Swiss Transportation Safety Investigation Board STSB
Annual Report 2017


Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Swiss Transportation Safety Investigation Board STSB

Imprint
Swiss Transportation Safety Investigation Board STSB

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Images Fotolia

Edition 100

Published in German, French, Italian and English

6/2018

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1 Editorial

It is impossible to do it all. Therefore, it is all the more important to do the right things.

In 2017, the Investigation Bureau at the Swiss Transportation Safety Investigation Board (STSB) received 1,635 notifications concerning accidents and serious incidents during railway, cableway and public bus operation as well as in aviation, inland and maritime navigation. In-depth investigations were initiated in 111 cases. This means that sufficient potential for prevention through further investigations was seen in only about one in fifteen cases.

After an initial analysis of the facts, the decision to either initiate an in-depth investigation or to shelve the file is of crucial importance. Investigation Bureau staff need to make these decisions several times a day. A wrong decision can have far-reaching consequences. It may mean that an undue amount of resources is put into investigation-related activities. It might however be much more serious, as it could mean missing the chance to learn from the circumstances of an event and to feed back this knowledge into the industry – ultimately meaning that a future accident cannot be prevented because of a wrong decision.

Hence, the Investigation Bureau bears a lot of responsibility. Therefore, it has a team of highly competent and very experienced staff, who make their decisions independent of any outside influence; based on facts, but in the end also to the best knowledge and belief of each individual person. This is only possible in an independent organisation like the STSB, with framework conditions that support the work of the investigators.

It is the task of the STSB's extra-parliamentary board to constantly review these framework conditions and to adapt them as much as possible and necessary. Action was required in the development of the organisation with regard to the merger of the investigation bureaus for aviation, public transport and maritime navigation, which previously operated separately.

The focus was on giving more consideration to the special responsibilities assumed by the office holders of an independent organisation and thereby on strengthening governance. The appropriate measures were initiated by separating the roles of the Director of the Investigation Bureau and the Head of Division.

With this, the STSB Investigation Bureau has a future-proof leadership structure with even clearer role allocations and more focused responsibilities. We are convinced that this has created a good basis for the Investigation Bureau, also helping them to come to excellent decisions on event notifications in the future and thereby helping them to do the right thing – which ultimately allows them to make an important contribution to transport safety through professional safety investigations.

Pieter Zeilstra
President of the extra-parliamentary board

2 Management summary

In 2017, a total of 1,635 notifications concerning accidents and hazardous occurrences were received by the STSB. An analysis of these notifications led to 111 safety investigations being opened. 60 investigations were carried out into accidents and serious incidents and a further 71 summary investigations into events of lesser significance. As part of its investigations, the STSB issued a total of 38 safety recommendations and 8 safety advices during 2017.

The reporting year was characterised by an average number of accidents and hazardous situations in the sectors of public transport and aviation. The number of people harmed in accidents involving aircraft with a maximum permissible take-off mass of less than 5,700 kg was above average.

In the categories motorised aircraft with a take-off mass up to 5,700 kg and helicopters, the accident rates increased in 2017, albeit not significantly. The accident rate of gliders decreased not significantly. As in the previous year, there were again airproxes between manned and unmanned aircraft (drones) in 2017.

From 2016 to 2017, the number of accidents in public transport increased from 156 to 167. The increase occurred at the railways. With all other modes of transport, the number of accidents remained approximately the same. The number of fatalities was almost unchanged across all modes of transport; the number of people who were seriously injured increased from 97 to 135 in comparison to the previous year.

This annual report includes, among other things, a summary of all the safety recommendations and pieces of safety advice that were issued by the STSB in 2017. A short introduction and a statement of the reasons why they were addressed to the appropriate supervisory authority or the relevant stakeholders have been

added. Details on the progress of implementation are also given – where these are already available – for each safety recommendation.

Based on the statistics, the analysis of significant data over a period of several years has been continued. It is thus possible to show the development of the accident figures and accident rates concerning motorised aircraft with a maximum permissible take-off mass of less than 5,700 kg for the period between 2007 and 2017, for helicopters and for gliders. With regard to railways accidents, the notifications were evaluated according to various event types. The annual report also explains the methodology which was used for this evaluation.

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

3 Board

3.1 Personnel and organisation

The number of investigators for aviation incidents was unchanged in 2017. A vacancy in railways and inland navigation that had existed since the autumn of 2016 was filled by hiring a new investigator. 7 new part-time investigators were commissioned on a freelance basis. A total of 6 long-standing part-time investigators retired during the reporting year. At the end of 2017, the STSB had 116 part-time investigators with specialist expertise across all modes of transport which may be subject to an investigation.

A new senior manager joined the STSB as Head of Central Services in September 2017. The job of Director of the Investigation Bureau was advertised at the end of 2017. The Board's preventative analysis of organisation-related risks determined that the roles of Director of the Investigation Bureau and the Head of Division should not and cannot be fulfilled by the same person. With this step, more consideration was given to the special responsibilities assumed by the office holders of an independent organisation, and this also strengthens governance. This concludes the development of the organisation with regard to the merger of the investigation bureaus for aviation, public transport and maritime navigation, which previously operated separately.

There was again a training course in work safety at accident sites for the STSB investigators and part-time investigators who work on accident sites in the field of aviation. In addition, staff were offered a pilot course in psycho-social emergency care. Furthermore, knowledge regarding interviewing techniques was enhanced as part of a workshop.

3.2 Finances

In the reporting year, the Swiss Transportation Safety Investigation Board had a budget of 8.21 million Swiss francs at its disposal. Of this, 7.51 million francs were actually used, which includes the entire personnel and operations expenditure. Nearly 0.7 million francs were not used as not all staff positions were filled, purchases were postponed and the investigation expenditure, for external expertise for example, was under 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. The work of the STSB is therefore almost exclusively publicly funded. All STSB products, in particular the final reports of investigations, are provided free of charge on the Internet, for example. Printed and bound copies of these reports can be purchased for a fee individually or by subscription if required. The sale of these printed products generated a total of 38,250 francs in 2017 and represented the STSB's only regular external source of income.

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

Projects and initiatives

- Redesign of the processes for major accidents in civil aviation and public transport
- Improvement of the analysis methods
- Adjustment of content, level of detail and scope of investigations and final reports

The milestones planned for these initiatives were reached and the projects are expected to be completed by the end of 2018.

Performance targets

Targets and indicators	2016 ACTUAL	2017 TARGET	2017 ACTUAL	2018 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
Quick 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. In this context, completed means that the investigative activities are finished and the draft of the respective report is ready for comment or the final quality control.				
Investigations into serious incidents and accidents involving aircraft with a take-off mass of less than 5,700 kg completed within 12 months (%, minimum)	64	70	60	80
Investigations into serious incidents and accidents involving railways, boats and buses with a federal licence completed within 12 months (%, minimum)	55	60	72	70

Targets and indicators	2016 ACTUAL	2017 TARGET	2017 ACTUAL	2018 PLAN
Investigations into serious incidents and accidents involving aircraft with a take-off mass of more than 5,700 kg completed within 18 months (%, minimum)	88	75	78	80
Summary investigations into serious incidents and accidents involving aircraft completed within 2 months (%, minimum)	44	70	40	70
Summary investigations into serious incidents and accidents involving railways, boats and buses completed within 2 months (%, minimum)	58	60	30	65

The performance targets were partially achieved. There were great discrepancies in the following areas, concerning quick completion of safety investigations:

Most of the summary investigations could not be completed within two months. This is not a statutory period of time. In addition, it often took longer than expected to establish the required facts. As this part of the investigation can hardly be influenced, the internal processes were simplified to shorten the summary investigation procedure this way.

It was not yet possible to complete 70 % of the investigations into serious incidents and accidents involving aircraft with a take-off mass of up to 5,700 kg within one year as stipulated, because there were significantly more serious incidents in the last two years than in the years before. It was however possible to increase the total number of completed incident investigations compared to the previous year, and there is a plan in place to decrease the number of pending cases.

4 Investigation Bureau

4.1 Overview of investigation findings

During 2017, the STSB received a total of 1,635 notifications concerning accidents and hazardous occurrences. In fact, the number of notifications has steadily increased over the last few years. Safety investigations were opened in 111 cases, i.e. for approximately 7 % of notifications. In total, 131 investigations into accidents and serious incidents were completed. These included 71 summary investigations into incidents of lesser significance. 57 final reports (see Annexes 1 and 2) and 60 summary reports were published. As part of its investigations, the STSB issued a total of 38 safety recommendations and 8 pieces of safety advice during 2017. At the end of the year, 161 investigations were still in progress.

93 investigations concerning aviation incidents were completed. 30 final reports (see Annex 1) and 48 summary reports were published. With regard to aviation, 15 safety recommendations and 3 safety advices were issued. At the end of the year, 111 investigations were in progress.

For the five modes of transport railways, cableways and buses as well as inland and maritime navigation, 38 investigations were completed as well as 27 final reports and 12 summary reports published in the reporting year. In 2017, a total of 23 safety recommendations in final reports as well as five pieces of safety advice were issued. At the end of the year, 50 investigations were in progress concerning railways, cableways and buses as well as inland and maritime navigation.

4.2 Overview by mode of transport

Aviation

In 2017, 1,259 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. Based on these preliminary enquiries, a total of 44 investigations into accidents were opened and 42 investigations into serious incidents. These included 8 airproxes with a high or considerable risk of collision. An extensive investigation was opened for 34 incidents, whilst the initial investigation findings suggested a summary investigation for 52 events.

In 2017, there were 45 accidents on Swiss territory involving aircraft with a maximum permissible take-off mass of up to 5,700 kg. Here, 13 occupants were fatally injured, and 12 occupants seriously injured. With regard to aircraft with a maximum permissible take-off mass exceeding 5,700 kg, investigations into 12 serious incidents were opened. In two cases, there were problems with pressurising the cabin. In 2 other cases, a strong development of suspected toxic gases or smoke was detected on board, resulting in a return to the point of departure or an emergency landing.

Given the fact that the number of unmanned aircraft (drones) used in Switzerland is continuing to increase, there were also airproxes with other aircraft in the reporting year. In one case, where a wide-body aircraft approaching Zurich Airport narrowly missed a drone, a summary investigation was carried out.

Railways

In 2017, 342 events relevant to safety on the railways were reported, 30 of which concerned trams. In 47 cases, an investigator attended the scene. An investigation was opened in 22 cases.

The events of greater significance include, in chronological order, the derailment of an ETR 610 in Lucerne (LU) on 22 March 2017, the derailment of a city train (S-Bahn) in Bern (BE) on 29 March 2017, the collision between a shunting movement and a railroad excavator in Samstagern (ZH) on 13 July 2017, the collision between a locomotive and passenger carriages in Andermatt (UR) on 11 September 2017, a runaway vehicle on the Alp Grüm (GR) on 19 September 2017 and the derailment of an ICE in Basel (BS) on 29 November 2017.

In the events reported to the STSB, 69 people sustained minor injuries and 19 were seriously injured. One railway company employee was fatally injured, 8 were seriously injured and 12 sustained minor injuries. In the sector of railways (incl. trams) another 22 people were fatally injured, 34 seriously injured and 31 sustained minor injuries. The most common cause of accidents involving people is careless behaviour by individuals crossing the tracks in a manner that is not permitted. Transport or infrastructure companies can exert virtually no control over such incidents.

Cableways

10 notifications concerning cableways were received. In one case, investigators attended the scene. In one case, an investigation was initiated. The investigation concerned a vehicle crash.

1 passenger was seriously injured, and 3 sustained minor injuries in the reported events. 2 staff members of cableways companies suffered serious injuries and one suffered minor injuries. Besides passengers and staff members, no other people sustained minor or serious injuries. Most frequently, passengers suffered injuries while entering or leaving a cableway.

Buses

The STSB was alerted to 18 incidents concerning buses. In one case, the investigator attended the scene. No investigations were initiated in any of the cases.

1 passenger was seriously injured, and 21 sustained minor injuries in the reported events. One bus company employee suffered serious injuries and one employee minor injuries. 2 other people were fatally injured, 2 seriously injured and one suffered minor injuries. 8 out of the 18 events were related to a fire in which nobody was hurt. Most of the injuries to persons were the result of buses colliding with other means of transport.

Inland navigation

In 2017, the STSB was alerted on 3 occasions. An investigation was opened in 2 cases.

The two events are the collision between a motor ship (MS) and the embankment in Zug Bahnhofsteg (ZG) on 17 September 2017 and the running aground of MS Diamant at Kehrsiten (LU) on 7 December 2017.

No passengers or staff members of the shipping companies were harmed, but 2 other people sustained minor injuries.

Maritime navigation

During 2017, three incidents involving maritime navigation ships sailing under the Swiss flag were reported to the STSB. In one case, a tanker carrying chemicals ran aground. However, this did not cause any damage to the environment or major damage to the ship. During a manoeuvre in a harbour, a multipurpose cargo ship collided with a cargo ship that was moored to the pier, without causing major damage to the ships or to the environment. When this multipurpose freight ship continued its journey, it collided a little later on with another moored ship. There was no significant damage and no injuries to people in this case either. Nobody was injured in any of these cases and the situation did not justify the opening of a safety investigation from the point of view of preventing further incidents.

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, state-run safety investigation body also exists, which is expected to impartially clarify the reasons for an accident or a serious incident. Since the introduction of the EU Safety Directive, this also applies to incidents on the railways in EU countries. Because of the 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), which is to provide uniform and binding rules on aviation safety in the European aviation sector on behalf of the member states. Since that time, EASA has increasingly exercised its authority, particularly in the areas of technology, flight operation, air traffic control and aerodromes. 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 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 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) sets only general standards, but also declares 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), as per 1 February 2015 (SR 742.161). The OSITI implements the EU Safety Directive (2004/49/EC) equivalently into Swiss law. This EU Safety Directive is part of the Annex to the agreement between the Swiss Federation and the European Union on the carriage of goods and passengers by rail and road. However, the EU revised the Safety Directive completely in 2016. Thus, certain enforcement responsibilities should now be assumed by the EU authorities. If Switzerland followed this development, it would be conceivable that certain recommendations from the STSB concerning the railways would also be addressed to the EU authorities in future.

Safety objectives and requirements for cableways installations and their operation are regulated by EU cableways Directive 2000/9/EC dated 20 March 2000. 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. This is intended to reduce the risk of accidents at sea, the pollution of the seas through maritime navigation and the loss of human life at sea. EMSA advises the European Commission on technical and scientific matters concerning the safety of maritime traffic and in relation to preventing the pollution of the seas by ships. It plays a part in the ongoing development and updating of legislative acts, the monitoring of their implementation and in assessing the efficacy of existing measures. However, it has no authority to issue directives over Switzerland. Any safety recommendations from the STSB are therefore addressed to the Swiss Maritime Navigation Office as the national supervisory authority.

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

- **Implemented:** Measures have been adopted which are very likely to significantly reduce or eliminate the identified safety deficit.
- **Partially implemented:** Measures have been adopted which are very likely to slightly reduce the safety deficit or eliminate it in part, or a binding implementation plan with

a defined timeline is at hand and has been initiated which is very likely to lead to a significant reduction in the safety deficit.
– **Not implemented:** No measures have been adopted which have led or will lead to any noteworthy reduction in the safety deficit.

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 and 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 pieces of safety advice issued by the STSB in interim or final reports during 2017 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. At the end of each safety recommendation, the implementation status as at the end of February 2018 can be found. 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 a commercial aircraft during its approach to Basel Airport, 20/07/2014

During the descent phase of an Airbus A319-111, the change of reference of the target speed, from MACH to kt, was not performed and the aircraft's speed progressively increased until it reached the maximum permitted operating speed VMO. The pilot reacted by pulling sharply on the side stick, inducing a load factor of 2.33 g. Three of the four cabin crew members were thrown to the floor and one of them suffered a serious injury to the left ankle.

Safety deficit
The OVERSPEED PREVENTION and OVERSPEED RECOVERY procedures recommend maintaining the automated functions and allowing the overspeed protection to perform its function, even at the risk of exceeding the VMO limit. For a pilot, the concept of a "limit" is usually perceived as an absolute maximum which must not be exceeded; conditioned by this concept of danger, his first reflex may be to seek to avoid it.
The overspeed prevention and overspeed recovery procedures are not categorised as memory items, i.e. those which must be applied without referring to paper documentation. In both cases, flight situations are very dynamic, or even critical, and applying such procedures according to the "read and do" principle should be excluded.

Safety recommendation no. 524, 19/10/2017
The European Aviation Safety Agency (EASA) should ensure that consideration is given by the manufacturer with a view to increasing awareness of, and training in, overspeed situations for flight crews of Airbus A320 series aircraft.

Implementation status
EASA acknowledged safety recommendation no. 524 on 4 December 2017. Awaiting response.

Near miss involving two F/A-18 fighter aircraft and a civilian aircraft in the region of Kerzers, 21/11/2014

Payerne radar handed over two F/A-18C military jets to the Payerne Arrival approach control centre to guide them to runway 23 for an instrument approach and, to this end, they communicated on the Payerne arrival frequency.

At the same time, the pilot of a civilian aircraft contacted Payerne Tower requesting transit permission for the terminal control area (TMA) towards La Chaux-de Fonds. At

this time, the F/A-18C leader was flying the downwind approach at 5,000 ft, followed by the trailer.

Shortly afterwards at the same altitude, the leader flew past the civilian aircraft at a distance of 0.4 NM.

Safety deficit
The investigation showed that for flights under instrument flight rules (IFR) at an air force base with high traffic volume, which allows visual flights to transit the TMA without contacting air traffic control, the TMA's inappropriate airspace classification constitutes a safety deficit.

Safety recommendation no. 512, 28/08/2017
The Federal Office of Civil Aviation (FOCA) should take measures to ensure IFR traffic is safe from other air-space users in the area surrounding Payerne Airport.

Implementation status (FOCA letter from 07/11/2017)
Before taking any measures, a risk assessment must be carried out. This assessment must list the risks and the appropriate mitigations as well as potential negative effects on the overall system. FOCA will carry out this assessment in 2018 together with the stakeholders. The problem addressed by the safety recommendation is to be analysed in the process. The aim is to reduce the risk associated with operations to an acceptable range.

Accident involving a commercial aircraft when landing at Zurich Airport, 04/12/2014

On 4 December 2014, the ATR 72-202 commercial aircraft, registered as D-ANFE, was approaching Zurich Airport (LSZH) with two pilots, two female flight attendants and 26 passengers on board. The commercial aircraft touched down on runway 14 in a light northerly wind. After the nose wheels had come into contact with the runway approximately 1,050 m after the threshold, both tyres separated from the wheel rims in such a way that the nose landing gear continued to skid on only the wheel rims from approximately 1,520 m after the runway threshold.

Safety deficit
During the investigation, the valve input lever of the hydraulic differential control selector valve (DCSV) was found to be attached rotated by 180°. The design of the freely rotating input lever was identified as a contributory factor in the accident. Back in May 2009, a similar incident occurred involving a different airline in New Zealand, in which the valve input lever being attached rotated by 180° was the cause. Thereafter, the aircraft maintenance manual was supplemented. The most recent incident from 25 August 2015 involving yet another airline in Brazil, the cause of which could also be attributed to the valve input lever being attached rotated by 180°, clearly shows that the risk of incorrect assembly has still not been eliminated.

Safety recommendation no. 529, 16/06/2017
Together with the aircraft manufacturer, the European Aviation Safety Agency (EASA) should ensure that it is no longer possible to incorrectly attach the valve input lever of the hydraulic differential control selector valve (DCSV).

Implementation status
Not implemented. The European Aviation Safety Agency (EASA) has assessed the incident as well as the problem addressed in the safety recommendation in collaboration with the aircraft manufacturer and has come to the following conclusion: The aircraft involved in the incident had been operating for several months without any steering problems being reported and without maintenance being carried out in the corresponding section of the aircraft. There was no evidence that the required functional check following the replacement of the hydraulic differential control selector valve (DCSV) was carried out.
During the certification of the ATR aircraft, the loss of nose wheel steering was classified as 'minor'. The contribution of the hydraulic DCSV's valve input lever in such an incident is minor. The movement of the nose landing gear would only be restricted at low speeds and a large steering angle – both of which are common for the area near the gate. Meanwhile, ATR has adapted the relevant component maintenance manual (CMM) and job instruction card (JIC), and added a warning for the attachment of the control valve. Considering this, EASA will take no further steps with regards to this problem. For this reason, the STSB believes the present safety deficit still exists. Therefore, the safety recommendation is considered as not implemented.

Accident involving a helicopter in Erstfeld, 26/02/2015

During the approach to the operations base, the pilot of an AgustaWestland AW109SP helicopter reduced the helicopter's forward speed whilst maintaining the rate of descent. The pilot continuously raised the collective to reduce the rate of descent. However, it did not reduce. During the transition from forward flight to hover, the helicopter's power requirement increased. At a forward speed of less than 20 kt, the rate of descent increased from 1,100 ft/min to more than 1,300 ft/min in the final seconds before impact and could no longer be controlled. Eventually, the helicopter hit the ground in a meadow next to the operations base. Three of the four occupants were injured and had to be admitted to hospital.

Safety deficit
It was determined that a causal factor for the accident was the pilot failing to notice that the rate of decent was too high during the final approach to the operations base.

Safety recommendation no. 525, 08/06/2017
The Federal Office of Civil Aviation (FOCA) and the European Aviation Safety Agency (EASA) should take measures to ensure that helicopter crews are alerted to the danger of an impending or developing vortex ring state close to the ground by an acoustic warning.

Implementation status
Not implemented. FOCA advised that it did not have any authority regarding this topic. The safety recommendation could only be dealt with by the relevant certification authorities, i.e. EASA.
EASA advised that it agreed with the intention behind the safety recommendation and it was in the process of clarifying the feasibility of such a measure from a technical point of view.

Safety deficit
This investigated accident concerned the collision of a helicopter with the ground, whose impact was, in principle, survivable for the occupants due to the acting forces. The helicopter type was fitted with impact-attenuating seats to prevent injuries. Despite this, two crew members and one passenger sustained serious back injuries. The investigation has shown that the seats were neither defective nor did they have any manufacturing or design faults. They had been certified in accordance with current regulations and fulfilled the approval requirements. The reason for the aircraft occupants' injuries was that the dynamics of the impact were significantly different from those the protection system was designed for. It is therefore doubtful whether the approval test is sufficiently realistic as it is based on only one possible scenario. At least regarding this investigated accident, the test scenario appears to be inadequate as the seats should have absorbed the forces involved.

Safety recommendation no. 530, 08/06/2017
The Federal Office of Civil Aviation (FOCA) and the European Aviation Safety Agency (EASA) should examine whether the test procedures for impact-attenuating seats in the AgustaWestland AW109SP helicopter type conform to the actual conditions arising in a crash that is in principle survivable. If necessary, the testing and approval requirements should be improved so that the seats offer sufficient protection in accidents of this type.

Implementation status
Not implemented. FOCA is of the opinion that the safety recommendation can only be processed by the relevant certification authority, i.e. EASA.

EASA pointed out that the AW109SP helicopter type meets all the current applicable resistance demands with regards to an impact that can occur during an accident, which is in principle survivable, or an emergency landing. Possible recommendations for the certification authorities are developed as part of the Rotorcraft Occupant Protection Working Group (ROPWG) of the Aviation Rulemaking Advisory Committee (ARAC), which EASA is also involved in. Amongst other things, these recommendations relate to improving chances of survival in accidents. EASA wants to wait for the results of this working group and, where applicable, incorporate them in new rules and guidelines concerning aircraft which are manufactured and approved in Europe.

Safety deficit
In the approximately four years prior to the accident, the aviation company had recorded 15 cases in which the acceleration sensors of the ARTEX C406-N HM type emergency location transmitter (ELT) were not functioning during routine checks and therefore needed to be repaired.
In this investigated accident, the emergency location transmitter of the same type did not work because all six acceleration sensors were defective.

Safety recommendation no. 531, 08/06/2017
The Federal Office of Civil Aviation (FOCA) and the European Aviation Safety Agency (EASA), together with the manufacturers of the AgustaWestland AW109SP helicopter type and the ARTEX C406-N HM emergency locator transmitter, should take appropriate measures to ensure the functioning of the aforementioned emergency locator transmitter after an accident.

Implementation status
Not implemented. FOCA advised that it did not have any authority regarding this topic. The safety recommendation could only be processed by the relevant certification authority, i.e. EASA.
EASA advised that they were evaluating the safety recommendation and measures that could be taken to ensure the functioning of the ARTEX C406-N HM emergency location transmitter.

Airprox between a commercial aircraft and a hot-air balloon near Wigoltingen, 03/06/2015

On 3 June 2015, an airprox occurred between a commercial aircraft and a hot-air balloon within the terminal control area (TMA) of Zurich Airport. The commercial aircraft was approaching Zurich Airport using radar vectoring. The hot-air balloon had entered the terminal control area several times without clearance from an air traffic control centre because the balloon pilot was insufficiently aware of the risks he was posing even if only entering into such airspace by a short distance.

Because the transponder was switched on, the hot-air balloon was in theory visible to air traffic control. However, the display on the air traffic controllers' monitors was so inconspicuous that the unauthorised entry went unnoticed until the airprox.

Safety deficit

Similar safety deficits were established as part of the investigations into the following near misses:

- The investigation into a near miss involving a commercial aircraft and a glider in the TMA of Zurich Airport on 11 August 2012 identified the pilot's lack of risk awareness regarding unauthorised entry into class C airspace as the direct cause.
- The same near miss revealed the following systemic risks: an airspace structure around Zurich Airport with a low fault tolerance and a limited obligation to use a transponder which makes it harder to detect unauthorised entry into the terminal control area.
- The investigation into a near miss between a sport aircraft and a hot-air balloon in the TMA of Bern Airport on 15 September 2012 showed that it was primarily caused by the balloon pilot's lack of awareness regarding the balloon's spatial position relative to the airspace structure.
- Another contributing factor to the same near miss was that the pilot was not carrying a transponder and was therefore undetectable by air traffic control.

All of these airproxes have the following elements in common:

The respective pilots had sufficient knowledge of the airspace structure itself and, using the means available, would have been able to respect the boundaries of the terminal control area or to contact air traffic control to ask for permission to enter, if necessary. However, they were of the opinion that marginal entries into terminal control areas were not a problem, because there were sufficient safety margins. These were incorrect assumptions. Contrary to their beliefs, Swiss airspace is characterised by very small safety margins as – in order to restrict light and sport aviation as little as possible – the distances between areas where aircraft under visual flight rules (VFR) are allowed to move freely and areas where predominantly large aircraft are guided according to instrument flight rules are reduced as much as possible. To accommodate the needs of light and sport aviation however, the boundaries of airspace must consistently be adhered to, because otherwise considerably dangerous situations can arise instantly. Furthermore, even if airspace users are sufficiently aware and demonstrate great discipline, minor mistakes might still happen occasionally, and because even minor mistakes can have very serious consequences, a system should be sought that provides a certain resilience when mistakes happen. If unauthorised entry into a controlled airspace were detectable by air traffic control at an early stage, corrective action could be taken in good time.

In principle, a number of strategies are available to reduce this safety deficit:

a. Airspace remains as it is, but the crews' awareness regarding the low tolerance for mistakes is raised, and it is ensured that all aircraft are suitably displayed to the air traffic controllers, by the latest when an aircraft enters the controlled airspace. It should also be ensured that the systems, such as those which are fitted to large aircraft to warn of airproxes and to avoid collisions, can take over their role as the last safety net.
b. No operational or technical measures for decreasing the collision risk are taken but the airspace in which large aircraft in particular are guided according to instrument flight rules is enlarged to create bigger safety margins. These additional buffer zones must be designed big enough that large aircraft cannot be endangered, even if light aircraft and sport aircraft which cannot be detected by air traffic control make navigational mistakes.

As part of the investigations into the two near misses in 2012, the Swiss Transportation Safety Investigation Board consulted the public concerned as prescribed by law to be able to issue safety recommendations which are broadly supported and easy to implement. The majority of the public that were consulted back then were in favour of a technical-operational solution and the STSB subsequently issued safety recommendation no. 466, which would constitute a relatively easy and inexpensive possibility for improvement:

"In cooperation with the supervisory authorities of neighbouring countries, the Federal Office of Civil Aviation should, where appropriate, define airspace surrounding Swiss airports in which only aircraft equipped with a functioning and activated transponder are allowed to fly (transponder mandatory zones – TMZ). These TMZ should include the control areas and terminal control areas and contain vertical or horizontal buffer zones with regard to this airspace."

When contacting almost the same public involved as part of the investigation into the serious incident in question which happened around three years after the near misses in 2012, the STSB found out that hardly any concrete measures have yet been taken to decrease the abovementioned risk of collision between large air-craft and light and sport aircraft which mistakenly enter terminal control areas. The public involved blamed each other for the safety deficits still existing and the slow implementation of improvements. The Swiss Transportation Safety Investigation Board refrains from commenting on the actions of the public involved. However, the STSB urgently points out once again that the well-known risks of collision between large aircraft and light and sport aircraft still exist because the complex Swiss

airspace is not very forgiving of mistakes and the safety nets of air traffic control and of commercial aircraft can become ineffective as it is not mandatory to carry a transponder.
Therefore, the Swiss Transportation Safety Investigation Board once more recommends, in line with safety recommendation no. 466, introducing transponder mandatory zones to protect control zones and terminal control zones.
In line with the different strategies outlined above, which are possible to reduce the current safety deficit and thus support a holistic method of resolution, the STSB issues the two additional safety recommendations below.

Safety recommendation no. 518, 20/03/2017
For the operation of aircraft that can pose a danger to large aircraft, the Federal Office of Civil Aviation (FOCA) should make it obligatory, without exception, for the former to carry an operational and active transponder when flying over Swiss territory. Here, attention should be paid to the greatest possible degree of compatibility with the most commonly used traffic alert and collision avoidance systems. Together with air traffic control, FOCA should define technical and operational general conditions which enable optimum use of this requirement for a transponder for the benefit of air traffic control.

Implementation status
Not implemented. FOCA initially considered a nationwide obligation for all aircraft which may pose a danger to large aircraft to carry an operational and activated transponder as disproportionate, in particular because large aircraft can operate in all airspace classes and a moderate extension of today's obligation to carry a transponder is already planned as part of the current partial revision of the VRV-L2 revision. However, it was discovered last year that most aircraft are now equipped with a transponder. Therefore, FOCA will organize a review of implementation in 2018.
Last year, the GS-DETEC tasked FOCA with redesigning the airspace structure in Switzerland and, with this, its aviation infrastructure, using a clean sheet approach. According to FOCA, this task is being carried out with high priority as part of the AVISTRAT-CH New Airspace and Aviation Infrastructure Strategy programme. FO-CA expects the first results in form of a vision for the Swiss airspace and the aviation infrastructure to be available in 2020. FOCA does not want to make a decision on a potential partial implementation of safety recommendation no. 518 until the relevant strategic guidelines are available.

Safety recommendation no. 519, 20/03/2017
The Federal Office of Civil Aviation should, where appropriate in collaboration with the supervisory authorities from neighbouring countries, specify simply designed and sufficiently large controlled class C and D airspaces in the areas surrounding Swiss airports, in order to prevent light aircraft and sport aircraft which enter this air-space without clearance from posing any danger to large aircraft in the future.

Implementation status
Not implemented. Last year, the GS-DETEC tasked FOCA with redesigning the airspace structure in Switzerland and, with it, its aviation infrastructure, using a clean sheet approach. According to FOCA, this task is being carried out with high priority as part of the AVISTRAT-CH New Airspace and Aviation Infrastructure Strategy programme. FOCA expects the first results in form of a vision for the Swiss airspace and the aviation infrastructure to be available in 2020. FOCA is of the opinion that the planned programme could in principle address the safety recommendation in question. However, it takes the view that the danger posed to large aircraft can never be completely ruled out. Only when the relevant strategic guidelines are available, FOCA will decide on a partial implementation of the safety recommendation no. 519.

Safety deficit
The hot-air balloon was visible on the air traffic controllers' monitors in the pale-brown colour typical of uncontrolled VFR flights. Approximately 12 minutes passed between the first unauthorised entry into the TMA and the closest approximation. During this time none of the three air traffic controllers involved noticed the hot-air balloon's unauthorised entries.
An automatic warning system for the air traffic controller in the case of an unauthorised entry of a VFR aircraft into a TMA had been suggested at Skyguide in the past. However, to date this has not been put into effect. Taking into consideration that other airspace violations had been investigated, the STSB is convinced that an effective improvement of air safety could be achieved by introducing a warning system of this kind swiftly.

Safety recommendation no. 520, 20/03/2017
The Federal Office of Civil Aviation, together with Skyguide air traffic control, should develop measures to warn air traffic controllers of unauthorised entry into airspace that mainly serves instrument flight rules traffic.

Implementation status
Implemented. Skyguide has developed a new VFR Display Priority filter function for their radar systems to display only those visual flights to the air traffic controllers which could become relevant for a conflict situation in a particular airspace. This filter function includes the new area infringement warning (AIW) system. Visual flights travelling with a transponder that is switched on and flying into controlled airspace without permission are displayed in red to alert the air traffic controller to the airspace violation. The filter function can be switched on and off by the air traffic controller,

but the AIW cannot. These new functions were launched in Zurich in March 2017 and in Geneva in July 2017.

Safety deficit
Air traffic control's ground-based short-term conflict alert (STCA) system did not warn of the commercial aircraft approximating the hot-air balloon. In order to prevent unnecessary warnings from being emitted, it had been programmed in such a way that captured aircraft with a ground speed of less than 30 knots were not taken into account. During its entire flight, the hot-air balloon's ground speed was significantly below this value. The programming of the STCA system is therefore not suitable for warning of conflicts involving slow-flying aircraft.

Safety recommendation no. 521, 20/03/2017
The Federal Office of Civil Aviation, together with Skyguide air traffic control, should improve the short-term conflict alert (STCA) system so that it also warns of conflicts with slow-flying aircraft.

Implementation status
Implemented. On 9 June 2017 and 22 June 2017 respectively, the ground-based short-term conflict alert (STCA) systems in Zurich and Geneva were adjusted so that air traffic controllers can also detect conflicts involving slow-flying aircraft.

Safety deficit
The balloon pilot's inhibition to contact air traffic control was identified as a contributory factor. Furthermore, widespread knowledge deficits regarding the use of altimeters and transponders were found to be a systemic risk. These factors point to opportunities for improvement in training and need to be considered in light of the fact that, after the initial training of balloon pilots, no periodic proficiency check or further training is planned, as is already mandatory and common practice for pilots of gliders and motorised aircraft.

Safety recommendation no. 522, 20/03/2017
The Federal Office of Civil Aviation, together with the relevant aviation associations, should take measures regarding periodic proficiency checks and further training for balloon pilots.

Implementation status
Partially implemented. The Swiss Balloon Association (SBAV) runs the theory courses for balloon pilots on behalf of FOCA. The SBAC also runs an annual safety seminar both in German and in French. The focus of the seminar is on knowledge of airspace, specifically Swiss procedures and the correct use of technical instruments such as transponders, as well as collaboration with air traffic control. The training material is publicly available on the SBAV website. In addition, the SBAV organises regional refresher courses, thereby offering regular opportunities for further training and providing the foundations for avoiding airspace violations. The voluntary refresher courses are currently being expanded.

Accident involving a helicopter in Wolfenschiessen, 21/09/2015

On 21 September 2015, a helicopter approaching for landing collided with the cable of a transport cableway in the area of the mountain station of the Bannalpbahn. The cable had been recorded in FOCA's (Federal Office of Aviation) air navigation obstacle register and marked on the relevant air navigation obstacle map and the respective electronic data base.

Safety deficit
In addition to this cable, there were further cables in the area of the accident site which were also marked on the air navigation obstacle map. A ski lift in the area of the accident site was not marked on the air navigation obstacle map because it was lower than the threshold of 25 m above ground for mandatory reporting.
During the approach, the pilot interpreted the ski lift as one of the marked obstacles and therefore thought that he was seeing all of the cables and had them under control. However, in doing so, he overlooked the cable he would then collide with.

Safety advice no. 14, 28/03/2017
Helicopter pilots flying close to the terrain should be aware that the obstacle layout marked on obstacle maps may be incomplete or wrong. On the one hand, there may be obstacles which are not marked, either because they have not been reported or because they are lower than the minimum height for mandatory reporting. On the other hand, real-life obstacles may be in a different position to that marked on the map.
Therefore, it is of utmost importance to interpret the obstacle situation correctly. On the one hand, this includes matching the real-life obstacles with those marked on the map, and verifying their position. On the other hand, the pilot must always consider that there may be additional obstacles that are not marked on the map.

Serious incident involving a commercial aircraft in Lugano, 13/10/2015

On 13 October 2015, a ground proximity event occurred under visual meteorological conditions approximately 3 km south-west of Lugano Airport (LSZA) during an approach by commercial aircraft DHC-8-402, registered as OE-LGL, with

55 passengers on board. On account of the 'pull up' ground proximity warning, the flight crew initiated a go-around, followed the missed approach procedure to the holding area above the PINIK waypoint and subsequently decided to make a diversion landing at Milan-Malpensa (LIMC).
On approach to Lugano, the flight crew followed a visual approach on prescribed track, which had been developed by the aviation company and was used in training. The procedure used was inexpedient and did not comply with any of the procedures outlined in the Swiss Aeronautical Information Publication.

Safety deficit
After the evaluation of this visual approach procedure had been completed and approximately one year before the serious incident took place, the aviation company entrusted the operator of Lugano Airport and the air traffic control tower in Lugano with all documents.
Within the Federal Office of Aviation (FOCA), there is a working group for flight procedures (AGF), which holds regular meetings with all airports in Switzerland that have IFR procedures. In cooperation with key experts, such meetings would have ensured a prompt exchange of essential information and thus improved supervision by FOCA. The last meeting with representatives of Lugano Airport was held back in 2005. This ancient exchange of information regarding flight operations in Lugano was therefore identified as a safety deficit.

Safety recommendation no. 535, 14/12/2017
The Federal Office of Civil Aviation (FOCA), together with all Swiss aerodrome operators who have instrument flight rules (IFR) procedures as well as the relevant experts, should take appropriate measures to ensure that information is exchanged regularly.

Implementation status
Implemented. In a letter dated 22 January 2018, the Federal Office of Civil Aviation (FOCA) responded that the working group for flight procedures (AGF) ensures a regular exchange of information between airports with IFR procedures and FOCA, and assists FOCA in the assessment of existing as well as new IFR procedures or IFR procedures to be amended. Furthermore, it develops decision criteria for the approval of IFR procedures.

In accordance with the mandate, the main tasks of the AGF are:
- Involvement in the development of a yearly programme for the systematic review of existing IFR approach and take-off procedures (periodic review in accordance with the legal mandate).
- Integral review of existing IFR approach and take-off procedures taking into consideration the infrastructure used for these procedures as well as available infrastructure. This also includes reviewing the types of aircraft used and, when necessary, the crew qualification.
- Conclusive air-traffic-control-related technical and operational analysis of requests for amended or new IFR procedures, in particular new IFR approach and take-off procedures.
- Creation of reports and recommendations regarding the results from the review of existing, amended or new IFR procedures. These go directly to the head of safety and infrastructure or the overall project manager.
- Tackling of specific problematic areas in connection with new navigation technologies.
- Sharing of knowledge among experts.

Two meetings per year are scheduled for national airports, and one meeting per year for regional airports. As required, the AGF can convene further meetings at any time.

Accident involving a motorised aircraft in Bex, 18/11/2015

On 18 November 2015, an aircraft of type EA 300 / 200, registered as HB-MSW, took off from runway 33 at Bex aerodrome (LSGB) to perform aerodrome circuits. The pilot was seated at the rear of the aircraft and the instructor at the front.
After making an approach with no power in order to simulate engine failure, the pilot re-established gliding flight without sideslip at a height of approximately 3 m and landed the aircraft. With the intention of allowing the pilot to improve his skills, the instructor directed him to perform a touch-and-go landing in order to repeat this exercise. The pilot advanced the throttle and the aircraft climbed to approximately 2 to 3 m above the ground, at which point the crew realised that the engine lacked power. The instructor took control of the aircraft, cut engine power and guided HB MSW back down to earth without delay. The aircraft overshot the end of the runway, and its nose touched the ground before it came to rest upside down. The investigation was not able to exclude the causal factor being that the fuel selector lever was in the 'WING TANKS' position throughout this exercise, which could have induced a loss of the engine's fuel supply.

Safety deficit
When aircraft of type Extra 300 / 200 are not being used for aerobatics and if their wing tanks contain fuel, certain operators recommend using them from 800 ft above aerodrome level (AAL) after take-off and returning the fuel selector lever to the 'CENTRE (ACRO) TANK' position on approach, at around 1,000 ft AAL. During multiple aerodrome circuits, this procedure means that the fuel selector lever needs to be moved numerous times within a relatively short period. This increases the risk of the pilot forgetting to move the

fuel selector lever.
Furthermore, as the wing tanks are permanently interconnected, the transfer of fuel can occur without the pilot's knowledge in the event of a loss of control.
The majority of the approaches made by the Extra 300 / 200 is performed with a sideslip to the left, which is often maintained until a few metres above the ground. Transfer tests have shown that if such approaches are made with the fuel selector lever in the 'WING TANKS' position when there is a small amount of fuel in the wing tanks, this can pass quickly and in its entirety to the left-hand side and cause a loss of fuel supply to the engine.

Safety advice no. 16, 07/06/2017
With the aim of reducing the risk of a loss of fuel supply, operators should assess the benefits of using the wing tanks during aerodrome circuits, compared to the risk of forgetting to change the position of the selector lever to 'CENTRE (ACRO) TANK' prior to landing.

Commercial aircraft endangered by luggage trolleys at Zurich Airport, 09/02/2016

On 9 February 2016 at Zurich Airport, seven luggage trolleys, which were connected in a row, were moved by stormy winds and rolled on their own across the landing runway which was in operation at the time. This endangered a commercial aircraft, which landed shortly afterwards.

Safety deficit
It was determined that the systemic cause of this serious incident was that the luggage trolleys were insufficiently secured to prevent them from rolling away because there were no relevant means or procedures. It was also found that similar incidents had occurred on several occasions in the past.

Safety recommendation no. 526, 20/03/2017
The Federal Office of Civil Aviation, together with aerodrome operators, should take appropriate measures to prevent the possibility of luggage trolleys and other operating materials on aerodrome aprons being moved in an uncontrolled manner by strong winds.

Implementation status
Implemented. FOCA has implemented the safety recommendation as follows: The provisions regarding the order to store and securing luggage trolleys during storms at Zurich Airport were supplemented and clear areas of responsibility for the companies defined. The new stipulations include that the airport authority must be formally notified once the luggage trolleys have been secured. In addition, the luggage trolleys must be serviced at regular intervals and the date of the last service must be visible on a seal on the vehicle. Defective trolleys must be taken out of operation without delay. Zurich Airport monitors compliance with these stipulations, in particular when there is a storm warning, through additional checks. FOCA had already demanded before the incident that Zurich Airport dismantled runway section A4 which was no longer required, the same section on which the luggage trolleys reached the runway, as part of the restoration of runway 28. This measure reduces the width of the sealed area bordering the runway from now 100 m to 25 m and thus reduces the probability that a similar incident will happen.
At Geneva Airport, material is secured according to company-internal stipulations of the individual service providers. In the event of a wind warning, the apron is also checked by the airport authority to ensure that all objects which could be moved by the wind are correctly secured by the service providers or have been removed from the location.
The recommendation is not relevant for safety at other airports as they do not have a lot of operating material and luggage trolleys are not parked on the apron.
In the follow-up to the serious incident, FOCA carried out a risk assessment on this topic and added the risk posed by insufficiently secured mobile ground equipment to the register. Furthermore, the measures taken by the airports and documented in the aerodrome manual as part of its supervisory role will be checked at regular intervals.

Safety deficit
In addition to the inadequate securing of the luggage trolleys, it was determined that the cause of this serious incident was that the existing warning systems designed to guard the runway area from unauthorised runway access did not emit a warning.

Safety recommendation no. 527, 20/03/2017
The Federal Office of Civil Aviation, together with Skyguide air traffic control and aerodrome operators, should examine the extent to which the existing systems that warn of unauthorised runway access could be modified so that they include operating materials such as trolleys and similar items.

Implementation status
Implemented. FOCA has implemented the safety recommendation as follows: Zurich Airport has assessed the modification of the existing runway incursion monitoring and collision avoidance system (RIMCAS) and concluded that this is not a suitable tool for detecting smaller objects such as luggage trolleys. The introduction of an additional system (e.g. a radar for the detection of foreign-object debris (FOD) had already been considered some years ago but was dismissed because of the state of the technology available at the time. The serious incident on 9 February 2016 has led to a reconsideration. With the partial replacement of the ground radar, which is planned for the end of 2018,

it has been assessed whether objects, such as the luggage trolleys or even FOD, on runway 28 could be detected using a system of this kind. Due to the fact that this has proved impossible, a re-examination will take place in the context of a later replacement of the entire ground radar.
Together with Skyguide, Geneva Airport has adapted the existing RIMCAS so that primary echoes are not hidden as before. This measure had already been initiated before the incident on 9 February 2016. In addition, the installation of an FOD radar has been assessed by the end of 2017, but rejected due to the current state of the technology. Furthermore, a process on the inspection of the technical condition of ground equipment, in particular luggage trolleys, has been carried out and parking zones for luggage trolleys, in particular in the case of weather-related risks, has been defined by the end of 2017.
The recommendation is not relevant for safety at other airports as they don't have a lot of operating material and luggage trolleys are not parked on the apron. A warning system for unauthorised runway access is not installed and would be disproportionate.
In the follow-up to the serious incident, FOCA has carried out a risk assessment on this topic and added the risk posed by insufficiently secured mobile ground equipment to the register. Furthermore, the measures taken by the airports and documented in the aerodrome manual as part of its supervisory role will be checked at regular intervals.

Safety deficit
The investigation into this serious incident identified the following systemic risk factors:
– The responsibilities regarding the maintenance of pooled luggage trolleys were insufficiently regulated.
– There was no overview of the technical condition of the luggage trolleys.
– The maintenance concept in use was exclusively reactive.
As a result, it was possible that defects on the brakes of these luggage trolleys remained undetected for a long time.

Safety advice no. 15, 28.03.2017
The companies tasked with the operation and maintenance of luggage trolleys and other operating materials on the aerodrome aprons should develop effective procedures to ensure the functionality of this equipment.

Accident involving a motorised aircraft near Löhningen, 26/08/2016

Shortly before 19:05 on 26 August 2016, the pilot of the Robin DR 400/180 R aircraft registered as HB-EQN took off for a sightseeing flight with three passengers on board at maximum engine power and into a light headwind. Immediately after taking off, the aircraft began to bank to the left with a high angle of attack and hardly gained any altitude. Owing to a drift to the left over sloping terrain, the flight phase at an unstable speed rapidly worsened outside of the ground effect, with the result that the aircraft stalled, tilted over the left wing and, from a low altitude, crashed onto the hard, dried-out soil of a sunflower field.

Safety deficit
As a consequence of the pitching motion of the aircraft that occurred on impact, the occupants sustained injuries of varying severity depending on the restraint systems fitted to the respective seats:
– Thanks to the 4-point belt system installed and worn, the pilot did not suffer any head injuries.
– The passengers sustained serious back and head injuries; in the case of the female passenger in the front, right-hand seat, the impact of her head against the instrument panel resulted in a very severe traumatic brain injury and led to her death a few days later.
The STSB established that – as part of the adopted EU Regulation 2016/1199 – the revised requirement, which makes only a 3- or 4-point restraint system mandatory for aircraft with a certificate of airworthiness dated from 25 August 2016 onwards, represents a clear backward step in respect of the protection from serious physical injuries afforded to aircraft occupants. Equally, against this back-drop, the function of the occupants is irrelevant and the restriction on flight crew seats following the introduction of EU Regulation 965/2012, which entered into force on 28 October 2012, for 'Non-Commercial Air Operations with Other-Than-Complex Motor-Powered Aircraft [PART-NCO]' is inexplicable.

Safety recommendation no. 536, 18/12/2017
The European Aviation Safety Agency (EASA) should take measures to ensure that all those on board, particularly those on the front seats, are protected from significant injuries to the head and upper body.

Implementation status
Not implemented. In a letter dated 8 February 2018, the European Aviation Safety Agency (EASA) responded that the requirements stipulated in the federal aviation requirements (FAR) and certifications standards (CS) are identical, and concern design specifications, which must be observed as part of the certification of an aircraft.
Irrespective of these certification criteria however, the STSB considers the revised requirement as part of the issued EU Regulation 2016/1199 – which makes only a 3- or 4-point restraint system mandatory for aircraft with a certificate of airworthiness dated from 25 August 2016 onwards – as being a clear backward step in respect of the protection from serious physical injuries afforded to aircraft occupants. Equally, against this back-drop, the function of the occu-

pants is irrelevant and the restriction to flight crew seats following the introduction of EU Regulation 965/2012 is not safety conscious.
For these reasons, the STSB is of the opinion that the present safety deficit still holds true. Therefore, the safety recommendation is considered as not implemented.

5.3 Railways

Fire in a locomotive in Hergiswil, 17/07/2014

On 17 July 2014 at 19:45, the development of heavy smoke was noticed on a Zentralbahn locomotive which was coupled to the end of a shuttle train. The air conditioning unit in the rear driver's cab, which was not occupied, caught fire.

Safety deficit
The fire can be attributed to the fact that the electric motor for the radial fan set in the air conditioning unit located in the unoccupied rear driver's cab first jammed, continued to be fed by its power source because there was no protective device and then heated up until it ignited.
The electric motor was powered directly from the power supply, without overcurrent protection, which is permissible for electric motors of this power class. However, this incident demonstrates that it may lead to fire breaking out. The consequences could be devastating, in particular if fire breaks out whilst travelling through long tunnels.

Safety recommendation no. 83, 21/03/2017
The FOT should examine standards for monitoring electric motors with regard to separation from the power supply in the event of technical problems and amend them if necessary.

Implementation status
Implemented. In the Implementing Provisions to the Railways Ordinance (IP-RailO), the FOT sets out the protection objective, and refers to the EN standards that must be observed in this regard. In the FOT's view, the regulations are clearly defined and do not require additional supplementation. The correct application of the standards is the responsibility of the railway company.

Derailment of a passenger train after a landslide in Tiefencastel, 13/08/2014

On 13 August 2014 at 12:18, the Rhaetian Railway train RE 1136 St. Moritz – Chur was hit by a landslide between Tiefencastel and Thusis and derailed. A carriage crashed about 20 m down a steep slope into trees. Of the approximately 150 passengers, eight were severely injured and eight were slightly injured. Nine days after the accident, one seriously injured person died of their injuries. There was considerable damage to infrastructure and rolling stock.

Safety deficit
Parts of the ceiling panelling landed on the floor of the passenger compartment. A ceiling panel is made of aluminium, parts of it have sharp edges, and it weighs about 6 kg. The ceiling panels are fastened to the carriage ceiling with snap-action catches. In the event of a train accident such as collision or derailment these ceiling panels can easily become dislodged from their holders and fall into the passenger space, resulting in injury to any individuals.

Safety recommendation no. 111, 02/03/2017
The FOT should check guidelines for securing interior panels of train carriages and amend them, where necessary, so that these panels cannot come loose in the event of severe shaking.

Implementation status
Partially implemented. The FOT has incorporated safety recommendation 111 into the latest IP-RailO revision. This means that guidelines for securing interior panels of train carriages are being reviewed in the course of the further development of the IP-RailO provisions. Publication of the IP-RailO revision is planned for 2020.

Safety deficit
Due to a gap in mobile phone network coverage, emergency services could not be deployed immediately.

Safety advice no. 4, 02/03/2017
Rhätische Bahn AG (Rhaetian Railway) should ensure that in the case of an emergency, it is possible to contact emergency services at any time and at any point on their rail network.

Appenzeller Bahnen fractured wheel disc in Jakobsbad, 30/09/2014

On 30 September 2014 at around 06:15, the leading bogie of intermediate carriage B 245 of train 1057 derailed after the arrival points at Jakobsbad railway station. When the carriage was put back on the rails a fractured wheel disc was discovered. The fractured wheel disc on intermediate carriage B 245 can be attributed to too much stress being placed on the wheel disc. The excessive stress on the wheel disc was caused by increasing the cornering speed from 40 to 45 km/h.

Safety deficit
When the operational conditions were adapted it was not ensured that safety-relevant aspects of the technical network access conditions were safeguarded.

Safety advice no. 5, 13/07/2017
To ensure safe operations, the effects on rolling stock must be considered even when operational conditions (adaptation to the track geometry, increase of cornering speed) are changed only slightly.

Derailment of a low-loader wagon in Aarau, 24/05/2015

On 24 May 2015 at 01:27 in the Aarau freight yard, three axles of a 32-axle low-loader wagon that was lined up in a train derailed at a set of points shortly after departure. Prior to this, the load – a transformer – had to be shifted sideways. At the time of the derailment, the wagon was on two diverging sets of points in an S-bend. No one was injured and there was little material damage.

The derailment can be attributed to two causally connected factors:
- The sideward shift of the load was too large and resulted in the outer wheels being unloaded in an S-bend;
- An incorrect specification in the setup due to an error in the 'Railwin' IT tool, which made a prohibited route possible.

Contributing were:
- The unscrutinised execution of a shift of the load by more than four times the stipulated value.
- The lack of a warning system for unacceptable wheel load.

Safety deficit
The low-loader wagon has technical equipment that warns of an excessive rolling distance by means of a rotating orange light, however, it does not detect unacceptable wheel load.

Safety advice no. 6, 13/07/2017
A device should be made that detects unacceptable wheel load and thereby triggers an alarm.

Safety deficit
In this case, the shift of the load exceeded the value specified in the setup by 400 % – which led to an unsafe state – and this excess was not scrutinised. Exceeding standard values by a huge margin can result in an unsafe state which can lead to operational limitations.

Safety advice no. 7, 13/07/2017
Staff should be instructed to scrutinise extreme deviations from standard values.

Runaway and derailment of a TRAVYS train at Baulmes (Canton Vaud), 02/10/2015

On Friday 2 October 2015 at 08:28 the empty goods train TRAVYS 8008, made up of control car BDt no. 53 and engine Be 4/4 no. 2, ran away a little after the station at Ste-Croix, on a line with a gradient of up to 44 ‰, and derailed on open track in a left-hand curve between the stations at Trois-Villes and Six-Fontaines. The driver jumped from the train when it was travelling at a speed of 30 to 40 km/h. He suffered contusions.
The control car, at the head of the train, landed on the rails after ripping off two contact line masts, and came to a stop below the track about 150 m after derailing. The engine derailed and became embedded in a contact line mast.
Train 8008 ran away because, during the two emergency stops, the level of automatic braking acting on the train had diminished, following various incidents of improper handling, so that the brake effort necessary to render the train composition immobile on a gradient of 40 ‰ was no longer sufficient.
Vehicles Be 4/4 no. 1 and no. 2, as well as control cars, which were placed into service in the late 1970s, have particular technical characteristics concerning the automatic brake and the door closure warning system.
Regarding the automatic brake, action of the fail-safe or the automatic train stop system causes drainage of the brake pipe and simultaneously of the supply line. Regarding monitoring systems, the door closure warning system (monitoring function) is grafted onto the circuits of the fail-safe (safety function).
The solutions adopted on these vehicles differ from those normally realised on other vehicles of that era. Should these devices fail, lack of knowledge of these peculiarities on the part of driving staff may create risk situations.

Safety deficit
Inadequate handling by the engineer while troubleshooting following the two emergency stops after Ste-Croix is due to a lack of technical knowledge or awareness of the situation.

Safety recommendation no. 112, 03/04/2017
The STSB recommends that the FOT, within the framework of training driving staff, plan specific training modules on braking and door closure for as long as these vehicles remain in service or as long as these peculiarities remain.

Implementation status
Partially implemented. The FOT will verify the effectiveness and/or the level of training on monitoring activities and considers this safety recommendation as having been implemented.

Safety deficit
The door closure warning system (control function) is grafted onto the circuits of the fail-safe (safety function) and causes drainage of the brake pipe and simultaneously of the supply line if a door fault appears.

Safety recommendation no. 113, 03/04/2017
The STSB recommends that the FOT separate the circuits of the door closure warning system from those of the fail-safe.

Implementation status
Not implemented. The number of vehicles to modify, the complexity and the costs of such a modification should be evaluated by the transport company. The plan for deploying these vehicles should also be considered, as well as their remaining service life. A count should also be made of the number of cases in which the emergency release system for doors was used by passengers while operating these vehicles. With all these parameters in hand it will be possible to evaluate the necessity (proportionality criteria) of ordering a modification or not.

The company TRAVYS indicates that the two Be 4/4 II are no longer used in commercial passenger service for reasons of comfort and access, but only to service the infrastructure.
TRAVYS estimates that the modification would cost around CHF 4,000 for each vehicle. The transformation consists of disconnecting the power supply instead of acting on the fail-safe.

In view of this, the FOT considers that modifying two vehicles that are used only to service the infrastructure would be disproportionate in terms of cost and effectiveness. In view of this, the FOT declines this recommendation. In any case, this specificity should be instructed to driving staff during their initial and continuing training. See also recommendation no. 112 with regard to staff training.

Safety deficit
Personality requirements are part of the admission examinations for category B or B100 engineers. Thus, as this inquiry has shown, an engineer can be declared fit to drive at the admission exams and declared unfit later on, having had a further personality examination. Furthermore, forecasts made when assessing personality include a level of uncertainty.
Inadequacy in the personality requirements represents a risk of latent inappropriate behaviour on the part of the engineer.

Safety recommendation no. 114, 03/04/2017
The STSB recommends that the FOT study the possibility of refining the current personality requirements for the admission of locomotive engineers, and to integrate these requirements into the current psychological assessment.

Implementation status
Implemented. The FOT has requested a position statement from the head of the psychological service.
Conclusion: it is possible for a person's aptitude to change over the course of his/her life.
Thus, the FOT considers that there are no elements that necessitate a fine-tuning of the personality requirements for the admission of drivers of motorised vehicles. This safety recommendation has been implemented.
No modification will be made to the FOT Directive 'Examens d'Aptitude Psychologique' (Psychological Ability Tests, in French).

Safety deficit
Providing guidance for the engineer after the practical driving exam could help detect weaknesses in the personality requirements.

Safety recommendation no. 115, 03.04.2017
The STSB recommends that the FOT study the possibility of stipulating periodic guidance for engineers in the first months of activity following the end of their training.

Implementation status
Implemented. This aspect is regulated by Art. 35 sentence 2 of the DETEC Ordinance of 30 October 2003 on the Licence to Drive Railway Locomotives (LDO; SR 742.141.21), which states that a driver should acquire half of the minimum driving practice during the first two months after passing the proficiency examination (see also the remarks on the stage of implementation of recommendation no. 112).

Derailment of three wagons of a freight train in Rotkreuz, 24/11/2015

On Tuesday, 24 November 2015 at approximately 05:21, three wagons of a freight train derailed on a turnout at Rotkreuz railway station. There was material damage to the railway track and to the rolling stock. No one was injured.

Safety deficit
The freight train derailed due to its composition, with heavy wagons being coupled behind lighter wagons. The positioning of heavy wagons behind light ones increases the risk of derailment during braking. Longitudinal forces can develop very quickly, particularly if the train is long and if the track geometry or topology is dynamically challenging, and this can promote derailment.

Safety recommendation no. 110, 03.02.2017
The FOT should ensure that attention is paid to the occurrence and possible consequences of longitudinal forces within trains with disparate trailer loads throughout the train composition.
Where possible, heavy wagons should be attached in front of wagons with lower axle load.

Implementation status
Partially implemented. In the FOT's view, operational account is taken of this part of the safety recommendation through rules on the control of longitudinal forces in mixed freight trains, Swiss Rail Service Regulations R300.5, section 3.3.1 (Braking regime, changing braking system) and R300.14, section 2.7.1 (Operating the automatic brake where train line pressure is reduced). The FOT has also written to the RU in question (on 11/4/2017) to draw its attention to the problem of braking in freight trains and to recommend raising the awareness of train drivers. In particular, the RUs are reminded that when a freight train is crossing points that are set in the diverting position and may only be traversed at max. 40 km/h, train line pressure may be reduced by a maximum 0.5 bar. This checkpoint will also be included in the 'Checklist for Freight Trains', which is used for operating inspections.
The FOT considers this second part of the safety recommendation (heavy wagons should be attached in front of wagons with lower axle load) impossible to implement operationally, or only with disproportionate effort.

Accident involving a person in Zürich Schweighof, 13/01/2016

On Wednesday, 13 January 2016 at approximately 17:29, a female passenger, whose arm had got trapped between the closed doors of a train operated by Sihltal Zürich Uetliberg Bahn (SZU) AG at the Zürich Schweighof stop, was pulled along by the departing train and seriously injured. The train driver was unaware of the incident and the train continued its journey.

Safety deficit
With the SZU's Be 556 vehicle fleet, the size of the rubber sections sealing the doors allows the doors to be closed and locked even when limbs are trapped, without the door's anti-trap facility registering the obstacle.
With the Be 556 vehicle fleet, the final positions of doors and running boards are not registered correctly and, despite this, are reported to the train driver as locked.
If, in case of failure, the doors are electrically and pneumatically disconnected, the doors and the running board need to be closed manually and locked mechanically using a square box spanner. With the Be 556 fleet, only one component needs to be locked mechanically and thereby also electrically to signal to the train driver that a door is completely locked. If a running board remains folded down and a door open, this goes undetected.

Safety recommendation no. 120, 09/06/2017
The FOT should ensure that the Be 556 fleet is equipped with an effective anti-trap facility which complies with approved technology and that the final positions of the doors and running boards are registered as being safe and definitely closed.

Implementation status
Partially implemented. The recommended retrofitting of the Be 556 fleet vehicles to approved technology (SN EN 14752 standard) is only possible if the entire door drive and its control system are replaced.
The Be 556 fleet is planned to be in operation until the middle of 2022, procuring the required replacement is already in planning. Today, the railcars are already in reduced operation (Monday to Friday during peak times).
The SZU, based on the final report's results, identified immediate measures and implemented them by the end of 2017. These include amongst other things:
- Attaching warning stickers;
- Preventing the response time for successive reversion from increasing (basis for all other safety measures);
- An active door-stop button on the centre boarding handrail also for forced closing;
- Pressing of the door-stop button on the centre boarding handrail by a passenger is indicated on the door control light in the driver's cab.

Further measures are planned. The detailed engineering design has not been carried out yet. Commissioning and type testing of the first upgraded platform are scheduled for March 2018. At the same time, the engineering design work, the approval concept as well as the development of the verification and the upgrade documentation are to be carried out.
On the basis of the event statistics, the FOT assesses the risk involved in the closing of the doors as low. It further states, that the measures proposed by the SZU significantly lower the risk once more.

Safety deficit
With the SZU's Be 556 vehicle fleet, the size of the rubber sections sealing the doors allows the doors to be closed and locked even when limbs are trapped, without the door's anti-trap facility registering the obstacle.
With the Be 556 vehicle fleet, the final positions of doors and running boards are not registered correctly and, despite this, are reported to the train driver as locked.
If, in case of failure, the doors are electrically and pneumatically disconnected, the doors and the running board need to be closed manually and locked mechanically using a square box spanner. With the Be 556 fleet, only one com-

ponent needs to be locked mechanically and thereby also electrically to signal to the train driver that a door is completely locked. If a running board remains folded down and a door open, this goes undetected.

Safety recommendation no. 121, 09/06/2017
The FOT should examine if a similar safety deficit exists with other vehicle types and take appropriate measures to eliminate them.

Implementation status
Implemented. The FOT examination has determined that the SZU operates further individual vehicles with a similar safety deficit, but that the SZU has taken measures to reduce the risk. The FOT considers the measures taken to be sufficient. It further states that other railway operators have modified and retrofitted the door sections of their vehicles and this did not present any equivalent safety deficits.

Derailment of a freight wagon during a shunting movement in Zürich-Mülligen, 20/01/2016

On 20 January 2016 the rearmost axle of a Habbiillnss type Wascosa wagon, which was lined up in the sixth position of a pushed shunting movement consisting of eight wagons, derailed at the Zürich-Mülligen station at set of points 318. The derailment of the rearmost axle of wagon no. 33 85 2891 025-4 at set of points 318 can be attributed to an imbalanced load on the set of wheels.
The imbalanced load on the set of wheels was caused by a combination of the following factors:
- Pre-existing damage to the buffers caused by excessive buffer pressures as a result of couplings not being loosened in tight track bends.
- Excessive lateral forces at the end of the wagon, caused by excessive buffer pressures.
- Pushed, empty wagons crossing diverging points.

Safety deficit
When travelling through bends or through a set of points with wagons that are coupled too tightly, strong forces develop between the buffers on the inside of the bend, generating lateral forces that affect the wagon body. This process has a significant influence on the risk of derailment in the running behaviour of longer wagons with a larger overhang. If, in particular with empty freight wagons, the ratio between the axle load and lateral force becomes unfavourable, it is possible for an imbalanced load on the set of wheels to occur at any time.

Safety recommendation no. 116, 01/05/2017
The FOT should make certain that technical means in the screw couplings ensure that no inadmissible buffering forces can develop when longer freight wagons travel on track curves with small radii.

Implementation status
Not implemented. The FOT advises that UIC standards and, if need be, technical specifications for interoperability (TSI) would need to be adapted to implement technical measures on the screw couplings. From the FOT's point of view using technical means would therefore not be possible within a reasonable period of time and appeared to be disproportionate.
However, the FOT sees potential for a significant improvement in the implementation of operational measures. The analysis of the coupling regulations defined in the Swiss transport service guidelines (FDV), which are of higher authority, is one of the points that needs to be actioned as part of the A2020 (year 2020) development plan. Thus, this measure is not exclusively limited to railway sidings (see safety recommendation no. 117) but extends to the entire railway infrastructure.

Safety deficit
To prevent the buffers from being damaged and to eliminate the risk of derailment, the screw couplings of freight wagons must be loosened in accordance with the regulations when travelling on track bends with a curve radius < 135 m. The information about the minimum radius of track curvature is not always listed in the operating instructions provided by the operators of the railway sidings. Without this information it is not possible for shunting staff to determine in which areas the couplings between the wagons need to be loosened.

Safety recommendation no. 117, 01/05/2017
The FOT should ensure that the minimum track curvature is listed in the operating instructions for railway sidings and that the operational measures for travelling on the tracks concerned are regulated.

Implementation status
Implemented. As part of audits and operational inspections of railway sidings, the FOT systematically checks whether tight track radii are recorded and whether this information is passed on by the operators of the railway sidings and whether the railway transport companies (EVU) have issued relevant regulations for travelling on tight track radii. Tight track curvatures and operational measures resulting from them have already been taken into account in the well-known templates for operating instructions for railway sidings (such as the VAP).

Explosion in the railcar of passenger train no. 538 in Fiesch, 08/03/2016

On 8 March 2016 at approximately 13:55 the tap changer fitted under railcar Deh 4/4 no. 52 of Matterhorn Gletscherbahn (MGB) train 532 exploded when the train approached the Fiesch-Feriendorf stop. Subsequently, a second explosion happened in the railcar's engine room.

Safety deficit
The explosion can be attributed to evaporated insulating oil, which originated from an incorrectly set tap changer, being ignited by an arc when the isolating contactor was opened.
As a commutation problem between the load switch and tap changer or a technical defect in the tap changer cannot be ruled out, it must be ensured that in the event of a tap changer malfunction, the main switch is triggered immediately and can no longer be reset. The lack of pressure monitoring in the tap changer constitutes a clear safety deficit.

Safety recommendation no. 118, 24/04/2017
The FOT should ensure that railcars with a BBC high- or low-voltage tap changer are fitted with a pressure monitor for the tap changer.

Implementation status
Not implemented. The FOT notes that there are still many vehicles with a BBC high- or low-voltage tap changer. Upgrading all vehicles would be a substantial undertaking, in particular when it cannot be done as part of an overhaul or modification. The cause was not the lack of pressure monitoring but the incorrect installation of the tap changer when it was overhauled. According to the FOT, it is commonly known that the installation of tap changers is a very delicate process and requires relevant knowledge. This vehicle type was built in 1972 and has been in operation without issue ever since. In this case, an upgrade only makes sense if these vehicles remain in operation for a longer period of time, the tap changers still have several overhauls ahead of them and the workshop is no longer able to adjust and test the tap changers correctly. This statement generally applies to all vehicles with a high- and low-voltage tap changer. It does not make sense to fit all vehicles with a pressure monitor because of this single event which can clearly be attributed to incorrect installation. It should be left to the operating companies to decide if and to what extend an upgrade with pressure monitoring switches is carried out or whether other measures are not equally expedient.
It appeared crucial that the companies should become and are aware of the problem that the assembly of tap changers as part of an overhaul requires relevant knowledge. This needs to be systematically maintained and taught where necessary. On 16 November 2017 the FOT sent a corresponding circular letter to the owners of vehicles with a high- and low-voltage tap changer. In this, the case is described in general and the companies are asked to raise awareness amongst the specialists accordingly, to train them where necessary and to ensure that the required level of knowledge is maintained.

Runaway of a service wagon in Olten, 08/06/2016

On 8 June 2016 at 01:30 the coupling point between a service wagon for construction and a railroad excavator became detached between Läufelfingen and the Trimbach stop, the wagon ran away, rolled through Olten railway station, derailed at a set of points on the exit side in the direction of Aarburg/Rohrist and was thereby stopped. No one was injured.

Safety deficit
Service wagons can receive approval even if they do not automatically brake in the event of a separation at the coupling point.

Safety recommendation no. 122, 09/06/2017
The FOT should examine the minimum requirement for the braking system of service wagons with regard to the risks of all possible uses and adapt it if and where necessary.

Implementation status
Awaiting response.

Safety deficit
The braking regulations for the shunting service allow unbraked vehicles to be used on a railway track with a gradient.

Safety recommendation no. 123, 09/06/2017
The FOT should examine whether the current rules regarding unbraked vehicles in shunting service should be limited to unavoidable situations or whether additional rules might be necessary.

Implementation status
Awaiting response.

Safety deficit
According to existing rules, service vehicles do not need to carry an identification label. The lack of identification labels makes it harder to identify service vehicles that are not approved and not compliant.

Safety recommendation no. 124, 09/06/2017
The FOT should ensure that an identification label displaying vehicle approval is affixed to all service vehicles.

Implementation status
Awaiting response.

Side-on collision involving a shunting movement and a freight train in Chiasso, 16/07/2016

On 16 July 2016 at 00:46 a shunting movement was involved in a side-on collision with a departing freight train in Chiasso Smistamento. Several wagons derailed, some of them tipped over or ended up in a tilted position. There was major material damage. No one was injured, and no dangerous goods were affected. The side-on collision can be attributed to the shunting movement travelling onto the track of the freight train.

Contributing factors to the accident were:
- The choice of a stopping place for turning the shunting movement that did not offer a direct view of the relevant dwarf signal.
- There were no effective track-based safety features.
- There was no effective train protection system for the shunting movement.
- There was no additional safeguard other than the regulations on the operation of shunting movements.

Safety deficit
Shunting operations are mainly regulated through guidelines. Compliance with the guidelines depends predom-inantly on human performance.
In many cases, track-based safety features and safety systems for the prevention of major consequences in the event of human misjudgements do not exist for shunting operations.
Knowing that people make mistakes, the lack of a fall-back level for situations that occur more frequently and can have greater effects constitutes a risk to the safety of rail operations.

Safety recommendation no. 119, 12/10/2017
The FOT should examine, whether:
- The current guidelines for assessing the risks posed on railway tracks by shunting movements are sufficient.
- The companies carry out standardised recurring assessments of such situations following a change in operational processes.

Implementation status
Implemented. The FOT considers the existing stipulations in the implementation rules for the railways ordinance (AB-EBV) and in the safety installations compendium of the Association of Public Transport (VöV), R RTE 25053, regarding the assessment of the risks posed on railway tracks by shunting movements, whilst considering the proportionality and the Swiss transport service guidelines for operational measures, to be sufficient. Furthermore, the FOT is of the opinion that an infrastructure operator must meet the requirements of Annex II (Safety Management System – SMS) of (EU) Regulation 1169/2010 to obtain the safety permit required to build and operate railway facilities. Procedures to fulfil these requirements have to be demonstrated for the submission of the application. The associated criteria include systematic and consistent procedures for assessing the risks of changes. The consideration of operational aspects is explicitly specified. By examining these requirements, it was ensured that the companies must have relevant procedures in place. The FOT randomly checks the application of these procedures, i.e. of the change management, as part of the safety monitoring.

Derailment of a passenger train, Les Brenets (Canton Neuchâtel), 26/07/2016

On Tuesday 26 July 2016 at 07:22, train 6 from Le Locle to Les Brenets, made up of railcar BDe 4/4 no. 5, derailed on open track at kilometre point 2.1, following failure of the leading axle shaft. No one was injured in this derailment. Apart from the axle breaking, damage to the railcar or the infrastructure were minimised.
The derailment of railcar BDe 4/4 no. 5 was due to the failure of axle 4, the leading axle in the direction train 6 was moving.

Factors contributing to the axle failure:
- Inadequate layout of the keyway on the axle shaft;
- Sharp angles at the intersection of the keyway and the journal fillet connecting the crown wheel and the wheel centre;
- The state of the rough surface of the machining of the keyway;
- The lack of a defined radius between the base and the keyway.

Safety deficit
The axles are an essential safety element. Any modification or adaptation of the manufacturer's original design can modify the pressures on the axle shaft and may have negative consequences for safety in operation.

Safety recommendation no. 126, 05/09/2017
The STSB recommends that the FOT, when ordering replacement axles, carries out dimensioning calculations on these axles.

Implementation status
Implemented. The FOT is of the view that this safety recommendation is already covered by article 8 of the railway regulation (EBV) and the FOT guideline 'Railway Vehicle Approval'. A company that carries out modifications on railway vehicles must assess if these modifications are safety-relevant. In general, this approach is known to the rail-

way companies, either because of the numerous previous contacts with the FOT or from the Association of Public Transport (VöV) guideline (D-RTE 49100) which is based on the FOT guideline mentioned above. The procedure for the approval of railway axles for metregauge railways, such as the Le Locle – Les Brenets line, is also described in the FOT guideline 'Structure Variations for Metre- and Special-Track Railways'.
In addition, an inadequate level of knowledge with regard to this process is amended during the random checks carried out by the FOT as part of periodic company inspections and audits.
In view of this, the Vehicles Section does not see any need for special measures, because the calculation of the axle strength is systematically requested and checked for changes that affect the running gear.

Safety deficit
The technical documentation provided by the suppliers for vehicles placed into service in the 1950s and the1960s is not very detailed. The wide range of designs submitted for appraisal demonstrates a certain difficulty in the technical follow-up of these vehicles. Technological development, the often very limited period during which spare parts can be ordered from the initial supplier, and the turnover of maintenance staff could favour the loss of technical knowledge.

Safety recommendation no. 127, 05/09/2017
The STSB recommends that the FOT have the TransN safety management system supplemented to include the process of obsolescence management for safety components of rolling stock.

Implementation status
Partially implemented. The safety management system (SMS) shows how a company deals with safety-relevant aspects in a systematic and targeted manner. The responsibility for this lies with the respective railway company.
During the substantive examination of the SMS with regard to the requirements defined in (EU) Regulations No. 1158/2010 (Annexes II and III) and No. 1169/2010 (Annex II), the FOT takes into account the activities and the complexity of the company. The applicant company must ensure that all operational risks are monitored and managed, and that the regulations are complied with.
TransN has safety authorisation and a safety certificate which is valid until 1 December 2018. The requirement for risk control regarding maintenance and material procurement (requirement B) was reviewed as part of the renewal in November 2015. In the process, evidence was provided that TransN has the necessary procedures for:
– The clear allocation of responsibilities for maintenance,
– The definition of the necessary requirements and
– The identification of risks resulting from defects, design errors or malfunctions during the operating life.

The official policies for defining the various limits for safety-relevant parts of the rolling stock were not checked or were not available.
This requirement and the corresponding policies will be examined in more detail as part of a management discussion in 2018.

Runaway of a shunting composition in Andermatt, 01/09/2016

On 1 September 2016 at 07:51 a driverless shunting tractor with four passenger train carriages rolled away from the railway siding at Andermatt station towards Göschenen. Below the Teufelsbrücke bridge the vehicles derailed in the Bäzberg gallery and were thereby stopped. There was no one in the vehicles. There was major material damage to the infrastructure and the vehicles. Railway operations between Andermatt und Göschenen were interrupted for several days.

The runaway can be attributed to inadequate clamping force of the shunting tractor's parking brake as the design of the brake rods could not ensure the required friction.

Contributing factors to the accident were:

Because the parking brake's braking rods are independent of the shunting brake, the brake pads never rubbed against the rotating wheel discs and were never bedded in to the wheel discs.
The lack of a guideline for the adjustment and assessment of the parking brake's braking effect.

The following factors were neither causal nor contributing in this accident, they were, however, recognised as risky:
In the event of a shunting brake failure only the shunting tractor's parking brake is still effective. In this regard, it is safety-relevant that, as a minimum, the parking brake provides the clamping force required for a gradient of up to 40 ‰. The current parking brake does not meet this requirement.

Safety deficit
The parking brake is mechanically and pneumatically independent of the shunting brake. It is exclusively used when the vehicle is stationary. The brake pads never rub against the rotating wheel disc and are therefore never bedded in to the disc. There is the risk that the friction surface between the brake pads and the wheel disc is too small and the expected braking effect cannot be provided. The shunting brake's brake pads, on the other hand, are worn during operation and are bedded in to the disc across the entire friction surface.
In the event of a shunting brake failure on a solo shunting tractor, only the parking brake on the shunting tractor is

still effective. In this regard, it is safety-relevant that, as a minimum, the parking brake provides the clamping force required for a gradient of up to 40 ‰.

Safety recommendation no. 129, 12/12/2017
The FOT should prompt the braking concept on shunting tractors of an identical type to be adjusted so that the parking brake is sufficiently effective at all times.

Implementation status
Awaiting response.

Safety deficit
Once a year, maintenance staff replace the parking brake's brake pads with partially worn brake pads from the shunting brake assuming that they would still be bedded in to the wheel discs. There are no guidelines for this work or for the adjustment of the parking brake's braking rods. There are also no guidelines for the assessment of the parking brake's braking effect. Due to the lack of checking the parking brake's effectiveness, there is a risk that inadequate braking effect may go undetected.
The STSB does not know if there are any other vehicles with a similar design featuring separate braking rods between shunting and parking brake. This risk would be the same in such vehicles.

Safety recommendation no. 130, 12/12/2017
The FOT should examine if there are other vehicles with a similar parking brake design and propose to the respective railway companies that they develop guidelines for the parking brake's adjustment and the assessment of its braking effect in these vehicles.

Implementation status
Awaiting response.

Two axle failures occurring between Le Locle and Les Brenets (Canton Neuchâtel) on 11 and 27/07/2017

On Tuesday 11 July 2017, a little after exiting the station at Les Brenets, the driver of train 23 noticed vibrations coming from below railcar BDe 4/4 no. 3. He immobilised the train. In conformity with service note TransN 45/2016, which was implemented following the derailment on 26 July 2016, the driver returned train 23 to the station at Les Brenets. Once the TransN technical service had begun to manoeuvre the railcar from Les Brenets station towards the depot to carry out checks, the leading axle of bogie 1 failed.
Since being placed into service in 2006, this axle had travelled approximately 320,000 km.
At the axle examination carried out by the STSB, it was noted that the axle had fractured between the crown wheel and the wheel body.

On Thursday 27 July 2017 at 09:20, at approximately kilometre point 2.5, the driver of train 10 experienced vibrations coming from below railcar BDe 4/4 no. 5. He reduced speed to about 5 km/h. At kilometre point 3.3, he realised that the vibrations were swelling. The driver cut the power. The railcar stopped. The driver then returned his train to the station at Les Brenets, at a maximum speed of 5 km/h. In the station, the technical service found that an axle had failed.
Since being placed into service in 2013, this axle had travelled approximately 140,000 km.
At the axle examination carried out by the STSB, it was noted that the leading axle of bogie no. 1 had fractured, as in the previous case, between the crown wheel and the wheel body.

Safety deficit
In terms of safety, the axles are one of the crucial elements of the running gear. They have to ensure the operational reliability of the vehicles.
In view of the number of failures that have occurred within such a short period of time on a series of identical vehicles, the potential risk of other axle failures is latent.

Safety recommendation no. 128, 05/08/2017
The STSB recommends that the FOT have TransN railcars BDe 4/4 nos. 2 to 5 taken out of service until all the axles currently in service have been replaced.

Implementation status
Implemented. In a letter dated 8 August 2017, TransN was asked to decommission railcars BDe 4/4 Nos. 2 to 5 from service.

5.4 Cableways

Collision involving two cableway cars and an obstacle in Ried Brig-Rosswald, 14/06/2014

On 14 June 2014, four cars were on the ascent of the Ried Brig – Rosswald (LRR) cableway. At approximately 18:07, cars 1 and 2 hit the railings of the protective scaffolding above national road 9. Thereby, the door of car 1 was opened, objects fell onto the protective scaffolding and one passenger was held back by fellow passengers preventing him from falling out of the car.

The collision involving the two LRR cars can be attributed to the fact that the cableway was not operated in accordance with the manufacturer's guidelines when the cars were lined up.

Contributing factors to the accident were:
– Incorrect troubleshooting.
– Allowing passengers to board car 1, which was ready for departure, outside of the designated area, i.e. behind the infrastructure device that locks the doors automatically.
– The vehicle distance between car 1 and car 2 was too short and led to excessive slack on the haul cable.
– An operations manager and a member of staff, both of whom had little experience, working together.

Safety deficit
The fact that both the operations manager and the member of staff who were working together had little experience contributed to the accident.

They had both been trained for one day each. The cases of incorrect troubleshooting indicate that it was not possible to gain sufficient expertise in this short period of time. In case of failure, operating exclusively with less experienced staff can have an impact on the operational safety of the cableway system.

Safety recommendation no. 103, 23/05/2017
As part of its supervisory activity, the FOT should examine whether the cableway companies sufficiently assume their responsibility for staff training and adequate duty-roster planning.

Implementation status
Partially implemented. The safety recommendation issued in the report is being implemented as part of the FOT's supervisory activity.

Safety deficit
Not locking the door of car 1 following its manual opening contributed to the accident.

Safety advice no. 3, 23/05/2017
During passenger operations, the metal bar for manually operating the door must only be used for opening the door in an emergency.

5.5 Buses

Postbus fire at Le Locle (Canton Neuchâtel), 13/12/2015

On Sunday 13 December 2015, at 16:30, a fire broke out in the engine compartment of a postbus at Le Locle. No one was injured, but the vehicle was severely damaged. The fire was caused by the fact that the synthetic pipes supplying fuel to the motor had melted due to the heat released by the housing. The fuel that leaked out burst into flames, causing the fire.
Contributory factor:
Incomplete requirements for the design of fuel lines, and the lack of monitoring of these fuel lines, contributed to the fire.

Safety deficit
The synthetic pipes supplying fuel to the motor, which passed close to the housing of the turbocharger, had melted due to the heat released by this housing. The fuel that leaked out burst into flames, causing the fire.

Safety recommendation no. 125, 05/09/2017
The STSB recommends that the FOT transmit to the Federal Roads Office (FEDRO) – which carries out type-approval testing pursuant to Article 12 of the Federal Act of 19 December 1958 on Road Traffic, as amended 1 October 2016 – the following safety recommendation:
At the type-approval test, particular attention should be paid so that no component made of synthetic material be installed in the engine compartment, without adequate protective equipment, close to an element that generates a significant level of heat.

Implementation status
Implemented. Solaris Switzerland has modified all of the vehicles in Switzerland of the relevant vehicle type (Solaris Urbino 8.9H). The turbo charger was fitted with heat shielding and the fuel lines' routing and their material were changed. The manufacturer of Solaris in Poland was also informed by the representative in Switzerland and the manufacturer has already made the necessary modifications to subsequent 8.9H type vehicles delivered from the factory.

6 Analysis

6.1 Aviation

As in the previous years' annual reports, statistical data from past years has also been analysed for this annual report. The methodology used is described in Annex 4. Definitions of the terms used can also be found in Annex 4.

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

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

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

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

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

Analysis of the accident statistics using the methods described and the definitions given in Annex 4 produces the following results for

the category of motorised aircraft with a maximum take-off mass of up to 5,700 kg (including motor gliders and touring motor gliders in powered flight):

– Absolute number of accidents in 2017: 7
– The increase in the anticipated number of accidents is estimated to be 2.9 % per year. However, this is not significantly different from zero (p = 0.559).
– The increase in the anticipated accident rate is estimated to be 4.3 % per year. This figure is also not significantly different from zero (p = 0.393).

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.

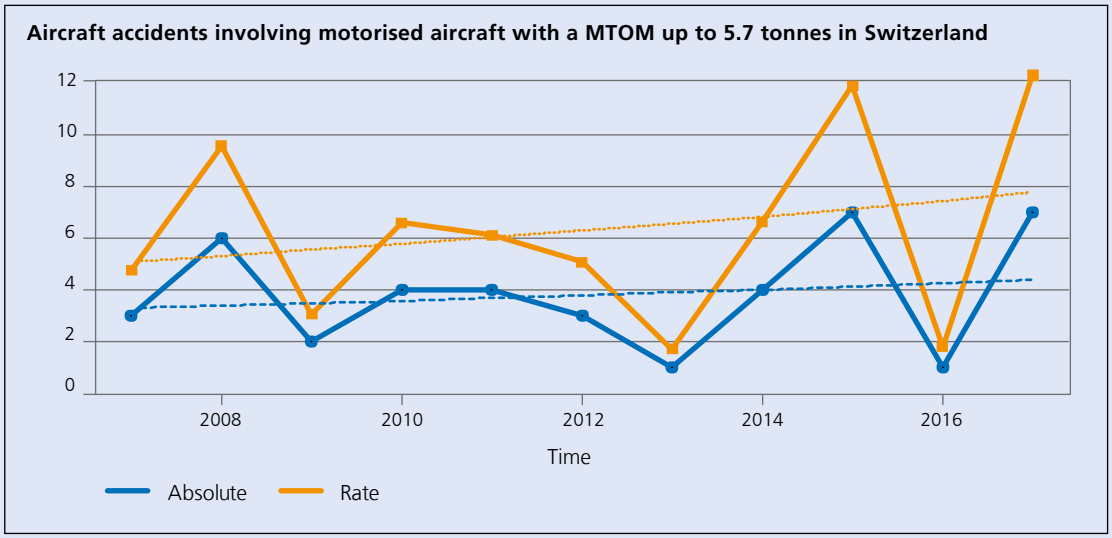
6.1.2 Gliders

Analysis of the accident statistics using the methods described and the definitions given in Annex 4 produces the following results for the glider aircraft category (including motor gliders and touring motor gliders when gliding):

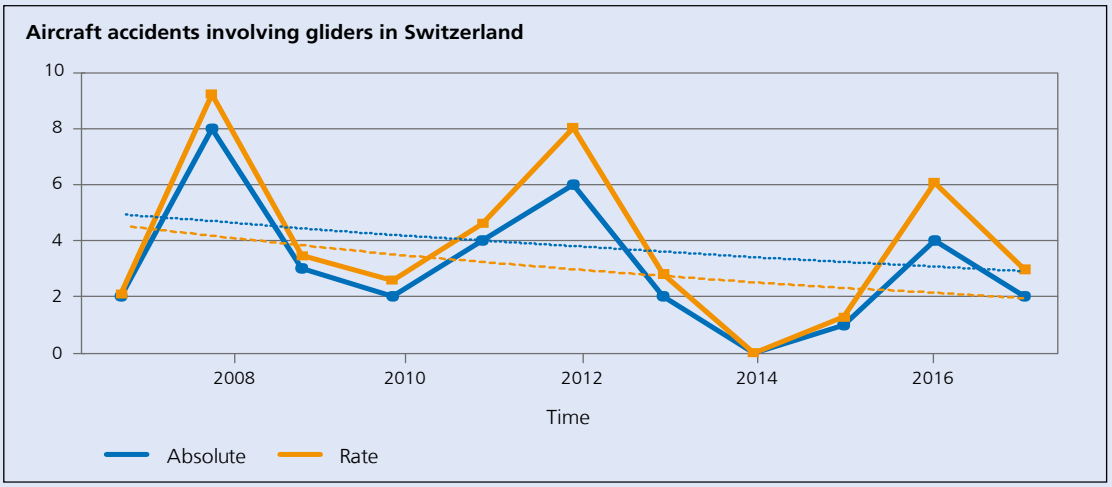
– Absolute number of accidents in 2017: 2
– The decrease in the anticipated number of accidents is estimated to be 8.0 % per year. However, this is not significantly different from zero (p = 0.132).
– The decrease in the anticipated accident rate is estimated to be 5.2 % per year. This figure is also not significantly different from zero (p = 0.334).

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)



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



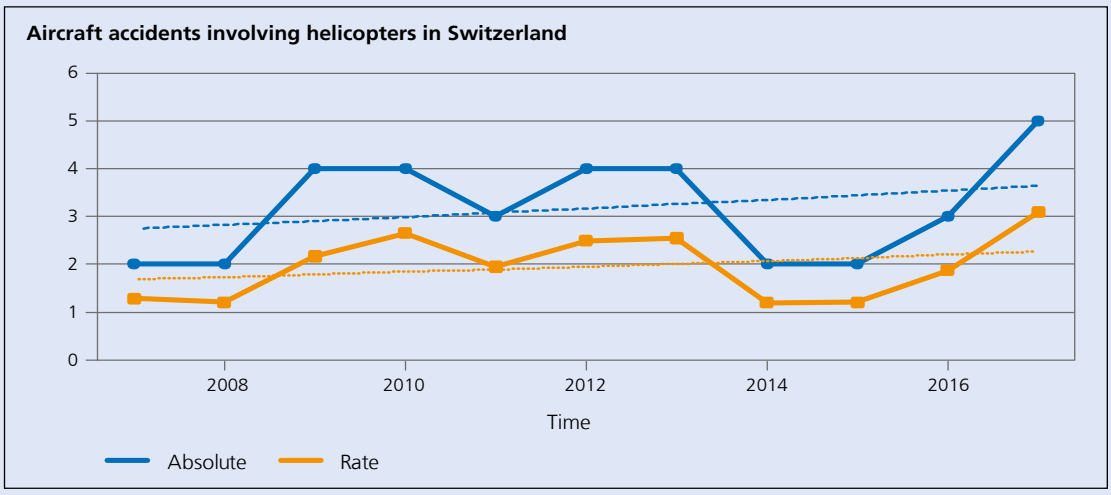
6.1.3 Helicopters

Following analysis of the accident statistics using the methods described and the definitions given in Annex 4, the following statements can be made for the helicopter aircraft category:

- Absolute number of accidents in 2017: 5
- The increase in the anticipated number of accidents is estimated to be 2.9 % per year. However, this is not significantly different from zero (p = 0.593).
- The increase in the anticipated accident rate is estimated to be 3.0 % per year. This figure is also not significantly different from zero (p = 0.582).

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. It has

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



to be noted that three out of the five helicopter accidents that took place in 2017 were, in actual fact, accidents at work where the aircraft remained undamaged and people who were not in the helicopter were injured.

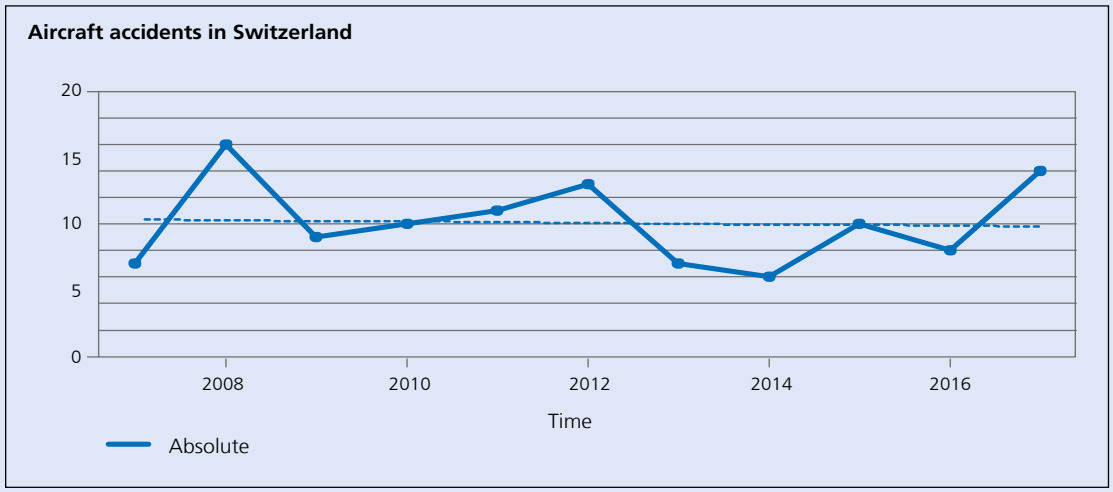
6.1.4 Total for motorised aircraft, gliders and helicopters

Following analysis of the accident statistics using the methods described and the definitions given in Annex 4, the following statements can be made for the consolidated aircraft categories of motorised aircraft with a maximum take-off mass of up to 5,700 kg, gliders and helicopters:

- Absolute number of accidents in 2017: 14
- The decrease in the anticipated number of accidents is estimated to be 0.5 % per year. However, this is not significantly different from zero (p = 0.857).
- Due to varying reference parameters, it doesn't make any sense to determine an accident rate for aircraft categories that have been combined.

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.

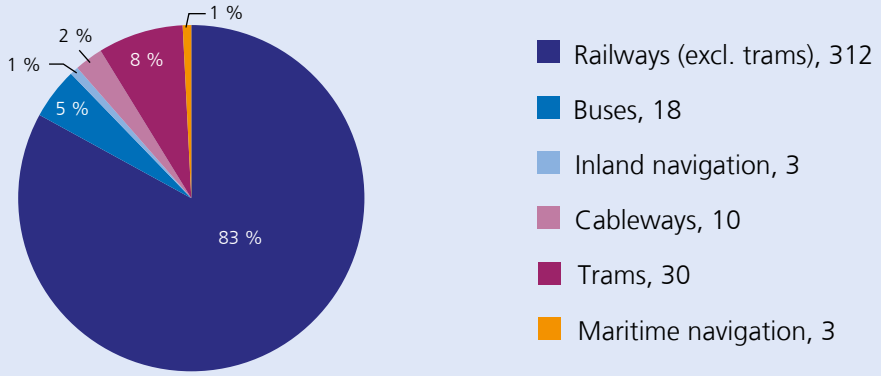
Absolute no. of accidents



As demonstrated by the above analysis, there is great uncertainty when estimating the anticipated accident figures. This is due to the fact that, with 11 observations, the time series is still very short. For this reason, the STSB takes the view that it is not possible to establish a trend concerning the development of flight safety over the last 11 years for motorised aircraft with a maximum take-off mass of up to 5,700 kg, gliders and helicopters.

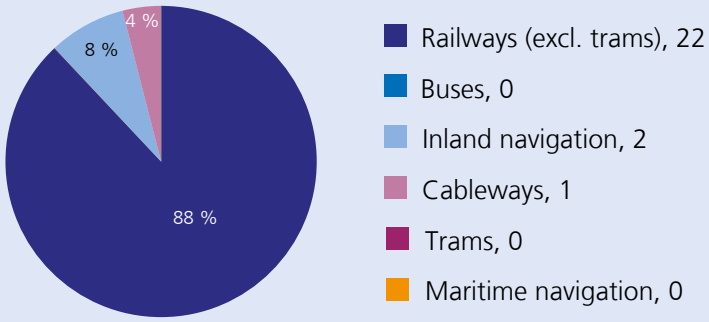
6.2 Railways, cableways, buses, inland and maritime navigation

Distribution of event notifications



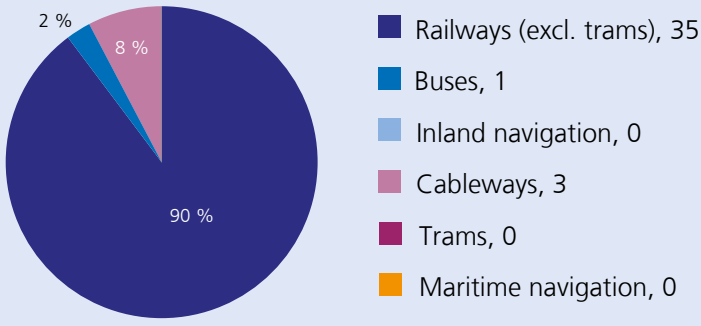
91 % of the notifications relate to railways (incl. trams). The remaining 33 – 9 % of the notifications – relate to the other modes of transport: buses and cableways, as well as inland and maritime navigation.

Distribution of investigations opened



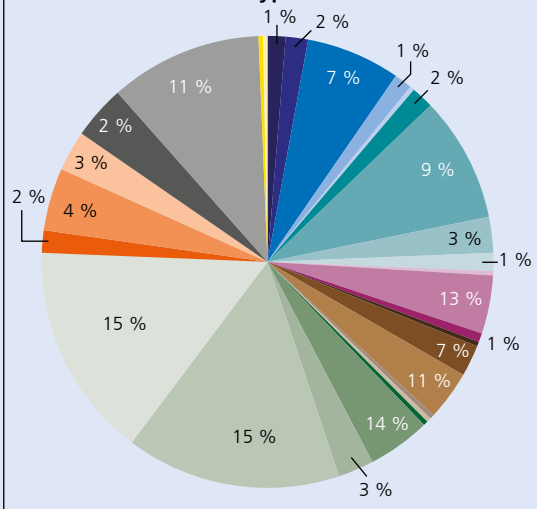
The majority of investigations opened relate to railways.

Distribution of reports published



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.

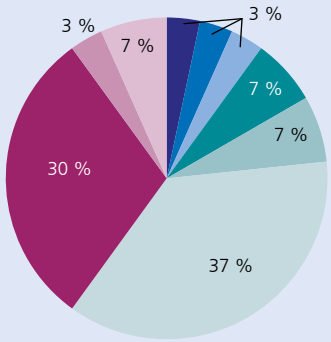
Distribution of event types from the event notifications for railways (excluding trams)



- Accident involving persons, later established as suicide, 48
- Sabotage/vandalism, 5
- Other, 14
- Accident involving high-voltage current, 9
- Irregularity with danger, 12
- Irregularity without immediate danger, 34
- Failure of safety equipment, 1
- Train/vehicle uncoupling, 1
- Accident at work, 4
- Construction site, 5
- Near miss / endangerment, 21
- Interruption of operations, 4
- Bomb scare, 1
- Fire, 5
- Shunting operation derailment, 28
- Train derailment, 8
- Runaway vehicle, 4
- Event involving hazaradous goods, 1
- Collision at level crossing with controls, 13
- Collision at level crossing without controls, 2
- Collision between vehicle and obstacle, 1
- Collision between shunting operations, 7
- Collision between shunting operation and obstacle, 11
- Collision between shunting operation and road vehicle, 1
- Collision between vehicles, 1
- Collision between train and shunting operation, 1
- Collision between train and obstacle, 14
- Collision between train and road vehicle, 8
- Accident involving persons, 48

For railways (excluding trams), the event types concerning accidents to persons constitute the majority of the 312 event notifications. This is followed by collisions, derailments and near misses / endangerments.

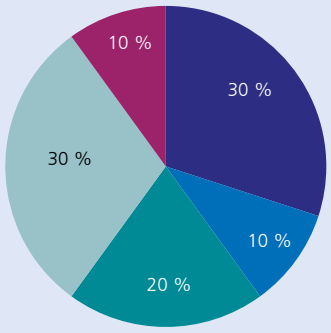
Distribution of event type from the event notifications for trams



- Accident at work, 1
- Near miss / endangerment, 1
- Shunting operation derailment, 1
- Train or tram derailment, 2
- Collision between trams, 2
- Collision between tram and road vehicle, 11
- Accident involving persons, 9
- Other, 1
- Irregularity without immediate danger, 2

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

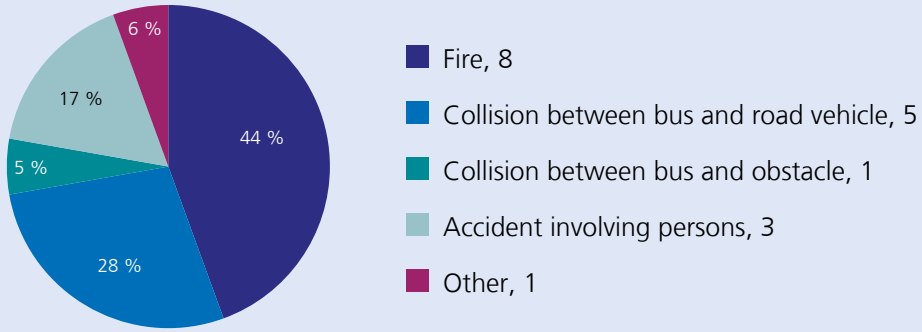
Distribution of event type from the event notifications for cableways



- Accident at work, 3
- Vehicle crash, 1
- Accident involving persons, 2
- Irregularity with danger, 3
- Irregularity without immediate danger, 1

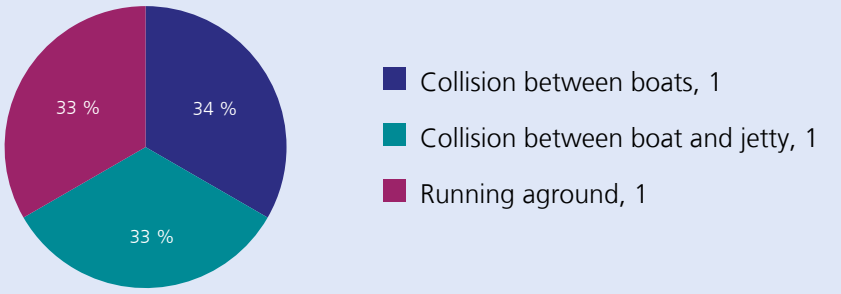
For cableways, the majority of the event notifications relate to accidents at work and irregularities involving endangerment. Irregularities involving endangerment as well as accidents involving persons refer to events that occurred in connection with the passenger change.

Distribution of event type from the event notifications for buses



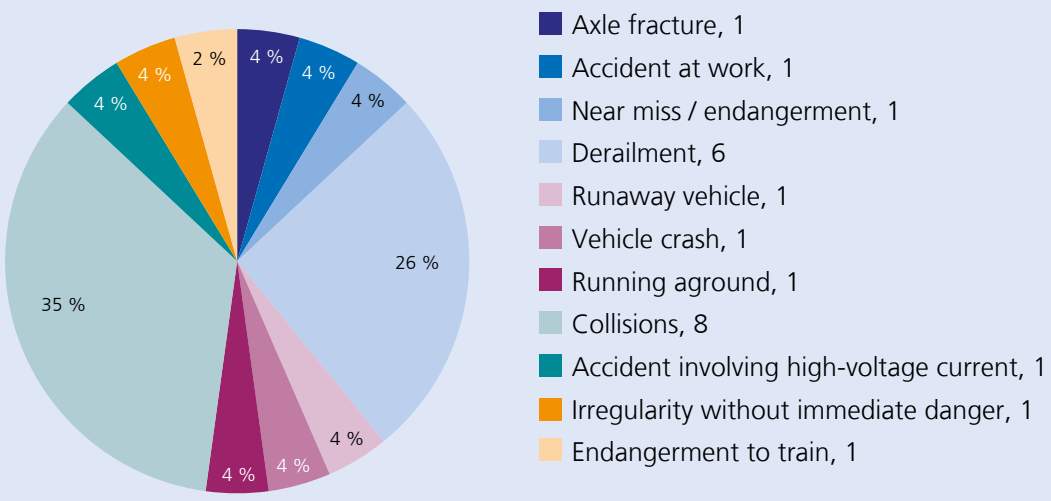
Incidents on public roads, which can be attributed to a violation of road traffic regulations, are not required to be reported to the STSB and are also not investigated. With regard to all event types, fires and collisions with road vehicles form the majority of events reported.

Distribution of event type from the event notifications for inland navigation



The 3 event notifications concerning inland navigation consisted of two collisions and one grounding.

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



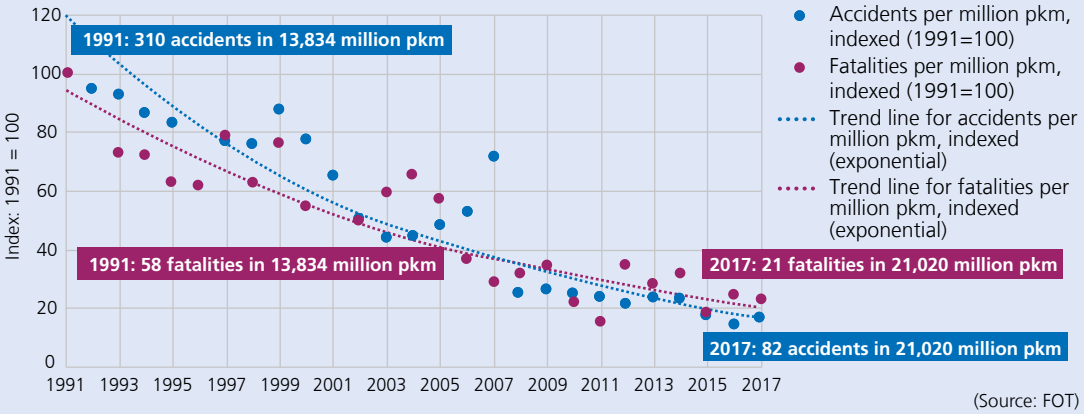
The majority of the 23 investigations opened relate to collisions (8), derailments (6).

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

	Accidents						Fatalities						Seriously injured persons					
Modes of transport	2012	2013	2014	2015	2016	**2017**	2012	2013	2014	2015	2016	**2017**	2012	2013	2014	2015	2016	**2017**
Railways	96	107	107	83	71	84	29	23	27	16	22	21	37	65	68	43	22	41
Trams	54	54	49	35	36	35	2	4	6	5	3	2	53	45	37	28	30	50
Cableways	9	4	8	10	6	5	2	1	3	1	0	0	5	3	5	9	6	5
Buses	67	39	37	49	42	42	4	2	4	5	4	7	59	34	39	44	37	39
Inland navigation	1	1	3	1	1	1	0	0	0	0	0	0	1	1	0	0	2	0
All modes of transport	**227**	**205**	**204**	**178**	**156**	**167**	**37**	**30**	**40**	**27**	**29**	**30**	**115**	**148**	**149**	**124**	**97**	**135**

During the past six years, the number of accidents showed a tendency to decrease (source of table: FOT).

Accidents and fatalities per million person-kilometers in railways 1991 to 2017 (indexed)



(Source: FOT)

During the past 26 years, the number of railway accidents and persons fatally injured on the railways has decreased by around a quarter. This is the result of the efforts made by all parties in the overall safety infrastructure, including those made by the STSB (source of chart: FOT).

Annex

Annex 1: List of final reports, interim reports and studies published in 2017 regarding aviation
Annex 2: List of final and interim reports published in 2017 regarding railways, cableways and inland navigation
Annex 3: Statistical information on aviation incidents
Annex 4: Method and conceptual considerations for the analysis of statistical aviation data

Annex 1

List of final reports, interim reports and studies published in 2017 regarding aviation

Number	Code	Date	Location	Safety recommendation	Safety advice
2280	HB-KDD	23/02/2015	Yverdon-les-Bains Aerodrome		
2281	HB-ZIG	11/02/2015	Guttannen		
2282	HB-ZOA	09/06/2015	Semsales		
2284	HB-WXC	21/06/2014	Cudrefin		
2289	N108MW	19/10/2014	Speck-Fehraltorf Aerodrome		
2291	HB-2207 / HB-SCS	31/05/2015	Oensingen region		
2292	HB-PKK / J-5013 / J-5006	21/11/2014	Payerne	512	
2293	HB-IOC	09/03/2014	Geneva Airport		
2294	HB-IYW / HB-BYI	03/06/2015	Zurich	518, 519, 520, 521, 522	
2295	HB-PQS	12/07/2015	Wilen near Wil		
2296	HB-JZQ	20/07/2014	Basel-Mulhouse Airport	524	
2297	HB-IZW	28/11/2013	Lugano		
2298	HB-ZRV	26/02/2015	Erstfeld Heliport	525, 530, 531	
2299	HB-ZGP	21/09/2015	Wolfenschiessen		14
2300	Trolleys	09/02/2016	Zurich Airport	526, 527	15
2301	HB-ZRU	22/06/2014	Brissago		
2302	HB-OQW / HB-CXK	24/08/2014	Rickenbach near Wil		
2303	D-ANFE	04/12/2014	Zurich Airport	529	
2304	HB-SEW	05/11/2015	Samedan		
2305	HB-3364	01/07/2015	Klosters		
2306	HB-MSW	18/11/2015	Bex Aerodrome		16
2307	HB-HFK	16/04/2015	Approx. 1 km north-west of Lausanne Aerodrome		
2308	HB-ERO	23/08/2016	Höhnwilen above Ermatingen		
2309	HB-ZIS	14/07/2015	Lauterbrunnen		
2311	HB-SFR	19/07/2016	Croix-de-Coeur		
2314	T-320 / HB-ZHD	04/05/2016	8 NM south-east of Dübendorf Air Base		
2315	HB-WGA	16/07/2016	1.3 km est of Ecuvillens		
2316	OE-LGL	13/10/2015	Lugano-Agno Airport	535	
2317	HB-ZIH	29/09/2016	2 km north-east of Fanas		
2318	HB-EQN	26/08/2016	1 km north-east of Schaffhausen Airfield	536	

Annex 2

List of final and interim reports published in 2017 regarding railways, cableways and inland navigation

Number	Mode of transport	Type of accident	Date	Location	Safety recommen-dation	Safety advice
2014051701	Railways	Collision	17/05/2014	Spiez		
2014061404	Cableways	Collision	14/06/2014	Ried-Rosswald	103	3
2014071701	Railways	Fire	17/07/2014	Hergiswil	83	
2014081101	Railways	Collision at unattended level crossing	11/08/2014	Wolfen-schiessen		
2014081301	Railways	Derailment	13/08/2014	Tiefencastel	111	4
2014093001	Railways	Derailment	30/09/2014	Jakobsbad	(73)*), (74)*), (75)*)	5
2015052401	Railways	Derailment	24/05/2015	Aarau		6, 7
2015100201	Railways	Runaway train	02/10/2015	Baulmes	(88)*), (89)*) 112, 113, 114, 115	
2015112402	Railways	Derailment	24/11/2015	Rotkreuz	110	
2015121302	Buses	Fire	13/12/2015	Le Locle	125	
2016011301	Railways	Injured person	13/01/2016	Zurich Schweighof	120, 121	
2016012001	Railways	Derailment	20/01/2016	Zurich Mülligen	116, 117	
2016022201	Railways	Collision between train and an obstacle	22/02/2016	Sihlbrugg		
2016030803	Railways	Fire – explosion	08/03/2016	Fiesch	118	
2016031601	Cableways	Cableways incident	16/03/2016	Stoos		
2016032904	Railways	Irregularity without immediate danger	29/03/2016	Zurich Altstetten		
2016040101	Railways	Shunting accident	01/04/2016	Stein-Säckingen		
2016051101	Railways	Construction site	11/05/2016	Oberrieden Dorf		
2016060502	Railways	Derailment	06/05/2016	Horw		
2016060802	Railways	Runaway train	08/06/2016	Olten	122, 123, 124	
2016071101	Railways	Collision between train and an obstacle	11/07/2016	Lucerne		
2016071601	Railways	Collision between trains during shunting operation	16/07/2016	Chiasso SM	119	
2016072601	Railways	Derailment	26/07/2016	Les Brenets	(105)*), 126, 127	
2016090101	Railways	Runaway train	01/09/2016	Andermatt	129, 130	
2016112401	Railways	Collision at unattended level crossing	24/11/2016	Lüscherz		
2016112801	Railways	Runaway train	28/11/2016	Andermatt	129, 130	
2017072701_ZB	Railways	Derailment	27/07/2017	Les Brenets	128	

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

Annex 3

Statistical information on aviation incidents

Contents

1. Preliminary remarks

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

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

2. Definitions

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

Incident

An event associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time it comes to rest at the end of the flight and the primary propulsion system is shut down, in which

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

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

b) the aircraft has sustained damage or structural failure which adversely affects the structural strength, performance or flight characteristics of the aircraft, and would normally require major repair or replacement of the affected component, except for engine failure or damage when the damage is limited to a single engine (including its cowlings or accessories), to propellers, wingtips, antennas, probes, vanes, tyres, brakes, wheels, fairings, panels, landing gear doors, windscreens, the aircraft skin (such as small dents or puncture holes), or minor damage to the main rotor blades, tail rotor blades, landing gear, and those resulting from hail or bird strike (including holes in the radome); or

c) the aircraft is missing or is completely inaccessible.

Serious injury

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

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

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

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

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

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

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

3. Tables and diagrams

3.1 Air accidents and serious incidents involving Swiss-registered aircraft

Year	Number of registered aircraft [1]	Flight hours [1]	Flight personnel licences [1]	Number of accidents investigated	Number of accidents with summary procedure	Total number of accidents	Number of serious incidents (incl. airproxes)	Airproxes investigated [2]	Total number of accidents and serious incidents	Number of fatalities
2006	3822	715 572	15 368	27	31	58	10	7	68	10
2007	3813	766 557	15 076	23	20	43	4	6	47	12
2008	3765	784 548	14 691	28	19	47	5	6	52	11
2009	3685	842 017	14 973	26	17	43	4	3	47	5
2010	3705	793 592	15 313	21	16	37	8	4	45	8
2011	3709	873 548	12 855 [3]	21	24	46	13	8	59	13
2012	3657	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	3556	919 987	11 563	18	28	46	13	5	59	8
2015	3494	865 404	11 536	29	24	53	22	4	75	12
2016	3414	849 373	11 563	21	16	37	46	16	83	5
2017	**3333**	**850 525**	**11 318**	**25**	**22**	**47**	**32**	**8**	**79**	**18**

[1] Source: Federal Office of Civil Aviation

[2] Incl. airproxes involving foreign-registered aircraft

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

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

Year	Number of registered aircraft [1]	Flight hours [1]	Number of accidents investigated	Number of accidents with summary procedure	Total number of accidents	Number of serious incidents (incl. airproxes)	Airproxes investigated[2]	Total number of accidents and serious incidents	Number of fatalities
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**

[1] Source: Federal Office of Civil Aviation

[2] Incl. airproxes involving foreign-registered aircraft

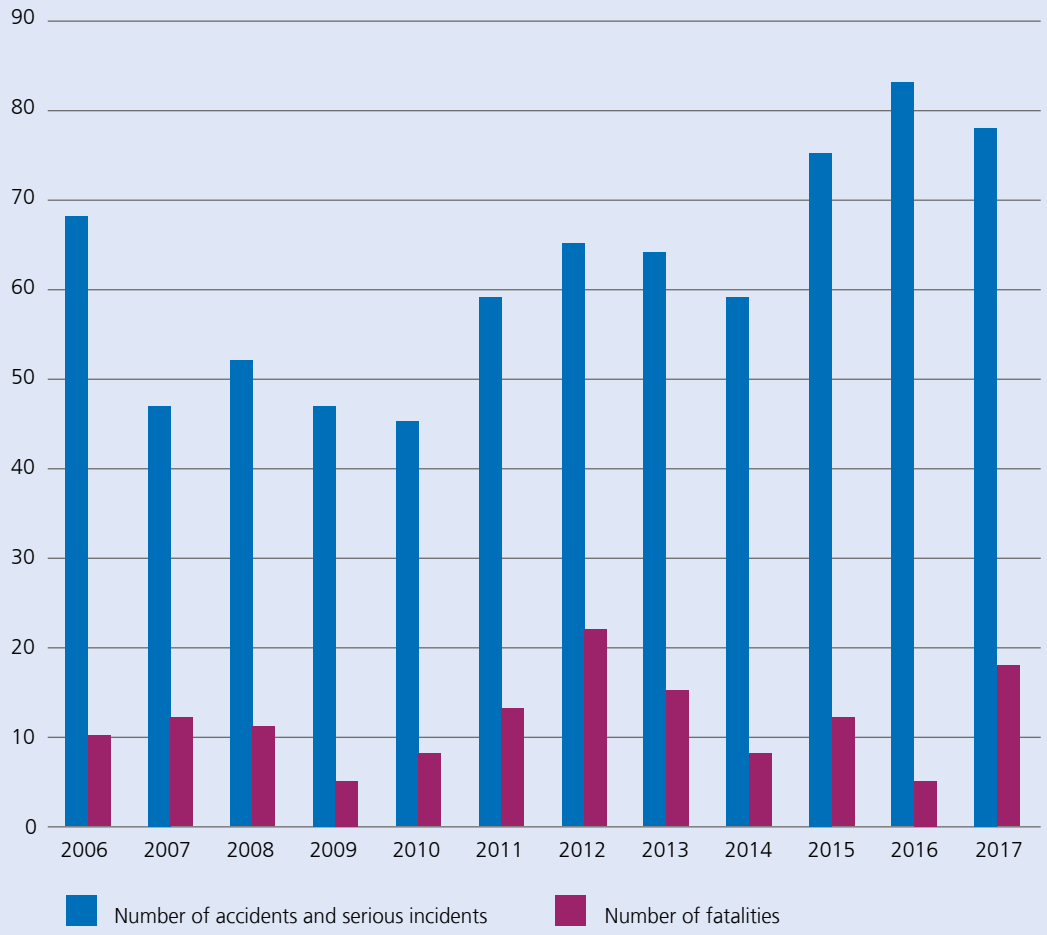
3.1.2 Air accidents and serious incidents involving Swiss-registered aircraft up to 5,700 kg MTOM

Year	Number of registered aircraft [1]	Flight hours [1]	Number of accidents investigated	Number of accidents with summary procedure	Total number of accidents	Number of serious incidents (incl. airproxes)	Airproxes investigated[2]	Total number of accidents and serious incidents	Number of fatalities
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**

[1] Source: Federal Office of Civil Aviation

[2] Incl. airproxes involving foreign-registered aircraft

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



3.2 Summary of accident data for the reporting period 2016/2017

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

	Accidents and serious incidents involving Swiss-registered aircraft						Accidents and serious incidents involving Swiss-registered aircraft						Accidents and serious incidents involving foreign-registered aircraft					
	domestic						abroad						in Switzerland					
	Total		of which with injured persons		of which without injured persons		Total		of which with injured persons		of which without injured persons		Total		of which with injured persons		of which without injured persons	
	2017	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016
Total	**70**	64	**14**	7	**56**	57	**9**	19	**2**	4	**7**	15	**13**	23	**2**	1	**11**	22
Aircraft with MTOM of up to 2,250 kg	**48**	22	**7**	1	**41**	21	**5**	9	**1**	3	**4**	6	**5**	3	**1**	0	**4**	3
Aircraft with MTOM of 2,250–5,700 kg	**1**	3	**0**	0	**1**	3	**1**	0	**1**	0	**0**	0	**0**	2	**0**	0	**0**	2
Aircraft with MTOM exceeding 5,700 kg	**3**	9	**0**	0	**3**	9	**3**	8	**0**	0	**3**	8	**7**	15	**0**	0	**7**	15
Helicopters	**11**	17	**5**	3	**6**	14	**0**	1	**0**	1	**0**	0	**0**	0	**0**	0	**0**	0
Motor gliders and gliders	**7**	11	**2**	3	**5**	8	**0**	1	**0**	0	**0**	1	**1**	2	**1**	1	**0**	1
Balloons and airships	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	1	**0**	0	**0**	1
Ultralight aircraft	**0**	2	**0**	0	**0**	2	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0

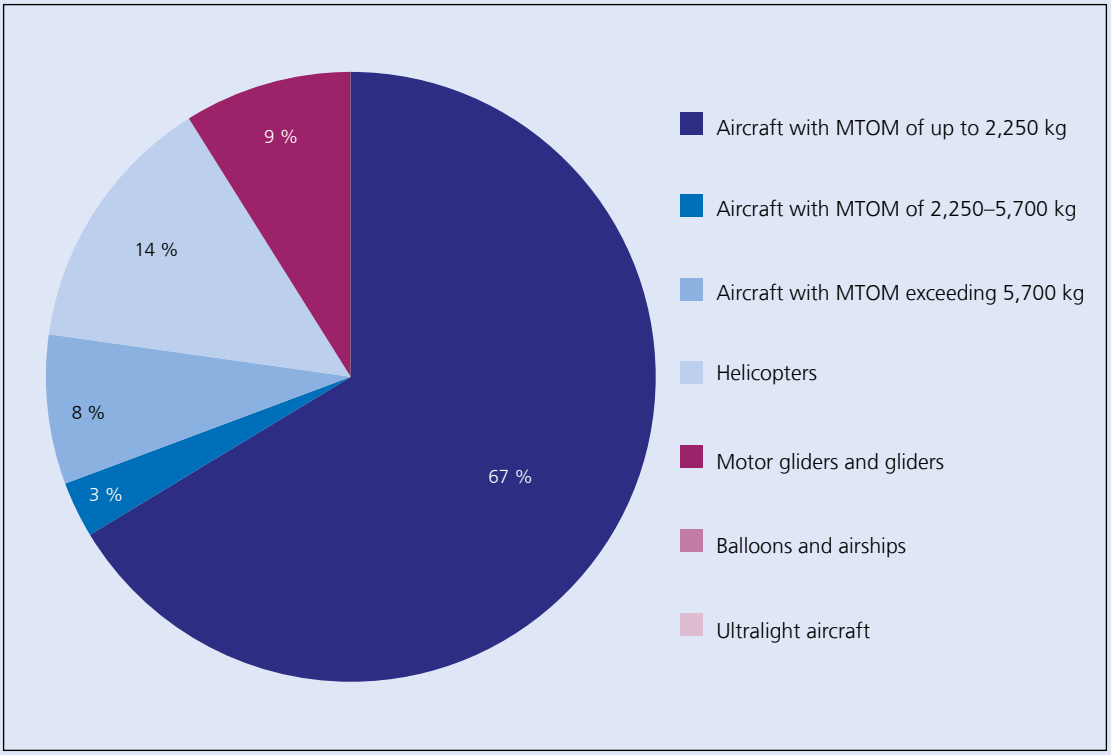
3.2.2 Accidents and serious incidents involving Swiss-registered aircraft

	Number of registered aircraft [1] (01/01/2018)		Total number of accidents / serious incidents	
	2017	2016	**2017**	2016
Aircraft with MTOM of up to 2,250 kg	**1358**	1382	**53**	24
Aircraft with MTOM of 2,250–5,700 kg	**174**	162	**2**	3
Aircraft with MTOM exceeding 5,700 kg	**254**	279	**6**	11
Helicopters	**335**	337	**11**	17
Motor gliders and gliders	**874**	907	**7**	11
Balloons and airships	**338**	347	**0**	0
Ultralight aircraft [2]	**–**	–	**0**	2
Total	**3333**	3414	**79**	68

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

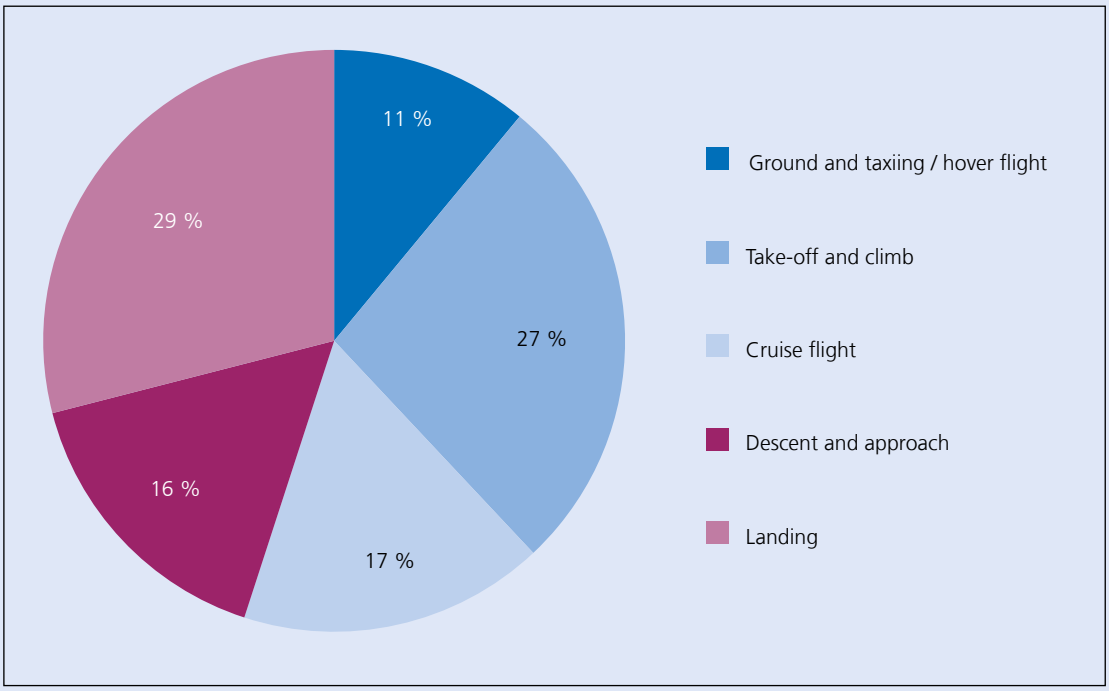
3.2.3 Accidents and serious incidents by aircraft type involving Swiss-registered aircraft

	2017	2016
Aircraft with MTOM of up to 2,250 kg	**67 %**	37 %
Aircraft with MTOM of 2,250–5,700 kg	**3 %**	4 %
Aircraft with MTOM exceeding 5,700 kg	**8 %**	20 %
Helicopters	**14 %**	22 %
Motor gliders and gliders	**9 %**	14 %
Balloons and airships	**0 %**	–
Ultralight aircraft	**0 %**	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	
	2017	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016
Aircraft with MTOM of up to 2,250 kg	**10**	3	**16**	6	**6**	5	**8**	5	**21**	15	**61**	34
Aircraft with MTOM of 2,250–5,700 kg	**0**	0	**1**	2	**1**	0	**0**	1	**1**	2	**3**	5
Aircraft with MTOM exceeding 5,700 kg	**0**	3	**4**	9	**3**	10	**5**	10	**1**	1	**13**	33
Helicopters	**1**	1	**4**	2	**3**	3	**2**	4	**1**	8	**11**	18
Motor gliders and gliders	**0**	0	**1**	4	**3**	3	**0**	1	**4**	6	**8**	14
Balloons and airships	**0**	0	**0**	0	**0**	1	**0**	0	**0**	0	**0**	1
Ultralight aircraft	**0**	0	**0**	0	**0**	0	**0**	1	**0**	1	**0**	2
Total	**11**	7	**26**	23	**16**	22	**15**	22	**28**	33	**96**	107



3.2.5 Persons injured in accidents

	Accidents and serious incidents involving Swiss-registered aircraft in Switzerland															
	Total		**Aircraft with MTOM of up to 2,250 kg**		**Aircraft with MTOM of 2,250–5,700 kg**		**Aircraft with MTOM exceeding 5,700 kg**		**Helicop-ters**		**Motor gliders and gliders**		**Balloons and airships**		**Ultra-light aircraft**	
	2017	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016
Accidents / serious incidents	**70**	64	**48**	22	**1**	3	**3**	9	**11**	17	**7**	11	**0**	0	**0**	2
Fatalities	**11**	3	**8**	1	**0**	0	**0**	0	**1**	0	**2**	2	**0**	0	**0**	0
Crew	**7**	2	**4**	0	**0**	0	**0**	0	**1**	0	**2**	2	**0**	0	**0**	0
Passengers	**4**	1	**4**	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
Persons seriously injured	**11**	6	**6**	2	**0**	0	**0**	0	**5**	3	**0**	1	**0**	0	**0**	0
Crew	**5**	3	**4**	1	**0**	0	**0**	0	**1**	1	**0**	1	**0**	0	**0**	0
Passengers	**2**	1	**2**	1	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
Third parties	**4**	2	**0**	0	**0**	0	**0**	0	**4**	2	**0**	0	**0**	0	**0**	0

	Accidents and serious incidents involving Swiss-registered aircraft abroad															
	Total		**Aircraft with MTOM of up to 2,250 kg**		**Aircraft with MTOM of 2,250–5,700 kg**		**Aircraft with MTOM exceeding 5,700 kg**		**Helicop-ters**		**Motor gliders and gliders**		**Balloons and airships**		**Ultra-light aircraft**	
	2017	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016
Accidents / serious incidents	**9**	19	**5**	9	**1**	0	**3**	8	**0**	1	**0**	1	**0**	0	**0**	0
Fatalities	**7**	2	**2**	2	**5**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
Crew	**2**	2	**1**	2	**1**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
Passengers	**4**	0	**1**	0	**3**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
Third parties	**1**	0	**0**	0	**1**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
Persons seriously injured	**0**	3	**0**	1	**0**	0	**0**	0	**0**	2	**0**	0	**0**	0	**0**	0
Crew	**0**	1	**0**	1	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0	**0**	0
Passengers	**0**	2	**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 2,250 kg**		**Aircraft with MTOM of 2,250–5,700 kg**		**Aircraft with MTOM exceeding 5,700 kg**		**Helicop-ters**		**Motor gliders and gliders**		**Balloons and airships**		**Ultra-light aircraft**	
	2017	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016	**2017**	2016
Accidents / serious incidents	**15**	23	**5**	3	**1**	2	**7**	15	**1**	0	**1**	2	**0**	1	**0**	0
Fatalities	**2**	2	**2**	0	**0**	0	**0**	0	**0**	0	**0**	2	**0**	0	**0**	0
Crew	**1**	2	**1**	0	**0**	0	**0**	0	**0**	0	**0**	2	**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
Persons seriously injured	**1**	0	**0**	0	**0**	0	**0**	0	**0**	0	**1**	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	**0**	0	**0**	0	**0**	0	**0**	0	**1**	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

Method and conceptual considerations for the analysis of statistical aviation data

Measures and their component parts

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

The advantage of accident rates is that they allow comparisons over a longer time period to be made more easily, even if the exposure[1] changes over this time period. As exposure generally fluctuates to a lesser extent than the number of accidents, the advantage of 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 FOCA's air traffic movement statistics. If this aircraft were to have an accident in Switzerland, this accident must also not be included in this analysis. This is because FOCA's air traffic movement statistics are included as a component part of the measure of accident statistics. 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 therefore they cannot be counted by the STSB; 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[2]. 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 –

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

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

or perhaps even the serious incidents – were to be included in the statistics, the figures being looked at would be higher and it would be easier to make statistical statements. However, 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 FOCA. FOCA collects these figures using forms that have been completed and submitted by the majority of aerodromes and heliports since 2007. Take-offs and landings are normally considered to be air traffic movements, meaning that a flight from A to B results in two air traffic movements. However, the term is not precisely defined by FOCA. The following types of air traffic movements are not recorded in FOCA's data collection:

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

Movements at Basel/Mulhouse/Freiburg Airport are recorded by FOCA, but are not included in the STSB's analysis. This airport is not 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

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

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

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

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

Statistical methods

The number of accidents U_t in the year t=2007,...,2017, 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 expected 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:

$$\begin{aligned} \log(U_t) &= \log(n_t) + \beta_0' + \beta_1' \cdot t \\ &\Leftrightarrow \\ U_t &= n_t \cdot \exp(\beta_0' + \beta_1' \cdot t) \end{aligned}$$

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:

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

However, the parameter λ_t' here is now the exposure-corrected expected number of accidents per year. Again, the model is estimated using maximum likelihood estimation in the generalised linear model framework. However, it is even more important that the accident rate's development over time can be deduced from the parameter β_1' In practice, the accident rate changes from one year to the next by the factor $\exp(\beta_1')$. 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 expected accident rate' over time. The test result is shown 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 accident rate is called 'significant'. If the p-value is equal or greater than 0.05, then the change is called 'not significant'.

NB: The accident rate is reported extrapolated to 1 million flight movements for easier readability.



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