GLIDER ACCIDENTS IN FRANCE FROM 1989 TO 1993: THE ROLE OF THE PILOT

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Summary

The purpose of this paper is to give a picture of glider accidents in France from 1989-1993 where 255 typical accidents were analyzed in the light of recent developments in cognitive psychology. It is shown how human factors in aeronautics can explain glider accidents: each accident is considered as an event resulting from an error linked to a cognitive process, frequently linked to particular causes. 255 criteria (type of flight, injuries, damage, pilot experience, type of errors, etc.) are compared as causal factors of the accident. Several suggestions are made with the hope of increasing the safety of soaring flight.

1 Introduction

This research was initiated by DGAC[1], ANEPVV[2], and FFVV[3], first to try to explain glider accidents from a human factor's point of view, second to increase the safety of soaring flight.

Accidents are an important consideration for soaring. In France, 20% of pilots are glider pilot's, flying 23% of general aviation flying time, representing 13% of general aviation airplanes. There are, on average, 90 accidents and 9 deaths each year. During the period examined, each repair cost on average 50 000 French francs[4], giving a total cost of 2 million French francs[5] per annum.

The study of glider accidents has mainly been limited to statistical analyses, in France (IGACM[6] [1,2,3,4,5] and DRAC[7] Sud-Est [6,7,8,9,10,11,12]), and in other countries (OSTIV[8] [13], BGA[9] [14], and NTSB[10] [15,16]). Only a few studies have tried to pinpoint causes (Inyzant-Hennequin [17]; Crance & al. [18]; Payen & al. [19] and Gitard [20,21]). These studies identify three important factors involved in glider accidents: l) the human operator plays an important role in each accident; 2) most of the accidents occur during the landing phase; 3) the pilots involved have a flying time of more than 100 hours. However, pilot behavior in the cockpit and their errors have never been examined.

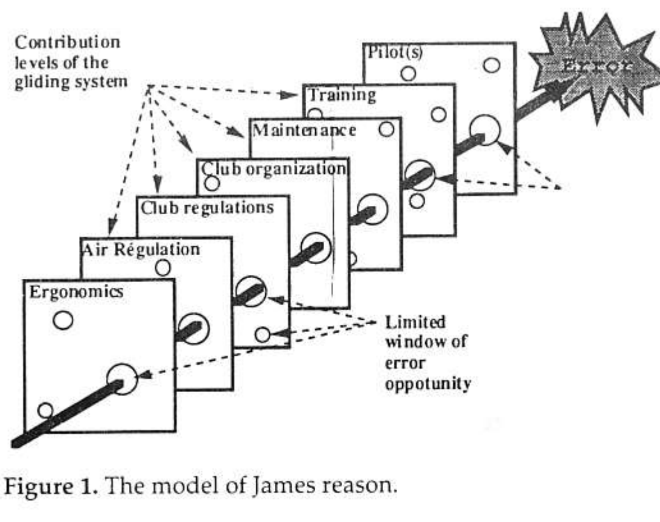

Figure 1. The model of James reason.

ABBREVIATIONS

1 Direction Générale de l'Aviation Civile (French FAA).
2 L'Association Nationale d'Entraide et de Prévoyance du Vol à Voile.
3 La Fédération Française de Vol à Voile.
4 £5300 or 14700 DM, or $9000.
5 £211000, or 590000 DM, or $345000.
6 Inspection Générale de l'Aviation Civile et de la Météorologie.
7 La Direction de l'Aviation Civile.
8 L'Organisation Scientifique et Technique du Vol à Voile (International Scientific and Technical Organization for Gliding.
9 The British Gliding Association.
10 The National Transportation Safety Board
11 Cockpit resources management

The numerous definitions of human error are controversial (error as a deviation to the norm, error as a deviation to an intention...) and often focused on its negative side. Moreover a good and exhaustive taxonomy is needed.

We base the present study on recent error models (Reason [22], Swain [23]), and on works in cognitive psychology and human factors [24,25,26,27,28,29,30,31].

The causal model realized by James Reason has been passed by ICAO to study the human factor [see Figure 1]. These figures shows how the different levels of the gliding system can lead to the breakdown of the human operator.

It is useful to distinguish four levels of analysis. The first level is a description of the events and history of each accident. These data are raw and objective. The second level provides an analysis of the causes (or contributing factors). The third level analyses the cognitive processes involved. It is a subjective analysis based on raw data. The fourth level examines errors as the result of mental processes. These errors reflect the visible behavior of the operator. Here I will focus on the two last levels.

2 Methodology

255 (because many were incomplete) of the 422 files from the FFVV have been analyzed and sorted according to the type of accident: 271 flying gliders (64%), 44 tow planes (10%), 98 powered engine gliders using the engine (23%), and 9 others (2%).

Data has been analyzed statistically and clinically to describe pilot behavior during accidents.

3 Results

In the first part of this paper, we provide a statistical description of the data obtained by the 255 concerning flying glider accidents in France during the years 1989 to 1993. Due to the lack of baseline rates (i.e. total number of flights in each category), we are unable to compare the frequency of accidents across categories, however, these data do provide a picture of the typical types of accident in France during this period. In the second part of this paper, we analyze these data in terms of the misfunctioning of cognitive processes leading to the accidents described in the first section.

3.1 Description of the accidents

Accidents were the most frequent and the most serious for plastic single and twin-seater planes: of the 255 accidents, 80% occurred in these two categories, responsible for 92% of the fatalities and 81% of the injuries (see Table 1).

Type of glider	*accidents*	*fatalities*	*injuries*
Plastic single seater	161 (63%)	11 (92%)	26 (62%)
Plastic twin-seater	43 (17%)		8 (19%)
Wood and stuff single	28 (11%)	1 (8%)	6 (14%)
Wood and stuff twin	18 (7%)		2 (5%)
Motor glider	5 (2%)		
Totals	*255 (100%)*	*12 (100%)*	*42 (100%)*

Table 1. frequency of accidents, fatalities and injuries according to the type of glider

All categories included, most of the accidents (80%) did not lead to physical harm to the pilots, 16% resulted in injuries, and 5% in deaths.

The most dangerous gliders were the H201 Libelle (40% replaced within the five years due to accidents), JP15-36 (33%), and WA 23 and 28 (40%). The LS class alone caused 40% of the fatalities within the five years.

Accidents occurred for all classes of pilots, irrespective of their flying experience (from beginners to competitors) [see Table 2]. The seriousness of the accidents was similar across levels of experience.

Experience	*accidents*	*fatalities*	*injuries*
< 50 hours	22 (9%)	2 (17%)	5 (12%)
50-100	34 (13%)	1 (8%)	5 (12%)
100-150	26 (10%)	2 (17%)	4 (10%)
150-300	44 (17%)	3 (25%)	8 (19%)
300-500	34 (13%)	1 (8%)	4 (10%)
500-1000	41 (16%)	1 (8%)	6 (14%)
>1000	54 (21%)	2 (17%)	10 (24%)
Totals	*255 (100%)*	*12 (100%)*	*42 (100%)*

Table 2. Frequency of accidents, fatalities and injuries according to pilot experience

A typical French glider pilot involved in an accident can be described:

- he is male (94%),
- he holds a glider pilots license (41%),
- he has no airplane pilot license (65%),
- he has a flying experience between 50 and 100 hours (25%),
- he has less than 30 hours on type (50%),
- he has less than 10 hours on the type during the last six months (50%),
- he flies local flight (57%).

More than half of the accidents occurred during local flights [see Table 3], and 19% during circuit flying. These accidents were relatively serious (45% of deaths and 81% of the injuries). Accidents were particularly serious (a disproportionately high number of deaths) in mountain flying.

Type of flights	*accidents*	*fatalities*	*injuries*
Local flight	132 (57%)	4 (36%)	23 (58%)
Distances 50, 300, 500 Km	9 (4%)		
Circuit flight	45 (19%)	1 (9%)	9 (23%)
Competition flight	15 (6%)		3 (8%)
Mountain flight	31 (13%)	6 (55%)	5 13%)
Totals	*232 (100%)*	*11 (100%)*	*40 (100%)*

Table 3. frequency of accidents, fatalities and injuries according to types of flight

Two thirds of the accidents occurred during landing; half in the country and half in airports [see Table 4]. Accidents during take-off were mainly due to cable dropping problems (technical or human operator problems). Accidents during the in flight phase involved mid-air collisions. Some were windscreen ergonomic problems. Half of the spins occurred during the in-flight phase, the other 50% during landings. Fatalities were the highest in the in-flight phase.

Phase of flights	*accidents*	*fatalities*	*injuries*
Rolling, towing, winching	47 (18%)	1 (8%)	10 (24%)
In flight	33 (13%)	6 (50%)	10 (24%)
Mountain flight	18 (7%)	2 (17%)	5 (12%)
Landing on the airfield	78 (31%)		7 (17%)
Landing in the country	79 (31%)	3 (25%)	10 (24%)
Totals	*255 (100%)*	*12 (100%)*	*42 (100%)*

Table 4. frequency of accidents, fatalities and injuries according to the phases of flights

Some totals are not the same as in previous tables, because many folders were incomplete.

3.2 Cognitive processes involved in accidents (according to the Reason Model)

Three processes (inaccurate environment representations, inaccurate representation of the glider status and incorrect choice of procedure [see Table 5]) were respon-

routines	C101, landing gear up
inaccurate representation of the glider status	G103, low speed on short final, with a late flare
inaccurate environment representation	Pégase, landing in the country in a field recently plowed, with a strong tailwind
incorrect choice of procedure	K6E, start of the approach too low for a landing in the country

Table 5: examples of the cognitive processes

Cognitive processes	*accidents*	*fatalities*	*% injuries*
routines	37 (16%)	1 (10%)	6 (15%)
inaccurate representation of the glider status	55 (23%)	7 (70%)	11 (28%)
inaccurate environment representation	64 (27%)		9 (23%)
incorrect choice of procedure	54 (23%)	2 (20%)	10 (25%)
bad resources management	9 (4%)		1 (3%)
wrong intention	12 (5%)		3 (8%)
violations	5 (2%)		
Totals	*236 (100%)*	*10 (100%)*	*40 (100%)*

Table 6: frequency of accidents, fatalities and injuries according to the cognitive processes

sible for 75% of accidents, 81% of write-offs and most of the injuries [see Table 6]). Inaccurate representation of the glider status caused most of the hospitalizations and deaths. These inappropriate processes were less frequent with experienced pilots. A fourth process, incorrect routines, was observed in 16% of the accidents. Routines occurred during poor monitoring of execution. They appeared when the tasks were highly automated, and concerned experienced pilots.

3.3 Human errors

According to the Reason model, 75% of the accidents were mistakes. A mistake is a misfunctioning at the moment of choosing an objective, or the means of reaching this objective. Two types of mistakes were observed: l) related to an inaccurate representation of the process or the status (27% of the errors), 2) resulting from an incorrect intention and/or a action (54% of the errors) [see Table 7]. These mistakes had the most serious consequences on pilots (injuries and fatality) [see Table 8], and caused the greatest number of write-offs. 27% of the mistakes were linked to an inaccurate representation of the environment. Slips were also observed for 16% of the accidents.

Slips	C101, mixing up between landing gear and air-brake lever (gear up instead of air-brakes up)
mistake from an inaccurate representation of the situation or the status process	LS1D, spin during down wind
mistake from a wrong intention, and/or a wrong action	G103, during a landing in the country, on short final, the pilot change the selected field for another one

Table 7: examples of the errors (according to the Reason Model)

Human errors	*accidents*	*fatalities*	*% injuries*
slips	39 (16%)	1 (9%)	6 (15%)
mistake from an inaccurate representation of the situation or the status process	65 (27%)	8 (73%)	15 (37%)
mistake from a wrong intention, and/or a wrong action	130 (54%)	2 (18%)	20 (49%)
violations	5 (2%)		
Totals	*239 (100%)*	*11 (100%)*	*41 (100%)*

Table 8: frequency of accidents, fatalities and injuries according to human errors (according to the model of Reason)

These errors appeared less frequent with experienced pilots.

Execution	Marianne, fly a (low) approach pattern, leading to a landing well before the runway
Omission	C101, landing gear up
Action not in time	G103, to high on finale, late correction
Error in choice action	LS1, pilot stop to apply back pressure on the control wheel during flare out

Table 9: examples of the errors (according to the Swain Model)

Human errors	*accidents*	*fatalities*	*% injuries*
Execution	156 (66%)	10 (91%)	30 (73%)
Omission	31 (13%)	1 (9%)	5 (12%)
Action not in time	29 (12%)		4 (10%)
Error in choice action	19 (8%)		2 (5%)
Sequence error	3 (1%)		
Totals	*238 (100%)*	*11 (100%)*	*41 (100%)*

Table 10: frequency of accidents, fatalities and injuries according to human errors (according to the model of Swain)

According to the Swain model

Two thirds were errors in execution of procedure (the action selected was correct, but the execution was incorrect) [see Table 9].

Three others errors were equally observed: omissions, action not in time (delayed or in advance), and errors in choice of action (unexpected action disconnected to the procedure) [see Table 10]. These errors appeared less frequently with experienced pilots.

3.4 Others questions

Did most accident landings occur in the country? Yes and no! Out of the 62% of accidents occurring during landings, 31% occurred in the country, and 31% in airfields. We have to keep in mind, an aircraft is vulnerable close to the ground. Especially if we add to the previous 62% the 18% of accidents occurring during taking-off.

Which accidents caused the most injuries? Taking-off, in flight and landings during local flights caused 50% of the injuries. Local flights caused one third of the fatalities, and mountain flights 50%.

Which type of flight caused the most accidents? Three types: local, circuit and mountain flights. During local flights, the most dangerous phases were take-offs and landings. During circuits, the most dangerous phase was landing in the country.

Are spins really deadly? Spins (17 over the 5 years) caused 50% of the fatalities, and 70% of the write-offs. It seems pilots are unprepared for spins, and do not know how to recover from them.

4 Conclusions

The mistakes show a problem of human-machine adjustment (pilot-glider here). In these accidents, the pilots had an incomplete idea, sometimes incorrect, about their glider configuration (system status, speed, etc.). This was aggravated by their lack of experience on the type of machine. Pilots have to improve their knowledge and practice about the glider.

80% of the accidents occurred close to the ground (landing = 62% and take-off = 18%). Concerning accidents during landings, the error occurred within the human-machine environment system. Once again, the only way to improve safety is by training and practice.

The plastic single-seater glider is dangerous. They are certainly good and safe, but these new aircraft require a high level of proficiency. Again, because pilots lack experience on type, they need more training and practice.

Four dangers in gliding have been identified : l) local flights, 2) mountain flights, 3) midair collisions, and 4) spins.

We must notice the preceding conclusions lead to the same advice: training, practice and procedures.

5 Recommendations

* *A glider accidents data base*

To reduce accidents, we need to understand them. But to understand them, we must know them. Moreover, it is easy to learn from the mistakes of others. Keeping in mind the fact that we do not have time to make them all ourselves. So, we need a data base, managed by an independent organization.

** A data base specialist*

He/she will be the authorized operator for the data base. He will be in charge of collecting the data, contacting people related to an event to obtain information, analyzing the data, and providing reports. But, the success of such a system needs voluntary reports of glider hazards from pilots.

**** Initial training should include training in human factor topics, and a CRM[11]course should be created for glider pilots.***

The goal is to teach pilots about safety. How they work while flying, their limits, but also how to take into account the positive role of their cognitive system.

** Training*

A lot of accidents show certain inadequacies in pilots training.

1) Inadequacies have been demonstrated especially during rolling. All the pilots concerned were licensed glider pilots, sometimes with the certificate D (a flight during five hours or more, a 1,000 meter climb, and a straight flight of 50 kilometers). So these pilots do not know to maintain directional control.
2) During the flight phase, most accidents are mid-air collisions. Pilots must be made sensitive to collision avoidance.
3) For spins, pilots must be taught to recognize spins, and how to recover from them.
4) Concerning landing on airfields, approaches and touches are badly performed.
5) For landing on the country, pilots seem unable to select a good surface. But the real issue is well before the selection, since numerous landings in the country are carried out without any planning. Pilots wait for the last minute to make the decision to abort their flight.

** Procedures*

1) Rolling, towing, winching: just add an item before the take-off procedure, to remind pilots what to do if the taking-off is interrupted.
2) In flight phase: is there a procedure used to secure mid-air collision avoidance?
3) Landing on the country: build a procedure to help pilots make the correct decision (especially on time) to land in the country.

** Recommendation*

Because 70% of the pilots concerned have a glider pilot license (41%) and a certificate D (28%), we have to make a statement: pilot are not completely proficient with a glider pilot license. All instructors know, a license does not mean training is over. Thus, this period should be seen as a transitional stage to more proficiency. We just want alert instructors and managers to keep attention on pilot, even though they got their license.

** Choices*

1) Pilots and gliders: because some new single-seater gliders require a high level of proficiency, flying schools should decide which pilots (according to their experience) can fly which glider.
2) Use of gliders: because some gliders are more fragile, others are very expensive, some are for competition, flying schools should decide which gliders can be used in which type of flight. Use of powered engine gliders: one third of the accidents are during landing in the country. To improve training for this exercise, the use or powered engine gliders could allow pilots to perform the landing as far as possible.
3) Mountainous flights: set the level of mountain flights and train pilots for each of this level.
4) Local flights: set what a local flight is, and according to the experience of the pilot, give them the right to fly a certain type of local flight.
5) Elderly pilots: aging is a difficult issue, especially for flying. Each flying school should set rules, to ensure older pilot flying safely. How, is the real issue.

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