/2019	Basel Bad. Bhf	143	19, 20
2019080401_ZB	Railways	Industrial accident	04/08/2019	Baden	141, 142	

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

5 Includes an interim report
6 Includes an interim report
7 Includes two interim reports

Published summary reports

Number	Mode of transport	Type of accident	Date	Location	Safety recom-mendation	Safety advice
2013052801	Railways	Accident involving persons	28/05/2013	Boll-Utzigen		
2015110501	Railways	Runaway train	05/11/2015	Lugano Vedeggio		11, 12
2016061402	Railways	Near miss / endangerment	14/06/2016	Trois-Villes		
2017110601	Railways	Irregularity without immediate danger	06/11/2017	Biel		
2018060301	Inland navi-gation	Running aground	03/06/2018	Weesen		
2018091701	Railways	Collision between train and shunting movement	17/09/2018	Zurich HB	109	
2018092502	Railways	Runaway train	25/09/2018	Realp		
2018112301	Railways	Runaway train / collision	23/11/2018	Chur		
2019052701	Railways	Accident involving persons	27/05/2019	St-Prex		

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:

Accident

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 5700 kg is classified in the "Transport" sub-category of the "Standard" airworthiness category 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 Aircraft accidents and serious incidents involving Swiss-registered aircraft, number of aircraft and fatalities

Year	Number of registered aircraft[8]	Flight hours[9]	Flight personnel licence[10]	Number of accidents investigated	Number of accidents with summary procedure	Total number of accidents	Number of serious accidents		Total number of accidents and serious incidents	Number of fatalities
							incl. airproxes	airproxes investigated[11]		
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[12]	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	12 264	21	16	37	46	16	83	5
2017	3 333	850 525	12 101	25	22	47	32	8	79	18
2018	3 284	872 408	12 027	16	15	31	68	28	99	36
2019	**3 211**	**903 030**	**12 131**	**16**	**7**	**23**	**38**	**13**	**61**	**5**

[8] Source: Federal Office of Civil Aviation
[9] Source: Federal Office of Civil Aviation
[10] Source: Federal Office of Civil Aviation
[11] Incl. airproxes involving foreign-registered aircraft
[12] Due to the revision of the Civil Aviation Act, provisional licences are no longer issued effective from 01/04/2011

3.1.1 Air accidents and serious incidents involving Swiss-registered aircraft exceeding 5700 kg MTOM

Year	Number of registered aircraft[13]	Flight hours[14]	Number of accidents investigated	Number of accidents with summary procedure	Total number of accidents	Number of serious accidents		Total number of accidents and serious incidents	Number of fatalities
						incl. airproxes	airproxes investigated[15]		
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
2017	254	482 135	0	0	0	6	2	6	0
2018	262	499 170	1	0	1	17	10	18	20
2019	**260**	**537 046**	**0**	**0**	**0**	**8**	**3**	**8**	**0**

13 Source: Federal Office of Civil Aviation
14 Source: Federal Office of Civil Aviation
15 Incl. airproxes involving foreign-registered aircraft

3.1.2 Air accidents and serious incidents involving Swiss-registered aircraft up to 5700 kg MTOM

Year	Number of registered aircraft[16]	Flight hours[17]	Number of accidents investigated	Number of accidents with summary procedure	Total number of accidents	Number of serious accidents		Total number of accidents and serious incidents	Number of fatalities
						incl. airproxes	airproxes investigated[18]		
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	3 135	377 723	21	16	37	29	7	66	5
2017	3 079	368 390	25	22	47	26	6	73	18
2018	3 022	374 743	15	15	30	51	18	81	16
2019	**2 951**	**367 537**	**16**	**7**	**23**	**30**	**10**	**53**	**5**

[16] Source: Federal Office of Civil Aviation
[17] Source: Federal Office of Civil Aviation
[18] Incl. airproxes involving foreign-registered aircraft

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

3.2 Summary of accident data for the reporting period 2018 / 2019

3.2.1 Accidents and serious incidents with and without injuries to 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					
	in Switzerland						abroad						in Switzerland					
	Total		of which injuries to persons		of which no injuries to persons		Total		of which injuries to persons		of which no injuries to persons		Total		of which injuries to persons		of which no injuries to persons	
	2019	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018
Total	**47**	90	**5**	9	**42**	81	**14**	9	**1**	3	**13**	6	**15**	25	**3**	1	**12**	24
Aircraft with MTOM of up to 2250 kg	**28**	46	**3**	3	**25**	43	**4**	2	**0**	2	**4**	0	**8**	11	**2**	1	**6**	10
Aircraft with MTOM of 2251–5700 kg	**3**	2	**0**	0	**3**	2	**0**	1	**0**	0	**0**	1	**3**	4	**0**	0	**3**	4
Aircraft with MTOM exceeding 5700 kg	**2**	14	**0**	1	**2**	13	**6**	4	**0**	0	**6**	4	**2**	5	**0**	0	**2**	5
Helicopters	**12**	16	**2**	2	**10**	14	**0**	1	**0**	1	**0**	0	**0**	0	**0**	0	**0**	0
Motor gliders and gliders	**2**	10	**0**	3	**2**	7	**3**	1	**1**	0	**2**	1	**2**	3	**1**	0	**1**	3
Balloons and airships	**0**	2	**0**	0	**0**	2	**1**	0	**0**	0	**1**	0	**0**	1	**0**	0	**0**	1
Ultralight aircraft	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	1	**0**	0	**0**	1

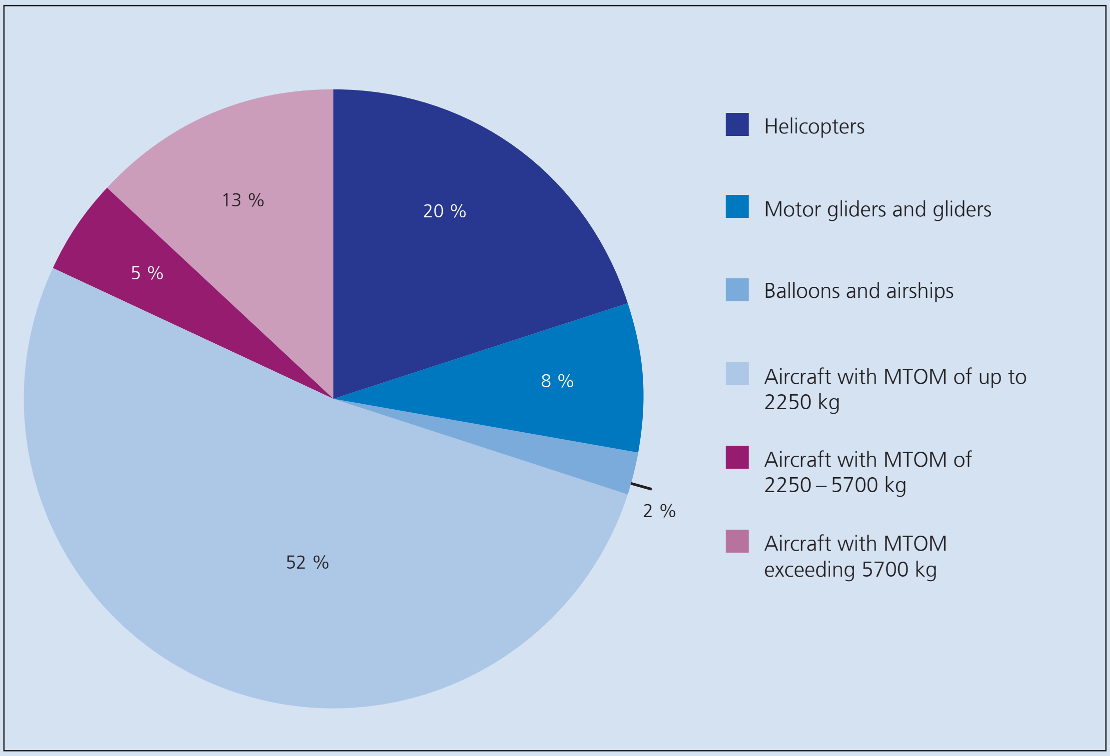
3.2.2 Number of registered aircraft and air accidents / serious incidents involving Swiss-registered aircraft

	Number of aircraft[19] (01/01/2020)		Total number of accidents and serious incidents	
	2019	2018	**2019**	2018
Aircraft with MTOM of up to 2250 kg	**1324**	1349	**32**	49
Aircraft with MTOM of 2250–5700 kg	**146**	162	**3**	3
Aircraft with MTOM exceeding 5700 kg	**260**	262	**8**	18
Helicopters	**345**	335	**12**	16
Motor gliders and gliders	**820**	844	**5**	11
Balloons and airships	**316**	332	**1**	2
Ultralight aircraft[20]	**0**	0	**0**	0
Total	**3211**	3284	**61**	99

[19] Source: Federal Office of Civil Aviation
[20] The number of ultralight aircraft is not collated separately.

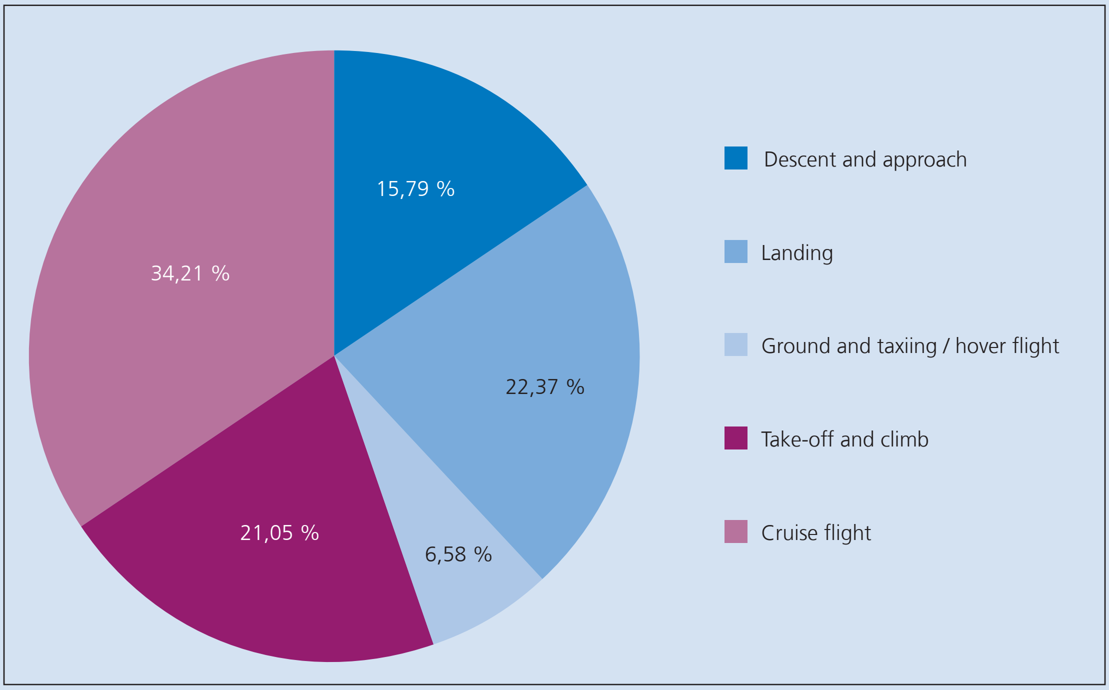
3.2.3 Accidents and serious incidents by type of aircraft involving Swiss-registered aircraft

	2019	2018
Aircraft with MTOM of up to 2250 kg	**52 %**	48 %
Aircraft with MTOM of 2250–5700 kg	**5 %**	3 %
Aircraft with MTOM exceeding 5700 kg	**13 %**	19 %
Helicopters	**20 %**	17 %
Motor gliders and gliders	**8 %**	11 %
Balloons and airships	**2 %**	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	
	2019	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018
Aircraft with MTOM of up to 2250 kg	**3**	12	**10**	10	**13**	12	**4**	8	**10**	17	**40**	59
Aircraft with MTOM of 2250–5700 kg	**2**	0	**1**	2	**1**	1	**2**	2	**0**	3	**6**	8
Aircraft with MTOM exceeding 5700 kg	**0**	1	**1**	7	**6**	7	**2**	8	**1**	0	**10**	23
Helicopters	**0**	0	**1**	9	**3**	3	**4**	1	**4**	3	**12**	16
Motor gliders and gliders	**0**	1	**3**	2	**3**	3	**0**	1	**1**	7	**7**	14
Balloons and airships	**0**	0	**0**	0	**0**	0	**0**	0	**1**	3	**1**	3
Ultralight aircraft	**0**	1	**0**	0	**0**	0	**0**	0	**0**	0	**0**	1
Total	**5**	15	**16**	30	**26**	26	**12**	20	**17**	33	**76**	124



3.2.5 Injured persons by role in accidents and serious incidents involving Swiss-registered aircraft in Switzerland and abroad, and foreign-registered aircraft in Switzerland

	Accidents and serious incidents involving Swiss-registered aircraft in Switzerland															
	Total		Aircraft with MTOM of up to 2250 kg		Aircraft with MTOM of 2250–5700 kg		Aircraft with MTOM exceeding 5700 kg		Helicopters		Motor gliders and gliders		Balloons and airships		Ultra-light aircraft	
	2019	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018
Accidents / serious incidents	**47**	90	**28**	46	**3**	2	**2**	14	**12**	16	**2**	10	**0**	2	**0**	0
Fatalities	**5**	31	**4**	8	**0**	0	**0**	20	**1**	1	**0**	2	**0**	0	**0**	0
Crew	**4**	8	**3**	2	**0**	0	**0**	3	**1**	1	**0**	2	**0**	0	**0**	0
Passengers	**1**	23	**1**	6	**0**	0	**0**	17	**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
Seriously injured persons	**4**	3	**2**	1	**0**	0	**0**	0	**2**	1	**0**	1	**0**	0	**0**	0
Crew	**1**	3	**1**	1	**0**	0	**0**	0	**0**	1	**0**	1	**0**	0	**0**	0
Passengers	**2**	0	**1**	0	**0**	0	**0**	0	**1**	0	**0**	0	**0**	0	**0**	0
Third parties	**1**	0	**0**	0	**0**	0	**0**	0	**1**	0	**0**	0	**0**	0	**0**	0

	Accidents and serious incidents involving Swiss-registered aircraft abroad															
	Total		Aircraft with MTOM of up to 2250 kg		Aircraft with MTOM of 2250–5700 kg		Aircraft with MTOM exceeding 5700 kg		Helicop-ters		Motor gliders and gliders		Balloons and airships		Ultra-light aircraft	
	2019	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018
Accidents / serious incidents	**14**	9	**4**	2	**0**	1	**6**	4	**0**	1	**3**	1	**1**	0	**0**	0
Fatalities	**0**	7	**0**	3	**0**	0	**0**	0	**0**	4	**0**	0	**0**	0	**0**	0
Crew	**0**	6	**0**	2	**0**	0	**0**	0	**0**	4	**0**	0	**0**	0	**0**	0
Passengers	**0**	1	**0**	1	**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
Seriously injured persons	**1**	0	**0**	0	**0**	0	**0**	0	**0**	0	**1**	0	**0**	0	**0**	0
Crew	**1**	0	**0**	0	**0**	0	**0**	0	**0**	0	**1**	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

	Accidents and serious incidents involving foreign-registered aircraft in Switzerland															
	Total		Aircraft with MTOM of up to 2250 kg		Aircraft with MTOM of 2250–5700 kg		Aircraft with MTOM exceeding 5700 kg		Helicop-ters		Motor gliders and gliders		Balloons and airships		Ultra-light aircraft	
	2019	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018	**2019**	2018
Accidents / serious incidents	**15**	25	**8**	11	**3**	4	**2**	5	**0**	0	**2**	3	**0**	1	**0**	1
Fatalities	**6**	2	**4**	2	**0**	0	**0**	0	**0**	0	**2**	0	**0**	0	**0**	0
Crew	**4**	1	**2**	1	**0**	0	**0**	0	**0**	0	**2**	0	**0**	0	**0**	0
Passengers	**2**	1	**2**	1	**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
Seriously injured persons	**1**	0	**1**	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	**1**	0	**1**	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

Aviation data for statistical analysis (chapter 6) and methods and conceptual considerations used

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 addressed, but also 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 changes over this time period. As exposure generally fluctuates to a lesser extent than the number of accidents, the advantage of using 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 the 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 the FOCA's air traffic movement statistics are included as a component part of the measure of accident statistics. This situation is taken into account in these 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 cannot therefore count them; in order to be consistent, the corresponding exposure must not be included in the measure. These accident statistics take this situation into account, too.

Accident
For an aviation event to be classified as an accident for the purpose of these 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. In this 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

[21] Here, exposure is equivalent to the number of air traffic movements.
[22] (EU) Regulation No. 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC.

being looked at would be higher and it would be easier to make statistical statements. However, these statements would more likely describe the reporting system and reporting culture, rather than safety.

Air traffic movement

Air traffic movements are used to quantify the exposure for the accident statistics. Figures for air traffic movements are provided by the FOCA. The 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 the FOCA. The following types of air traffic movements are not recorded in the FOCA's data collection:

- Movements on certain military airfields;
- Movements on open terrain, for example, off-field 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 the FOCA, but are not included in the STSB's analysis. This airport is not in 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

The following three aircraft categories have been analysed:

- Aeroplanes with a maximum take-off mass of up to 5700 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 5700 kg (in particular for commercial aircraft) as well as for airships and balloons, no statistics are produced due to the sample sizes being too small.

Statistical method

The number of accidents U_t in the year t=2007,...,2019, 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. The β_0, β_1 coefficients are estimated using the maximum likelihood method within the generalised linear model framework. For all adapted models, the null hypothesis $\beta_1 = 0$ is tested in each case. This corresponds to the statement "no change in the anticipated number of accidents" over time. The test result is given by the p-value. This parameter in the interval [0,1] states how compatible the observed data are with the claim of the null hypothesis (the bigger, the more compatible). The commonly used threshold, which is also used here, is 0.05. Which means: If the p-value is less than 0.05, the change in the number of accidents is called "significant". If the p-value is equal to or greater than 0.05, then the change is called "not significant".

A Poisson-rate model is used to estimate the accident rate. Here, the development of the accident rate, to which a logarithm is continuously applied, is described using a linear model, i. e.

$$\log\left(\frac{U_t}{n_t}\right) = \beta_0' + \beta_1' \cdot t$$

In this case U_t remains the accident rate in year t. In addition, n_t is the population size, i. e. the number of flight movements in year t. We regard the latter as a fixed observation value and therefore convert to:

$$\log(U_t) = \log(n_t) + \beta_0' + \beta_1' \cdot t$$
$$\Leftrightarrow$$
$$U_t = n_t \cdot \exp(\beta_0' + \beta_1' \cdot t)$$

Here, the population size n_t is used as an offset in the generalised linear model. That means the impact of the population size on the accident is assumed to be directly proportional without estimating a coefficient for this. Thus, we remain conceptually in the framework of the Poisson regression; after all, it is still true that:

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

The parameter λ_t' here is now the exposure-corrected anticipated number of accidents per year. Again, the model is estimated using maximum likelihood estimation in the generalised linear model framework. it is even more important that the accident rate's development over time can be deduced from the parameter β_1'. In practice, the number of accidents changes from one year to the next by coefficient $\exp(\beta_1')$. If β_1' is negative, the accident rate decreases and if β_1' is positive, the rate increases. Just as for the number of accidents, it is possible to make statements about the significance of this change, i. e. again, the null hypothesis $\beta_1 = 0$ is tested for all adjusted models, which is equivalent to the statement "no change in anticipated accident rate" over time. The test result is given by the p-value. This parameter in the interval [0,1] states how compatible the observed data are with the claim of the null hypothesis (the bigger, the more compatible). The commonly used threshold, which is also used here, is 0.05. Which means: If the p-value is less than 0.05, the change in the number of accidents is called "significant". If the p-value is equal to or greater than 0.05, then the change is called "not significant".

NB) The accident rate is reported extrapolated to 1 million (gliders and helicopters 100 000) flight movements for easier readability (see tables below).

Data and results of calculations (diagrams in chapter 6)

Motorised aircraft with maximum take-off mass of 5700 kg:

Year	Number of aircraft movements[23]	Number of accidents	Calculated accident rate	Calculated anticipated number of accidents	Calculated anticipated accident rate
2007	629 832	3	4.7632	3.3265	5.1531
2008	627 766	6	9.5577	3.4164	5.3615
2009	651 750	2	3.0687	3.5087	5.5782
2010	607 247	4	6.5871	3.6035	5.8037
2011	654 056	4	6.1157	3.7009	6.0383
2012	591 433	3	5.0724	3.8009	6.2824
2013	579 790	1	1.7248	3.9036	6.5364
2014	603 166	4	6.6317	4.0091	6.8007
2015	589 495	7	11.8746	4.1174	7.0756
2016	552 385	1	1.8103	4.2287	7.3617
2017	570 363	7	12.2729	4.3430	7.6593
2018	562 371	5	8.8909	4.4603	7.9689
2019	552 945	4	7.2340	4.5809	8.2911

[23] The number of aircraft movements shown in the table differs in some years slightly from the values published in the 2018 annual report. The reason for this is corrections made by the FOCA based on registrations. The deviation has no influence on the results presented in chapter 6.1.

Gliders:

Year	Number of aircraft movements[24]	Number of accidents	Calculated accident rate	Calculated anticipated number of accidents	Calculated anticipated accident rate
2007	95 132	2	2.1023	4.8029	5.2505
2008	86 438	8	9.2552	4.3273	4.8777
2009	86 444	3	3.4705	3.8988	4.5314
2010	77 286	2	2.5878	3.5128	4.2097
2011	86 634	4	4.6171	3.1650	3.9108
2012	74 474	6	8.0565	2.8516	3.6332
2013	71 066	2	2.8143	2.5692	3.3753
2014	79 487	0	0.0000	2.3148	3.1356
2015	78 136	1	1.2798	2.0856	2.9130
2016	65 755	4	6.0832	1.8791	2.7062
2017	67 121	2	2.9797	1.6931	2.5141
2018	67 438	1	1.5435	1.5254	2.3356
2019	63 467	1	1.5756	1.3744	2.1698

[24] The number of aircraft movements for 2018 differs by one unit from the value published in the 2018 annual report. The reason for this is corrections made by the FOCA based on registrations. The deviation has no influence on the results presented in chapter 6.1.

Helicopters:

Year	Number of aircraft movements	Number of accidents	Calculated accident rate	Calculated anticipated number of accidents	Calculated anticipated accident rate
2007	155 579	2	1.2855	3.2291	1.9972
2008	166 628	2	1.2003	3.1749	1.9610
2009	184 304	4	2.1703	3.1216	1.9255
2010	150 751	4	2.6534	3.0692	1.8907
2011	153 923	3	1.9490	3.0177	1.8564
2012	160 267	4	2.4958	2.9670	1.8228
2013	156 857	4	2.5501	2.9172	1.7898
2014	167 358	2	1.1950	2.8682	1.7574
2015	166 314	2	1.2025	2.8201	1.7256
2016	159 764	3	1.8778	2.7727	1.6944
2017	161 411	5	3.0977	2.7262	1.6637
2018	171 325	2	1.1674	2.6804	1.6336
2019	164 451	1	0.6081	2.6354	1.6040

All categories:

Year	Number of aircraft movements	Number of accidents	Calculated accident rate	Calculated anticipated number of accidents	Calculated anticipated accident rate
2007	n/a	7	n/a	11.0265	n/a
2008	n/a	16	n/a	10.7708	n/a
2009	n/a	9	n/a	10.5210	n/a
2010	n/a	10	n/a	10.2770	n/a
2011	n/a	11	n/a	10.0387	n/a
2012	n/a	13	n/a	9.8058	n/a
2013	n/a	7	n/a	9.5784	n/a
2014	n/a	6	n/a	9.3563	n/a
2015	n/a	10	n/a	9.1393	n/a
2016	n/a	8	n/a	8.9273	n/a
2017	n/a	14	n/a	8.7203	n/a
2018	n/a	8	n/a	8.5181	n/a
2019	n/a	6	n/a	8.3205	n/a



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