# How old are pilots involved in aircraft accidents?

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## Abstract

Lately, the BFU gained the impression to be investigating an increasing number of accidents with relatively old Pilots in Command (PIC). Amongst others, the BFU is/was, for example, investigating the following accidents:

- 28.08.2019 Egelsbach: Runway overrun accident of an 82-year-old PIC on a Cessna 525 CitationJet
- 28.08.2020 Arnsberg-Menden: Accident with serious injuries during approach stall with a 73-year-old PIC on a Cessna C401
- 08.05.2021 Horn-Bad Meinberg: Fatal in-flight incapacitation during thermal flight (74-year-old pilot) on a LS 4b glider
- 05.09.2022 Gelnhausen: Fatal collision of a glider with trees with unconnected elevator control of an 81-year-old PIC on an Olympia-Meise
- 24.09.2022 in Gera: Fatal mid-air collision during acrobatics with a 73-year-old PIC on a Zlin Z 526
- 17.11.2023 Dinslaken: Fatal accident during VFR night flight training with a 73-year-old flight instructor on a Cessna C172

Thus, the BFU set out to quantify this gut feeling by evaluating data of more than 18 500 accidents over the last 51 years in Germany. Generally, the data show a significant increase in the age of the pilots involved in accidents over time, with the average PIC having been about 58 years old in the last two years (2022 and 2023).

Concluding, the demographic change of people growing increasingly older can be seen in the accident occurrence. The age-related performance decline and how it influences flight safety should be further investigated and safety promotion should address this increasingly relevant topic and sensitize all stakeholders accordingly.

# 1 Introduction

The BFU has an overview of all aircraft accidents occurring in Germany. Firstly, there is an obligation (Regulation (EU) No 996/2010 and No. 376/2014) to report all accidents and serious incidents to civil aircraft immediately to the Safety Investigation Authority (SIA) of the occurrence state, in this case the German Federal Bureau of Aircraft Accident Investigation (BFU). Secondly, the BFU gathers as much information as possible, once notified of an occurrence.

On the one hand, this helps to make a sound decision whether and to what extent an investigation is initiated. On the other hand, this allows the BFU to conduct data evaluations and safety studies. Even though not all accidents are investigated in depth, they are registered in the ECCAIRS[1] (European Co-ordination Center for Accident and Incident Reporting Systems) database. Therefore, ECCAIRS is a great source for data analysis and research. It also helps to check for trends in the event occurrence, like the impression of an increase in the age of the Pilots in Command (PIC) involved in an occurrence.

To shed more light on the topic of age-related human factors and pilot performance and following the ISASI 2024 conference theme *"to safely navigate the unchartered waters"*, the BFU reviewed relevant literature and evaluated data of German license holders as well as of all accidents ever notified to the BFU. The first database entries date back more than 50 years to January 1973 and contained more than 18,600 accidents which occurred in Germany since then allowing insights on the development of diverse factors like the pilot age or occurrence categories over time. This paper will present the resulting findings and substantiate them with a variety of current accident examples and conclude with a discussion.

## 1.1 Human factors, safety-critical situations, and accidents

Human factors play an important role in causing accidents, contributing to most of the accidents and serious incidents. Therefore, it is of significance to investigate how and why human errors actually occur to counteract them and improve flight safety.

While flying, pilots continuously acquire a lot of different information (visual, acoustic, haptic or vestibular), filter and process them to finally translate them into actions. By taking in information, interpreting it and anticipating the future, pilots form a mental model of the flight situation (e.g., about flight attitude, course, position, especially in relation to obstacles or other aircraft on possible collision course, weather phenomena and aircraft characteristics as well as their own capabilities) to which they adapt their behavior ("situational awareness", Endsley, 1995). At any point during information processing, errors can occur.

[1] ECCAIRS is a digital platform to collect, share and analyze safety information from European National Aviation Authorities and SIA to improve Aviation Safety.

However, many factors within the complex *human-machine-environment system* (Rasmussen, 1982) influence the flying task and can increase its demand on the pilots and lead to safety-critical situations. The relation of the task demand and the pilots' capability (e.g., determined by skills, fitness, mental state, experience) to cope with the demand determines the probability of a safety-critical situation to escalate (see the task-capability interface model of Fuller, 2000). As long as the pilots' capabilities exceed the task demand, the situation stays under control. Hence, how much task difficulty pilots accept at a certain moment, for instance, which weather conditions or detriments in their own skills they accept, depends on motivational aspects such as their subjective risk estimations. In the reversed case of a task demand which is higher than the pilots' capabilities to handle a situation safely, or a generally high task demand as in sudden critical situations, pilot errors become more likely and pilot performance deteriorates.

Thus, the kept safety margins determine the time frames and scope of action for pilots to react to possibly safety-critical events. If pilots react too late, inadequately or not at all to these events, safety-critical situations often turn into accidents. For example, distracted pilots might cope well with normal traffic affordances, but as soon as there is an abrupt, unexpected change of demand, like a formerly obstructed or overseen other aircraft on collision course, they react slower. Maybe, pilots even lose control of the aircraft or encounter a collision.

However, not every safety-critical situation or sub-optimal pilot action inevitably results in an accident. As Reason (2000) describes in the "Swiss cheese model", there are always several "layers of cheese" or safety barriers which can prevent a safety-critical situation from escalating despite unfavorable actions and conditions. For example, stall warnings can help raise the pilots' attention to the stall condition and recovery maneuvers are regularly trained.

The occurrence of unexpected events can lead to strong physical and mental stress reactions and have a negative impact on the performance of any pilot. Such events can temporarily impair pilots' problem-solving and decision-making skills (*startle* and *surprise effects*, EASA, 2015). While some pilots are prone to hasty decisions and reflexive reactions as a result, others appear paralysed and do not react at all for a short time (100 ms up to 10 s depending on the task difficulty). Such effects particularly affect inexperienced, less currently trained and/or older pilots. The latter are already facing decreasing processing, problem-solving and reaction capabilities and would thus be even more affected. In the end, how well pilots have learned to recognize and deal with these natural, human reactions to unforeseen or contradictory situations determines how quickly and well they can regain control of the situation. In any case, they lose time, which further limits the scope for action in particularly time-critical situations.

## 1.2 Age-Related Changes in Human Performance

Human performance changes as part of the natural aging process, also human factors important for flying often deteriorate (AOPA, 2013, 2024), amongst others the following:

- Perception, e.g., reduced vision (limited peripheral vision, impaired near and night vision, difficulties to quickly change the focus) and hearing (radio communication)
- Musculoskeletal problems, e.g., reduced mobility, earlier onset of fatigue due to heat and turbulences, loss of strength and fine motor skills like pushing of small buttons
- Increased fatigue, e.g., stronger affected by sleep environment, work schedule, medical conditions and jetlag, etc.
- Memory, e.g., short-term memory loss when remembering altitudes, transponder codes and radio frequencies (additionally influenced by fatigue)
- Problems with attention distribution, information processing, problem solving, decision making and psychomotoric coordination, like reduced reaction time

In general, age-related changes are individually very different, proceed variably and are difficult to pin on a certain age (AOPA, 2013; Tsang, 1997). Investigations and findings from road traffic show that above all impaired vision, problems with attention distribution and general slowdown, especially with decision making, planning and execution of actions, influence the accident risk of older drivers (Schlag, 2008). Similarly, various aviation studies reviewed by the Aircraft Owners and Pilots Association (AOPA, 2013) show that accident rates reduce with increasing total flying experience, but older pilots in particular have higher accident rates with low current flight time (less than 50 hours per year). Regardless of the age, it is generally the case that accident rates increase with age when pilots have less than 1,000 hours of total flying experience and less than 50 hours of flight time per year.

### 1.2.1 Sudden In-Flight Incapacitation, Age Concerns and Limitations

Overall, active pilots are healthier and have a higher life expectancy than the general working population (Downey & Dark, 1992; Pizzi et al., 2008; Linnersjö et al., 2011). Similarly, their risk to die from cardiovascular or cerebrovascular diseases (main causes for age-related sudden in-flight incapacitation) is significantly lower (De Stavola et al., 2012; Qiang et al., 2003; Sykes et al., 2012; Hammer et al., 2014). According to AHA (2018) and Simons et al. (2019), medical conditions which bear a high risk to cause total in-flight incapacitation are sudden death, cardiovascular conditions, stroke, syncope, seizures, migraine, acute psychosis, and nephrolithiasis. However, such events are rare. In their literature review Simons et al. (2019) found a moderate increase of the incapacitation rate with age as most of the medical incapacitations are caused by non-age-related problems like acute gastroenteritis, laser strikes, headache, and ear/sinus conditions. Those medical conditions which increase incapacitation risk with age, especially for pilots over 50 years old, are cardiovascular and cerebrovascular medical events and should thus be monitored for more closely. However, as many accidents are related to inadequate pilot performance, also other aspects than medical fitness like individual cognitive and sensory performance should be assessed for a more complete picture of the pilot’s ability to fly safely.

According to Regulation (EU) No 1178/2011 (FCL.065, EASA, 2016), the limiting threshold for single-pilot Commercial Air Transport (CAT) operations is the age of 60 and in multi-pilot CAT operations, pilots can continue to operate until the age of 65. Simons et al. (2019, p. 56) found that *“the risk of the 55-64 age group is just within the margin of the acceptability limit for catastrophic system failures for single piloted CS 23 aircraft with a single reciprocating engine and a seating capacity for 0-6 passengers”*, thus underlining the urgent need to reduce their medical incapacitation risk. Therefore, an increase of the age limitation for single pilot operations from 60 years to 65 years would require additional measures to decrease the probability of pilot incapacitation like a medical screening (MED.A.045) and a proficiency or simulator check every six months.

For multi-pilot operations, Simons et al. (2019) recommended to keep the age limit for CAT pilots at the current 65 years. Extending the age limit further would require additional risk-mitigation measures like more specific and individual testing to inform a good aeromedical decision on the pilots’ fitness, also because the individual variability of physical and mental/cognitive health increases after the age of 65 years raising the probability for a high-risk case going unnoticed. Current tests are insufficient, only simulator checks, line checks, and peer reviews can help to detect below standard performance in pilots (Evans, 2011). Much more research, development and risk assessment procedures are necessary, focusing on sufficiently sensitive and valid dedicated simulator checks and neuropsychological assessment including assessment of essential cognitive factors of flight performance in the regular mandatory License Proficiency Checks (LPC) or Operator Proficiency Checks (OPC), especially to see how pilots cope with high-stress, time and safety critical situations.

### 1.2.2 Aeromedical Fitness and Pilot Age

Most younger pilots are physically fit so that the medical examination is of less significance. Yet the older pilots become, the more importance the medical examination gains. However, it currently lacks effectivity and reliability for any age group. Only a third of cases with a relevant risk are detected (Evans, 2011). A study of Simons et al. (2019) with 82,000 (temporarily) unfit-declared European CAT pilots showed that while until the age of 50, only 1.5 to 1.8% of pilots were declared unfit, the unfitness cases amounted to around 3 % when the pilots were over 60 years old independent of the examination class. The most common causes for unfitness were cardiovascular (19%), psychiatric (11%), neurologic (10%), and psychological conditions (9%), which coincides with the results of their previous literature review (e.g., Evans &

Radcliffe, 2012), Høva et al. (2017), and Jordaan (2017). Cardiovascular conditions are also the most frequent cause for disqualification in the older age groups with 21% for pilots 51-60 years old, 28% for 61-65 years, and reaching almost half of all cases (48%) in pilots over 65 years of age. However, psychiatric and psychological causes were most frequent for younger pilots between 20 and 40 years of age (15-20%), which also represented a significant age effect as for the cardiovascular conditions. To summarize, the study of Simons et al. (2019) showed a clear effect of increasing age on the medical disqualification rate.

Although the described studies mainly focused on CAT pilots, the age effects could most probably also be applied to General Aviation pilots, who do not face an age limitation and have to fulfil lower medical requirements. So, one could assume to find an even stronger influence of age on pilot fitness. However, it is an area that would be interesting to be explored further for GA pilots as well.

## 1.3 Age structure in German Population

In 2023, 448,4 million people populated Europe, with Germany as the most populated country making up 18,8% (84,4 million), followed by France with 15,2% (68,1 million) and Italy with 13,1% (58,9 million). The age structure of the three most populated European countries is rather similar when regarding the number of older people (INSEE, 2024; I.Stat, 2024).

In 2023, about 84,4 million people populated Germany (DESTATIS, 2024). The average age was 44,6 years. About 30%/22%/14%/9% of the German population was over 60/65/70/75 years old, representing an increase of ca. 10%/7%/7%/5% over the last 51 years since 1973 (Figure 1). According to projections into the future, the number of older people and the life expectancy is going to further increase over the coming years (DESTATIS, 2024).

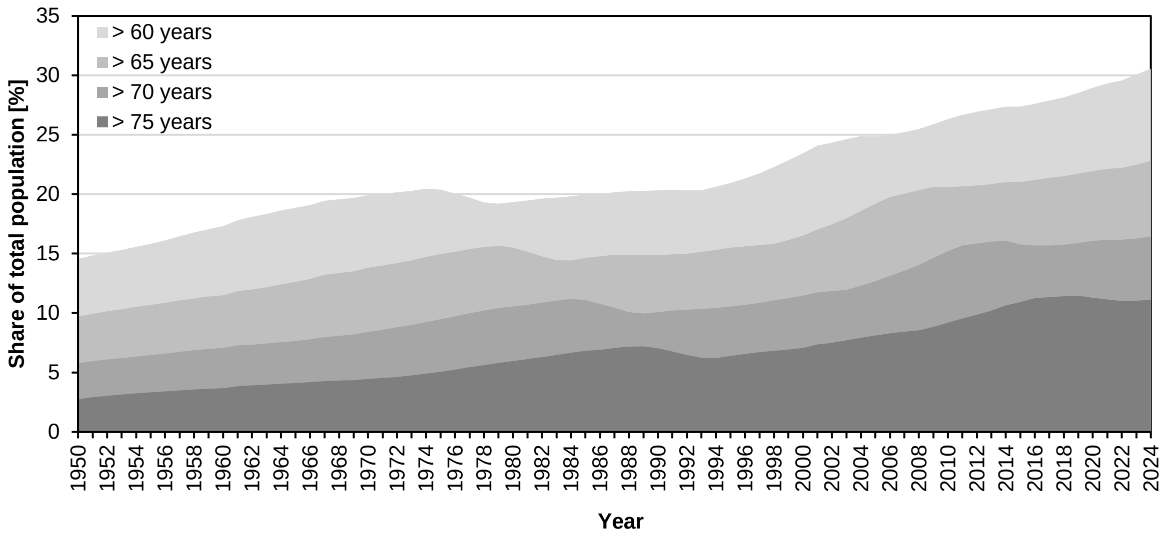


Figure 1: Development of the German population over sixty years of age (1950-2024) Source: DESTATIS

Figure 2 shows how much the age structure in the German population changed over 51 years. While in 1973, there was a disproportionate number of younger people (in their teens and 30ies), now there is a disproportionate number of older people (in their 60ies). In 2023, a third of the German population was under 30 years old and another third over 60. Almost half of the German population was over 50 years old (ca. 45%), the average age being 44,6 (compared to 39,3 in the year 1990).

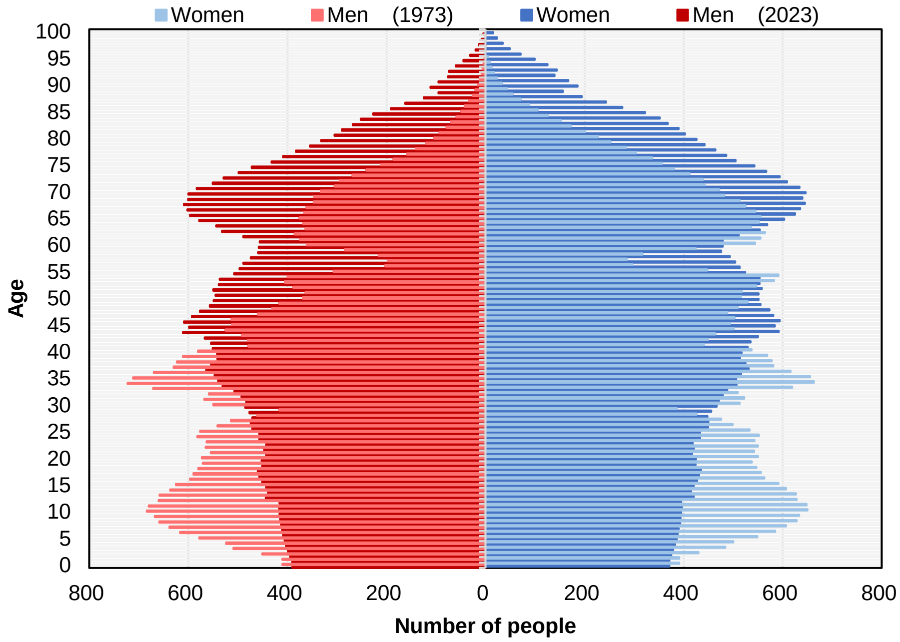


Figure 2: Age structure of the German population in 1973 (lighter colors) and 2023 (darker colors). Source: DESTATIS

## 2 Data evaluation

To evaluate the age structure in the German pilot population and among pilots involved in accidents, the BFU started a data inquiry through the LBA (Luftfahrt-Bundesamt, German Federal Aviation Office) and in the ECCAIRS database. The results will be presented in the following and enhanced by some accident examples of older pilots in the last 5 years.

### 2.1 Results

#### 2.1.1 Age Structure in German licensed Pilots

To get an overview of the age structure of the German pilot population, the BFU requested license data of all pilots holding a valid German pilot license of any type with a current medical from the LBA. While the LBA could provide us with an extract of all license data at the moment, they did not have any capabilities to look backwards. Thus, it was not possible to assess the development of the age structure over time as was done for the population and accident pilots.

Figure 3 illustrates the results of the LBA data extract for March 2024. There were 56,467 pilots holding a valid German pilot license with a current medical certificate of which the oldest pilot was 91 years old and the youngest 15. The average German licensed pilot was 49,5 years old (SD = 15,2 years) and the pilot age was not normally distributed, but rather skewed towards a higher age. About 29% of all accident pilots were holding a valid class 1 medical certificate. Amongst them the average age was somewhat lower with 43 years as many of them would fall under the prescribed age limitation of 60 or 65 years depending on single or multi-pilot operation for CAT pilots (see above).

Out of all pilots holding a German license ca. 24%/14%/7%/3% were older than 60/65/70/75 years old (Figure 3). Compared to the German population, the share of each age group of pilots is for most age groups much smaller, only the age group of over 60-year-olds is somewhat comparable with 24% compared to 30% in the German population.

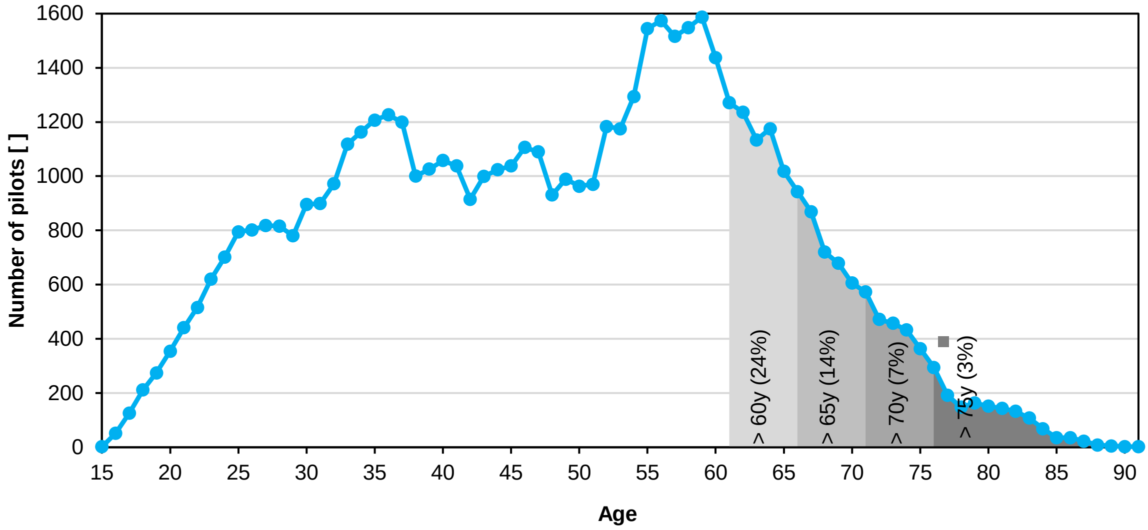


Figure 3: Age structure of all pilots with a valid German license and medical certificate in March 2024 Source: LBA/BFU

### 2.1.2 Pilots involved in Accidents in Germany 1973-2023

The ECCAIRS database contained 18 598 accidents which occurred in Germany from 1973 to 2023 of which around 93% were General Aviation accidents. However, the level of detail to which each dataset was filled in the database differed significantly, for example for around a third of all accident pilots their age was not entered in the database. These would mostly have been cases of lower severity or without injuries despite a substantially or worse damaged aircraft so that the BFU did not conduct a full-investigation. In addition, some accidents like a mid-air-collision would have at least two PIC, but only one entry, so we had to filter out these cases and add another separate age entry for our evaluation. In the end, we included 12 390 PIC and aircraft in this data evaluation.

According to the analyzed 12 390 accident pilots, the age of the oldest recorded PIC involved in an accident in Germany over the last 51 years was 88 years old and the youngest was 14. The data evaluation shows a significant increase ($p \leq .001$) in the age of the pilots involved in accidents over time (Figure 4). When looking as far back as the BFU accident databank allows, we can see a very clear trend of the average pilot age increasing by about 0,4 times every year over the last 51 years since 1973, ca. 0,5 times over the last 20 years since 2004 and even ca. 0,8 times over the last 10 years since 2014. While the average accident pilot in the 80-ies was around 40 years old, it is now nearing 60 years, with the average PIC having been ca. 58 years old in the last two years (2022 and 2023).

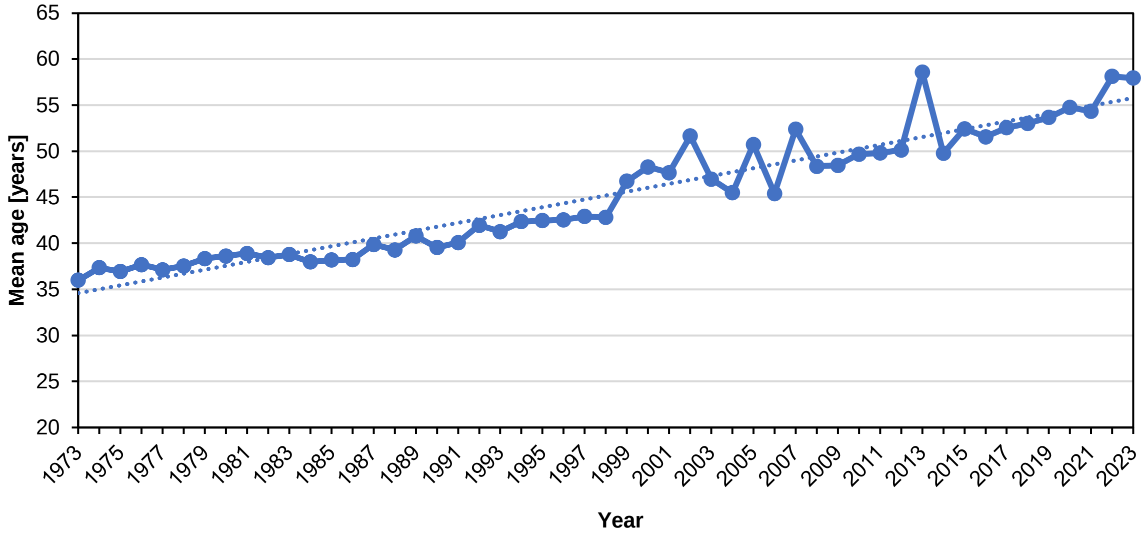


Figure 4: Mean age of pilots involved in accidents in Germany (1973-2023) Source: BFU

Figure 5 shows the share of PIC of an age over 60 years that were involved in an accident in Germany in the years 1973 to 2023. It can be seen that while in the 70ies and 80ies these pilots accounted for a marginal proportion of all accident pilots (under 10%), this proportion has increased significantly since then. More than on average a third of the PIC (ca. 36%) involved over the last 10 years (since 2014) was over 60 years old (ca. 23% over 65 years, ca. 13% over 70 years old and ca. 5% over 75 years old), with an increase of this percentage of over 60-year-old PIC by ca. 1,6 times each year.

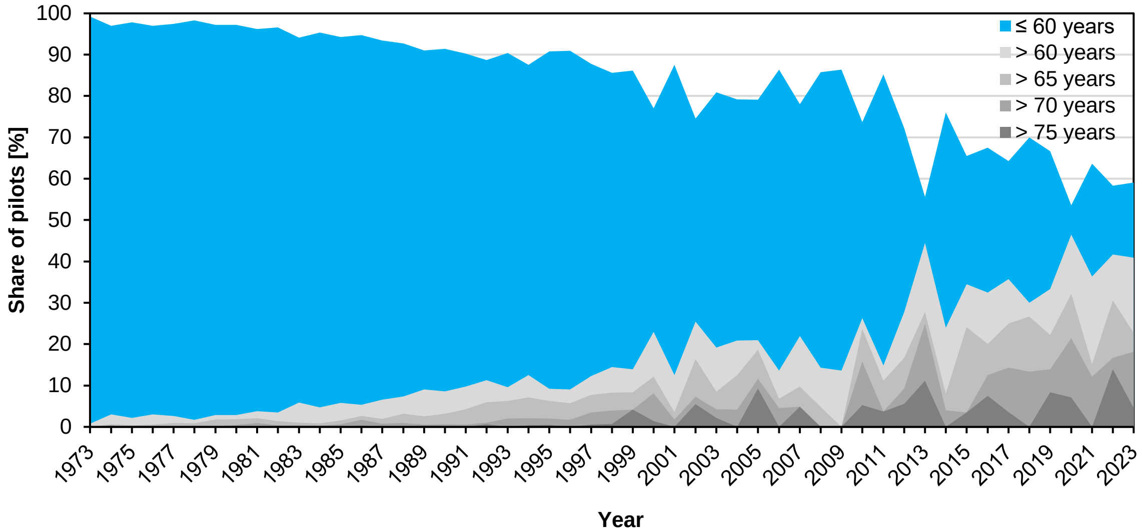


Figure 5: Share of PIC under/over sixty years of age involved in accidents in Germany (1973-2023) per year Source: BFU

### 2.1.3 ICAO Occurrence Categories

As Figure 6 shows the most frequent occurrence categories (ICAO, 2011) are rather normally distributed over the pilot age. As can be seen in Figure 7, the most common occurrence categories are ARC, OTHR and RE, followed by LOC-I, SCF-NP and -PP.

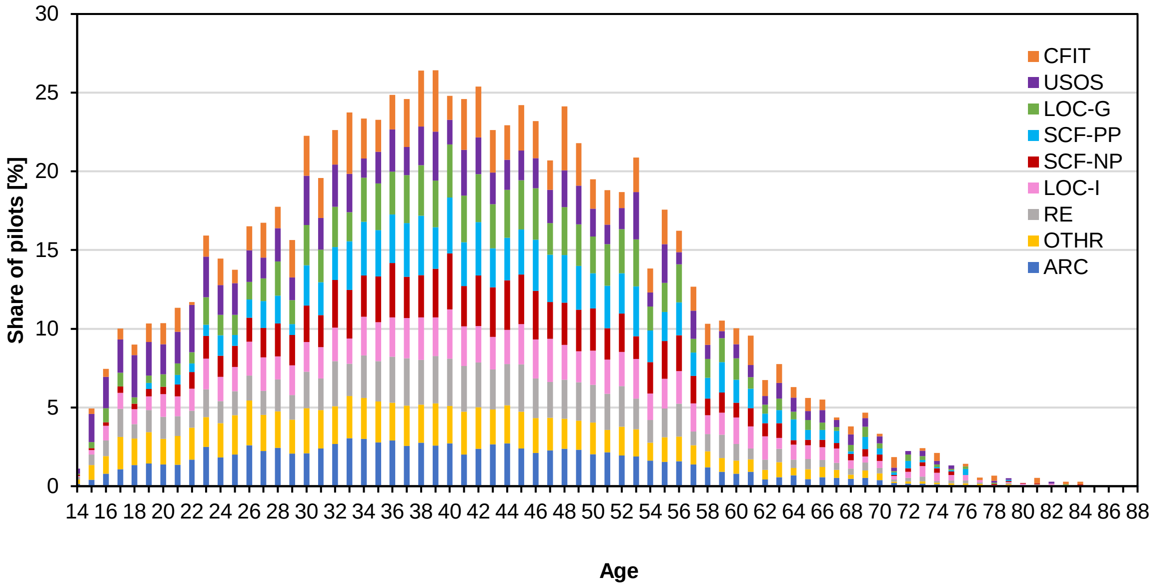


Figure 6: Age distribution over the most frequent ICAO occurrence categories Source: BFU

Figure 7 shows the percentage of PIC over the most frequent occurrence categories for all PIC and separated by PIC until the age of 60 years and above for accidents in Germany from 1973 to 2023. While for most categories the involvement is rather independent of the age of the PIC, loss of control accidents occur more than 2/3 more often in pilots >60 years old (ca. 1.6-1.7 times) than in total or compared to pilots until the age of 60 years. This means that while over all pilots loss of control only happens to ca. 15% of PIC, 25% of pilots >60 years old are involved in LOC-I accidents. Thus, LOC-I accounts for the second most frequent occurrence category for these pilots, shortly after ARC with ca. 33% and followed by OTHER. On the other hand, pilots ≥60 years old appear to be involved almost a fifth less often in abnormal runway contact accidents than the other two groups of pilots (ca. 0.8 times).

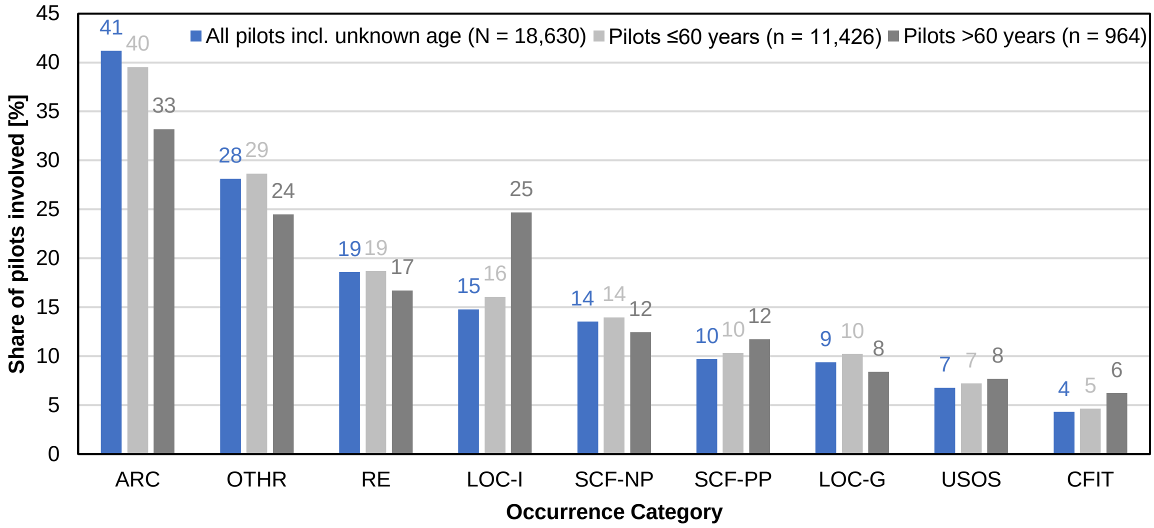


Figure 7: Share of pilot age groups in most frequent occurrence categories of accidents in Germany (1973-2023) Source: BFU

## 2.2 Latest exemplary accidents with older pilots involved[2]

### 2.2.1 Runway Overrun Accident without Injuries (82-year-old PIC)[3]

On 28 August 2019 at Egelsbach Aiport (Germany), a Cessna 525 CitationJet overshot the end of the runway during landing, broke through the airport fence, and came to a stop about 110 m behind the runway end on a grass field (Figure 8). The aircraft was substantially damaged.

The 82-year-old pilot held a valid Private Pilot License (PPL(A)) containing the type rating PIC Cessna C525 as Single Pilot operations (SP ops) and the Instrument Rating (IR) and a valid class 2 medical certificate, with the restrictions to wear glasses and hearing aid. He had a total flying experience of ca. 8,940 h of which about a fourth were flown on type and 60 h in 2019. He operated the complex jet with a MTOM of almost 4,900 kg (Non-Commercial operations with Complex motor-powered aircraft (NCC) according to Regulation (EU) 800/2013) as a single pilot and had last approached the rather demanding airport[4] right next to Frankfurt/Main Airport more than 20 years ago.

When approaching the destination airport, the pilot changed from instrument to visual flight rules, directly received a traffic advisory and then a flight information which advised him to watch his altitude as he had already entered airspace CHARLIE of Frankfurt/Main Airport above him. After that he had to handle an alert of his Terrain Awareness and Warning System (TAWS). He kept on oscillating in altitude during the entire approach and was still 200 ft above the glideslope on final approach, eventually being shortly established in ca. 600 ft AMSL (ca. 200 ft AGL) at ca. 0.5 NM prior to the threshold. The pilot stated he had not paid attention

[2] Since some of the following accidents are still under investigation, the here presented data is limited. However, there will be final report published on the BFU website in the end as indicated for the already concluded investigations.
[3] https://www.bfu-web.de/EN/Publications/FinalReports/2019/FReport_19-1185-3X_C525_Egelsbach_RE.pdf
[4] https://www.bfu-web.de/DE/Publikationen/Studien/Studie_Egelsbach_2022.pdf

to the lights of the Abbreviated Precision Approach Path Indicator (APAPI) visualizing the runway‘s glideslope. When finally touching-down about 300 m after the threshold the aircraft was still way too fast and overshot the runway.


Figure 8: Accident site (from above Egelsbach Airfield, top) and final position of the airplane outside the airfield fence (bottom)
Source: Google Earth / adapted: BFU and BFU

It seems that the pilot was overburdened with the complexity of the approach and handling all the different tasks at the same time so that he was not realizing that his approach was not stabilized and did not consider to abort the approach. His age certainly contributed to his inadequate performance, as especially attention allocation and multitasking deteriorate with age. It is thus questionable whether a pilot of his age should not have chosen such a demanding airfield close to a very busy international airport in addition to flying with a complex multi-engine aircraft which also demands quick, trained actions. The concept of stabilized approaches might not have been a big topic back in the days when he did his trained to get his license. However, it might be helpful to be better informed and especially adhere to all kinds of safety measures which have been introduced to increase flight safety like the recommendation of the Flight Safety Foundation in the “Approach-and-landing Accident

Reduction (ALAR) Briefing Note 7-1" that all flights must be stabilized by 1000 ft above airport elevation in IMC and 500 ft above airport elevation in VMC.

### 2.2.2 Final Approach Stall Accident with Serious Injuries (73-year-old PIC)[5]

On 28 August 2020 at Arnsberg-Menden Airport (Germany), a Cessna 401A twin-engine aircraft suffered an in-flight loss of control during final approach and the airplane impacted the ground short of the runway. The 3 occupants suffered serious injuries and the airplane was substantially damaged. The 73-year-old pilot held a valid a Private Pilot License (PPL(A)) and the required ratings to conduct the flight. He was experienced regarding his total time of flight being about 6,300 h and 500 h on type. In the last 90 days he had flown around 14 h and was current. The investigation did not reveal any acute health impairment of the pilot.

As Figure 9 shows, the pilot chose a flight path which required a turn with large bank angle to reach the final approach (teardrop-like) instead of a standard approach and did not comply with the criteria for a stabilized approach. Most of his previous approaches to the same runway had also been "unique", no traffic pattern or any sign of a routine approach. The chosen approach required continuous control inputs to reduce speed and adjust engine power to accommodate configuration changes, thereby placing a much greater demand on the pilot's performance capabilities than a standard traffic pattern.

During the short final, the pilot allowed his control inputs to cause the airspeed to fall below the planned approach speed and the airspeed to continue to decrease, aided by the insufficient monitoring of the airspeed indicator. He most likely concentrated his attention on the area ahead of the runway (caused by irritating runway markings not compliant with the required standards and the published AIP, Figure 10) and did not notice the red PAPI indication when it indicated an undershoot of the correct approach angle. The large white markings on the pre-threshold asphalt areas were visually much more striking than the markings of the threshold of runway 23 and likely suited to distract the pilots' attention on approach to land. In this phase the pilot focused on the situation outside of his airplane so that his attention allocation neglected the scanning of flight instruments, especially the airspeed indicator. He lost situational awareness, was possibly struggling with optical illusions (uphill approach) and monitored the flight progress and instruments insufficiently.

[5] https://www.bfu-web.de/EN/Publications/FinalReports/2023/Report_20-0571-CX_Cessna_401_Arnsberg_Menden.pdf

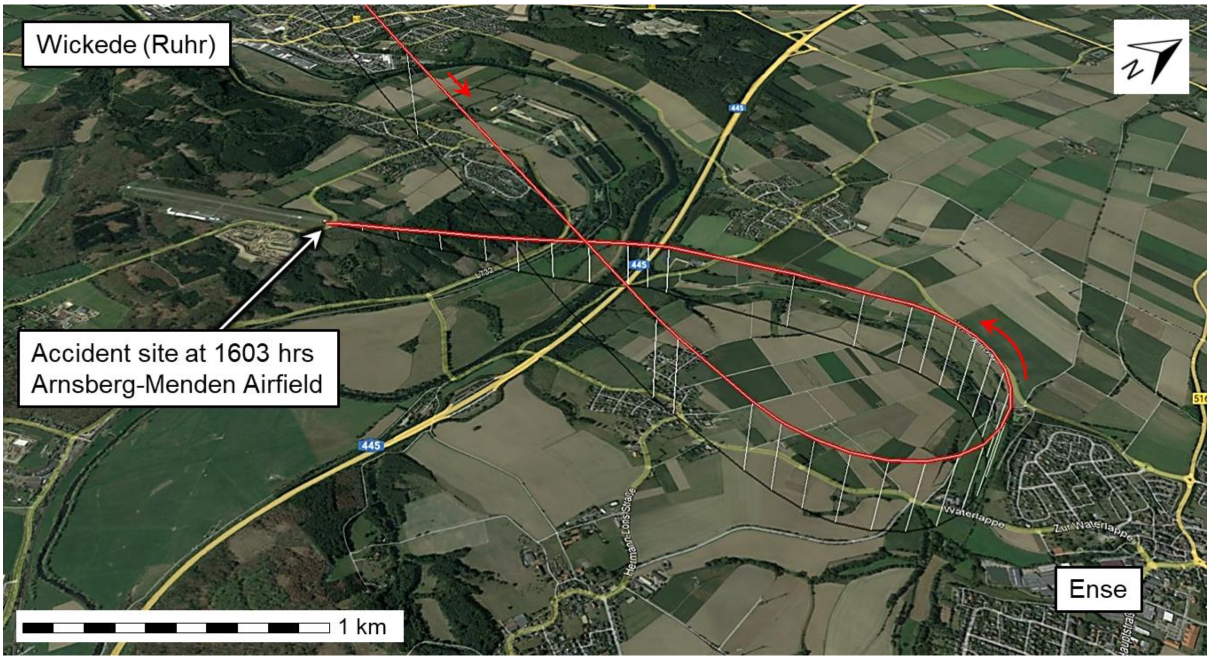


Figure 9: Approach based on GPS data Source: Google Earth™, adaptation BFU

Figure 10: Accident site, view to the south-west towards runway 23 Source: BFU

Thus, he failed to correct the approach angle by increasing engine power or abort the approach, instead he pulled on the elevator, thereby steering the airplane into an uncontrolled flight attitude during the flare. Even the acoustic stall warning sounding for a total of about 8 s prior to impact did not result in a noticeable reaction of the pilot. Although the airplane had already been at a very low height, the stall could still have been avoided, if the pilot had reacted immediately. He probably suffered from a tunnel-like attention allocation so that he neither noticed the approach angle becoming critical, the decreasing airspeed nor the stall warning horn. While the pilot was experienced and had flown frequently in the last 90 days, age-related limitations in his attention allocation (multitasking) and a slower reaction time probably affected his actions. The large number of continuously changing approach parameters most likely exceeded the limits of the pilot's capabilities and subsequently to keep controlling the airplane in a goal-oriented manner.

### 2.2.3 Fatal In-Flight Incapacitation Accident during gliding (74-year-old Pilot)

On 08 May 2021 in Horn-Bad Meinberg (Germany), a Rolladen Schneider LS 4b took off for a thermal flight, climbed in coordinated circles up to 2,000 m altitude until enormous altitude and speed fluctuations were recorded, reaching a maximum of about 290 km/h (Figure 11). Witnesses reported loud whistling noises and an uncoordinated course of flight. Proceeding with these conspicuous oscillating movements for 4min, the glider eventually impacted a field and was destroyed. It was later found that the pilot was incapacitated, which most probably happened when the uncoordinated movements began. He probably suffered from a cardiovascular problem before ground impact, as there was also not obvious bleeding from any of the injuries leading to the conclusion that he would have already died in-flight and no longer controlled the airplane.

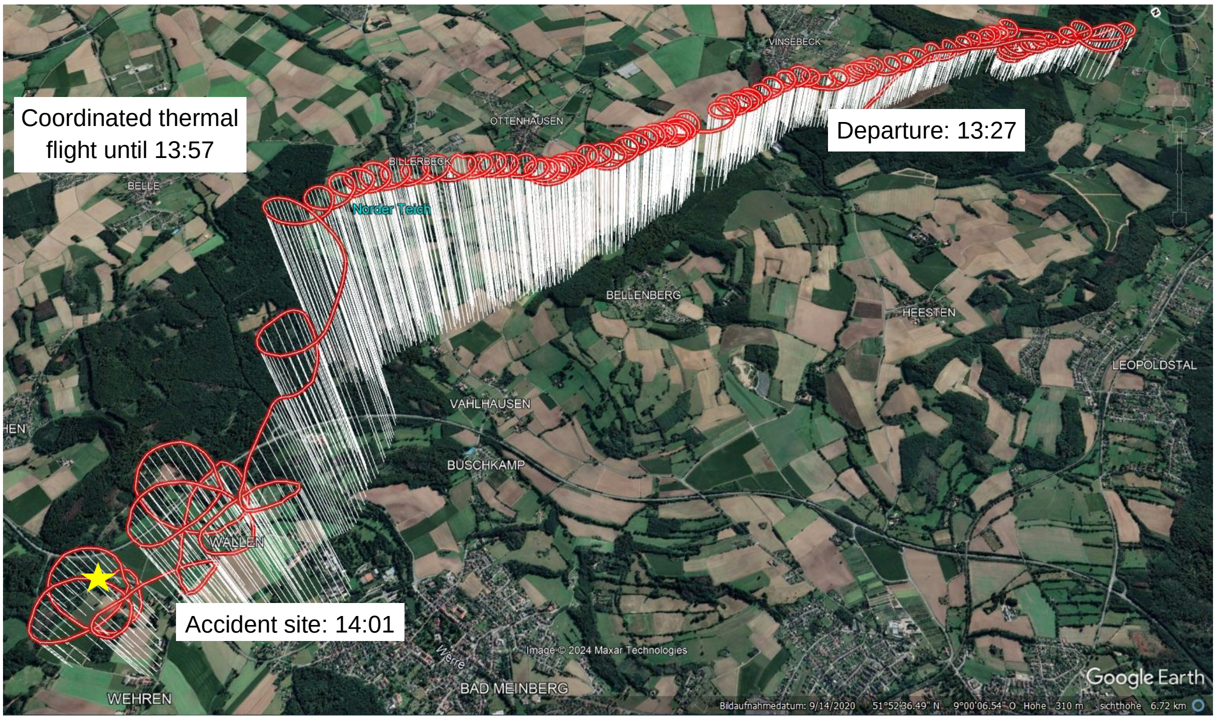


Figure 11: Flight path from departure to accident site Source: BFU, Google Earth©

### 2.2.4 Fatal tree collision with unconnected elevator control (81-year-old PIC)[6]

When rigging the glider in the morning of the 5 September 2022 in Gelnhausen (Germany), the elevator control of the Olympia-Meise glider was not connected or secured. Insufficient checks of the glider after the rigging and prior to the flight were performed so that the omission went unnoticed. As a result, the winch launching occurred without a functioning elevator so that the 81-year-old pilot was unable to control the pitch and climb angle during the winch launch. After the towing rope released from the center of gravity towing hook at about 90 m AGL, the glider went into a right-hand bank, collided with trees at the edge of the airfield and impacted the ground (Figure 12).

Figure 12: Accident site with main wreckage in the forest Source: BFU

The pilot had an adequate training level and extensive flying experience with about 1,600 h total flight time, flying gliders for 67 years and single-engine piston aircraft for 51 years. However, he had less current experience in rigging and flying this type (11 h of flight time and 4 take-offs over the last 4 years).

However, communication and team work among the persons involved in the rigging were insufficient and not all information was shared accordingly. Ultimately, the persons involved in the rigging omitted essential steps, such as connecting the elevator to the control stick, or performed them improperly without thoroughly checking the rigging process at the end and

[6] https://www.bfu-web.de/EN/Publications/FinalReports/2024/Report_22-0920-3X_Meise_Gelnhausen.pdf

noticing or rectifying the omission in good time. In the end, the take-off was carried out prematurely, most probably because the pilot felt a haste to take-off as soon as possible in the good weather conditions and also some social pressure to not hold up the take-off flow. With the insufficient pre-flight checks and the hasty take-off, he deprived him-self of potential safety barriers.

Although the pilot had a high level of total flying experience and was still described as a fit and reliable aerotow pilot, age-related limitations such as slower information processing, problem solving and reaction times may have affected his actions. Especially the morning rigging of two gliders in the open air and a possible lack of fluid intake in the hot, sunny weather could have exhausted or fatigued him and the others involved in flight operations and further limited their performance. It cannot be ruled out that this may have reduced his situational awareness and alertness and made him more susceptible to being distracted, forgetting steps and losing sight of the big picture.

On the other hand, the pilot's great flying experience could also have led to complacency and a certain superficiality. In his lifetime, he had rigged numerous gliders and successfully completed all his flights. It cannot be ruled out that safety-critical, more comfortable habits may have become ingrained and become the norm, so that on the day of the accident, less intensive checks were performed and the glider was prematurely assumed as ready to fly without verifying it sufficiently.

After the winch launch was aborted, the pilot could have fully concentrated on an emergency landing, actively chosen and headed with the remaining controls towards a suitable emergency landing field straight ahead in take-off direction to at least avoid the collision with trees to lessen personal injury. However, the very short flight and low altitude also gave the pilot hardly any time to realise, process, solve and react to the problem. For an emergency jump, the maximum altitude reached and the remaining time were too marginal.

It can be assumed that the realisation of the lack of elevator control surprised and shocked the pilot during the winch launching to such an extent that he suffered from the startle effect, meaning he was shortly paralysed and lost important time, which further limited his scope for action. Most probably age-related, slower processing and reaction times also contributed to the pilot not taking timely rescue measures in this time-critical emergency situation. As none of the witnesses perceived any control inputs during the winch launching, a medical problem was initially suspected, but the post-mortem examination could not find anything to that effect.

### 2.2.5 Fatal mid-air collision during acrobatics (73-year-old PIC involved)[7]

On 24 September 2022 in Gera (Germany), two Zlin Z-526 AFS aircraft collided mid-air during an aerobatic maneuver. They became wedged together, entered an uncontrolled flight attitude losing their horizontal velocity instantaneously and they impacted a field (Figure 13).


Figure 13 Accident site after mid-air collision of the two acrobatic aircraft Source: BFU

The pilot of aircraft 2 (73-year-old pilot) was the following pilot. He flew the aerobatic maneuver, transition to the mirror flight (Immelmann Turn, Figure 14), uncoordinated and incorrectly without realizing or too late that the aerobatics maneuver failed and he had lost reference to the position of aircraft 1 (42-year-old pilot). He most probably lost situation awareness and did not initiate a timely avoidance maneuver nor did the other pilot. On the other hand, pilot 1 could not see the other aircraft from his position. There were no indications of health or other impairments, but the acceleration forces effecting the body and the spatial disorientation after climbing with subsequent roll about the longitudinal axis as in the performed maneuver, most likely influenced the responsiveness and decision making of the pilot of aircraft 2.

[7] https://www.bfu-web.de/DE/Publikationen/Bulletins/2023/Bulletin2023-09.pdf

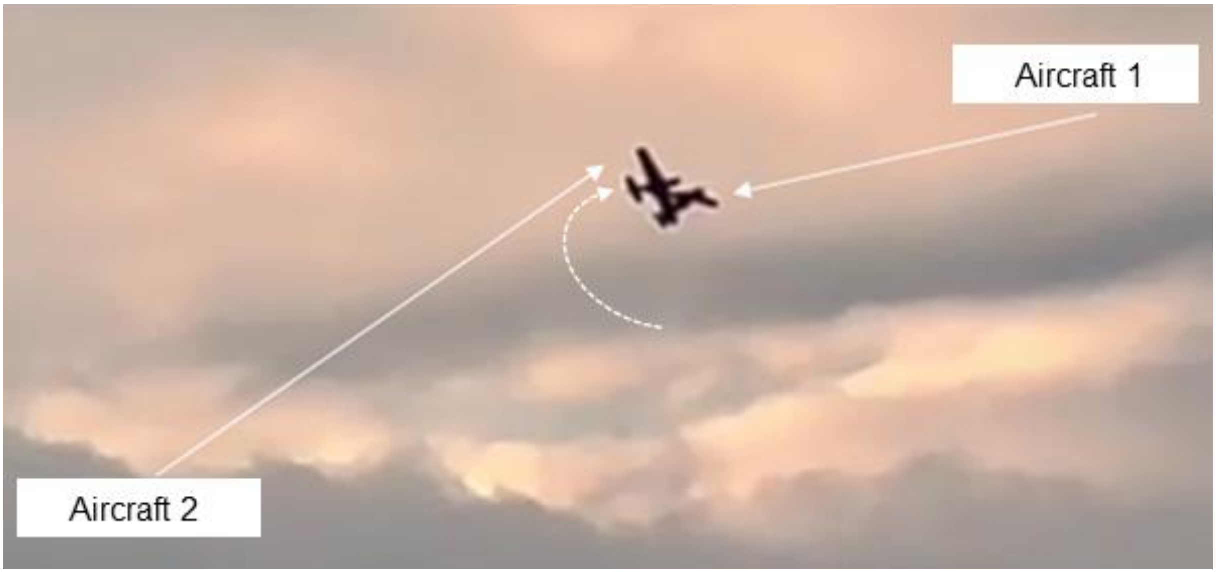


Figure 14: Decreasing distance of the two aircraft about to collide Source: Witness video, adaptation BFU

Both pilots had sufficient flying experience on type and to perform the aerobatics maneuvers. Yet still, their communication during the flown aerobatic maneuver was insufficient. Moreover, neither of them activated the carried emergency parachute to exit the aircraft. However, the 11 s between the mid-air collision and the ground impact most probably did not suffice to recognize the unexpected situation, make the decision to exit, throw off the canopy, open the seat belt, exit the aircraft and use the emergency parachute.

The investigation found a need for conduction of an independent risk assessment and definition of procedures for non-commercial aerobatics training. Moreover, age-related changes like impaired vision and neck flexibility to see the other aircraft and keep sufficient separation at all times and reduced processing as well as reaction time from realizing an incorrectly performed maneuver and reacting adequately to it also contributed to the accident and should be included in the risk assessment.

### 2.2.6 Fatal Accident during VFR Night Flight Training (73-year-old Instructor Pilot)

On 17 November 2023 at Dinslaken/Schwarze Heide airport (Germany), a Cessna F 172M aircraft flew into fog during the landing approach of a VFR night flight training. During the take-off maneuver, the aircraft collided with trees (Figure 15). The 58-year-old student pilot suffered fatal and the 73-year-old instructor pilot serious injuries. While the instructor pilot was a very experienced pilot (3,179 h total flying time) and had been flying over 15 h within the last 90 days, he had a limited amount of night flight experience (a total of 135 h). His last night flight was over a year ago. The student pilot had just received his PPL(A) license half a year ago after 58 h of flying time and had been flying quite a lot since then so that his total flight experience including the training hours amassed to 217 h. Since this investigation is still ongoing, the causes and contributing factors are still being determined. However, this case illustrates well that also student and instructor pilots can be of advanced ages.

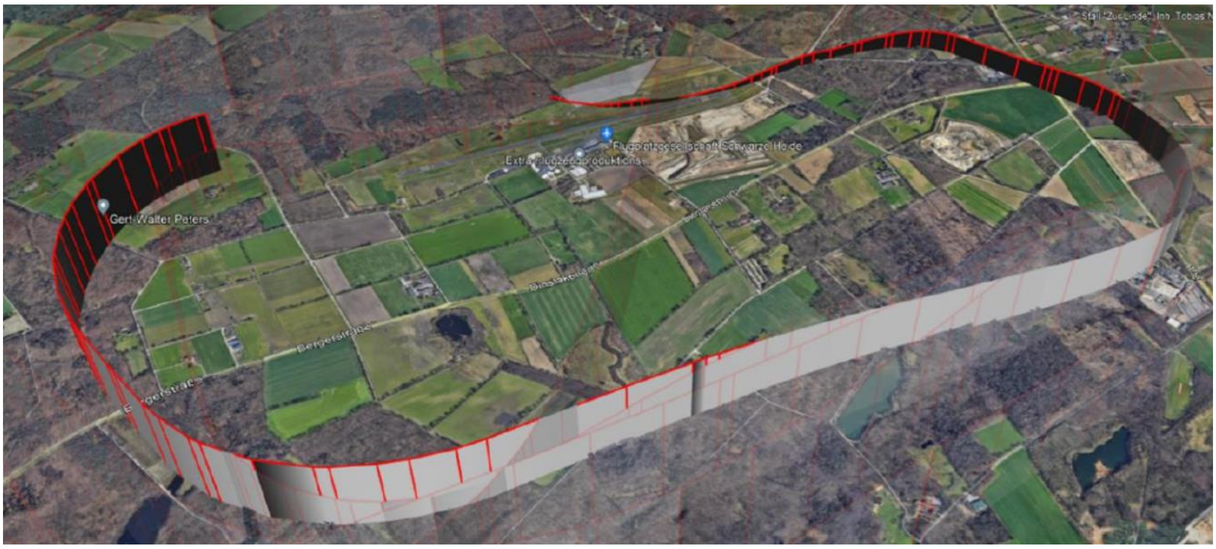


Figure 15: Flight of the last three minutes until tree collision Source: BFU, Google Earth©

## 3 Conclusion and Discussion

The data evaluation in this paper showed the demographic changes of people growing older are also represented in the occurrence of accidents. The average age of an accident pilot has increased immensely, around 50% over the last 40 to 50 years, from a former 40 years of age to almost 60. While the risk of in-flight incapacitations increases with age, also since of the medical unfitness and certain medical conditions like cardiovascular or cerebrovascular diseases increase, accidents due to in-flight incapacitations are rather rare events. However, there are some performance-limiting factors that come with age which do affect how well pilots perform in any given situation and become much more apparent or detrimental in high-pressure or safety-critical situations.

In conclusion, aging pilots are a topic to be investigated further as their sheer number will keep increasing over time regarding that life expectancy is increasing as well, and especially in the General Aviation, there is not age limitation as for CAT pilots. This means that license holders, provided that they still pass the aeromedical examination, can keep flying or begin flight training as a student pilot without any age limitations. So, the question arises how flight schools, instructors and examiners are prepared to adapt their flight training and check flights to the needs and affordance of older pilots as there are quite some human performance factors deteriorating with the natural aging process. However, flight limitations solely based on the chronological age of a pilot also disregard how individual all human beings experience the aging process and how well they cope with the resulting effects in various ways. Similarly, the accident causation cannot be limited to the fact that the pilot had advanced a certain age just because there are some performance limitations common amongst older pilots, many more technical, environmental, systemic and other human factors interact with one another and influence the pilot's capabilities to perform a safe flight any day.

Although the extent of deterioration and its effects are very individual, also their progression differs a lot and the current aeromedical examinations are insufficient to detect them adequately. While pilots can counteract various age-related changes to a certain degree with (long-time) experience, (current) training and behavioral changes (AOPA, 2013, 2024), every pilot should also honestly reflect their capabilities and include the result of this reflection in their risk assessment when planning to fly. Knowing and owning your weaknesses, allows one to not be surprised by them but rather incorporate them already into their preparation and maybe add some extra safety measures. For example, pilots can choose shorter legs or flights, plan more time for them (mainly with IFR flights), take co-pilots along for support, avoid high traffic airspaces and time periods, choose good and calm flying weather or also adjust personal minima to the current capabilities (see the pilot personal minimums contract by AOPA[8]). In

[8] www.airsafetyinstitute.org/vfrcontract

addition, pilots can also continuously attempt to maintain their skills. For example, pilots can train demanding situations or tasks intensely, improve their equipment for more comfort and safety, or use more technical as well as social support options. Similarly, angle of attack indicators can help to detect an impending stall condition earlier and thus especially give older pilots, who displayed an elevated number of loss of control accidents, more time to react to a stall or not even get into such a safety-critical situation. Other new developments like Ground Proximity Warning Systems (GPWS), ballistic parachute systems or an emergency autoland system can save the day in case a single pilot should feel unwell or indeed become incapacitated in-flight (e.g., EASA, 2021 and Garmin, 2024). On the other hand, all new technologies have to be learned, understood and monitored as well which might also create more workload. So, this development should be further researched as well.

Yet, there are limitations to this data evaluation. First of all, the findings are only based on German license holders and accident pilots. It would be of interest to see the results including serious incidents and also for other countries, especially for those with a similar age structure and an increasing number of older people.

Secondly, only for about 12,300 out of about 18,600 accidents (67% of all recorded accidents) the pilot age was recorded in the ECCAIRS database, thus allowing only two thirds of the data to be included in the age-related evaluations. Especially accidents of lower severity are usually investigated in less detail and unfortunately, the BFU stopped inquiring and/or recording the pilot age and some more details on such accidents in the ECCAIRS database in 1998 when it became independent from the CAA due to human resource limitations. However, in this way this data evaluation helped to shed light on how we as a Safety Investigation Authority (SIA) can improve our future data collection, recording and analysis. Similarly, the LBA should also make a retrospective data evaluation possible as they were only able to provide us with the current pilot license data but had no capabilities to retrieve older data and thus did not allow us to judge the development of certain factors such as the age of the German license holders, which would have been interesting as well.

It is worth noting that this data evaluation included all kinds of weight classes and aircraft (such as jets, gliders, balloons and ultralights) were included, without differentiating for the held licenses. The average General Aviation pilot involved in an accident might be even older since there are no age limits in place as in commercial air transport. Therefore, it might be of interest to analyze these factors further. Similarly, putting the accident data in relation to the number of flights or the number of current license holders at any given year in the past should be investigated. Yet again, these numbers are hard to come by and the advantages of recording these data in a retraceable and easily analyzable form still needs to gain more regard and relevance amongst all flight safety stakeholders. For example, corroborating the findings of the EASA contracted study of Simons et al. (2019), we found it to be generally difficult to register in-flight capacitation and other human factors in the ECCAIRS database to begin with and even harder to use the database for statistical analysis and identify them again later on. There is a compelling need to optimize the system to allow for better evaluation and also risk estimations of human factors, especially since they contribute to the occurrence of most accidents.

Since most of the cases were GA accidents, the majority was also single pilot operation, despite some of the aircraft flown being quite complex and thus especially demanding for older pilots with declining capabilities. In general, the data evaluation raised the question if the pilots' safety awareness with regard to age-related changes in their performance corresponds to the flight situations and risks, they accept. For example, it is questionable whether a 74-year-old pilot should still conduct VFR night flight training and especially in marginal weather and visibility conditions as an instructor when it is known that especially night vision deteriorates greatly with age and above all, his experience should help him judge weather conditions better and be a good example for his student. Similarly, many other accidents like the examples given in this paper show poor judgement (e.g., single pilot operation on complex aircraft at demanding airport), complacency (e.g., lack of pre-flight checks and use of checklists) and/or an overestimation of their own capabilities (e.g., flying risky acrobatic maneuvers at the age of 73 years). Of course, it is difficult to come to terms with one's declining capabilities, but we all have the responsibility to demonstrate good airmanship, be honest to ourselves and aware of the risks we accept as pilots-in-command, especially when we carry passengers.

Concluding, there is a clear increase of the age of accident pilots with time. However, this trend and correlation does not mean causation, no accident occurred just due to the age of a pilot. Then again, it should be further investigated how progressive aging and the accompanying decline of certain performance criteria influence flight performance, accident occurrence and flight safety. For example, research could analyze pilot performance in flight simulators and compare certain age groups or conduct within-subject studies to assess the decline of pilot performance over time and thereby, also develop and adapt performance test criteria for future examinations and checks. Finally, safety promotion should highlight age-related changes in human performance and how to cope with them.

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