Displaying Aircraft -
Lessons Learned from Flight Test Pilots

Results of the 5th European Flight Test Safety Workshop, Salzburg November 8-10, 2011

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Abstract

This paper summarizes the outcome of the European Flight Test Safety Workshop which was held in Salzburg in November 2011. The theme of the workshop was "Demonstrating Prototype Aircraft – Risks and Preparation.

1 Introduction

On November 29, 2006 one of Europe´s leading GA flight test pilots, Gérard Guillaumaud, was killed during a tragic accident. Gérard Guillaumaud died, when he presented the second prototype aircraft of the Grob SPn to visitors at his homebase, the Mindelheim-Mattsies Airport in Germany. The aircraft, a sleek light jet made mainly from carbon fibres and two jet engines mounted on the aft fuselage, disintegrated within seconds, when Gérard turned final in a shallow descent to demonstrate the aircraft at high speed. The slightly modified horizontal tail entered a flutter mode not expected at the chosen fly-by speed, disintegrated and the aircraft pitch nose-down, giving Gérard not the slightest chance to escape (Figure 1, Figure 2).

Here is the narrative [1]

> On the day of the accident, November 29, 2006, the airplane had conducted a 60-minute test flight from the factory airfield of manufacturer, Mindelheim-Mattsies Airport. Various flight maneuvers and system tests were completed and the airplane landed at 11:40. The aircraft was parked on the apron and prepared for the next flight.
>
> This flight would be a demonstration flight for a group of visitors with several fly-bys. The jet took off from runway 33 at 13:12 and the pilot flew a right hand circuit in and out of clouds. As it was lining up for a fly-by parts from the stabilizer separated. The pilot lost control and the airplane impacted a field.
>
> Given the weather circumstances, the flight should have been conducted using Reduced Flight Display specifications. These included a maximum speed of 200 knots. The probable speed of the accident airplane was between 240 and 270 knots. This speed was below the maximum allowed speed for flutter tests, 297 kts.
>
> The manufacturer had changed the design of the control surfaces on this second prototype due to anti-icing requirements and to provide more roll authority.

Figure 1: Prototype 1 of Grob G-180 [2]

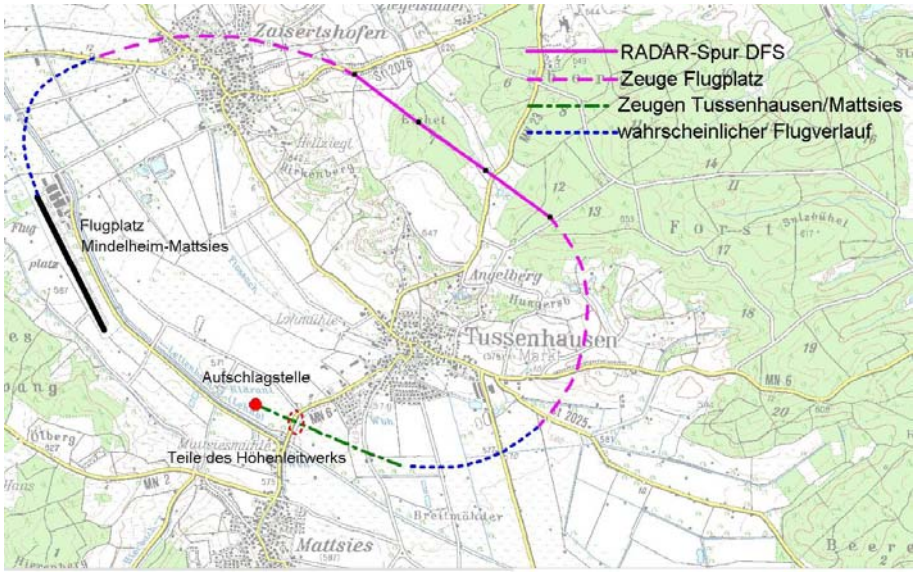


Figure 2: Reconstructed Flight Path of accident flight on November 29, 2006 [2]

The details of the accident with lessons learned and safety recommendations can be retrieved from the official accident investigation report [2]. The investigation was conducted by the German BFU.

For the purpose of this presentation, let me draw my personal conclusions:

- The pilot was highly experienced with 7.800 hours total time and fairly well familiar with the aircraft type, not that particular aircraft. He had accumulated 257 hours on the accident type.
- To an outsider, the modification might seem to be a minor change. Increasing the span of the horizontal stabilizer by a couple of centimetres and adding ballast does not seem a big deal. The experts, however, knew different. New flutter modes can arise from this change and the engineers conducted an analysis.
- Despite of the engineering analysis and the somewhat comforting remarks regarding the speed range available, this analysis did not prevent the accident. The pilot thought that he was safe at the fly-by speed when in fact he was not (see Figure 3, second row of arrows from the top).
- The display flight was squeezed into an otherwise busy flight test certification programme.

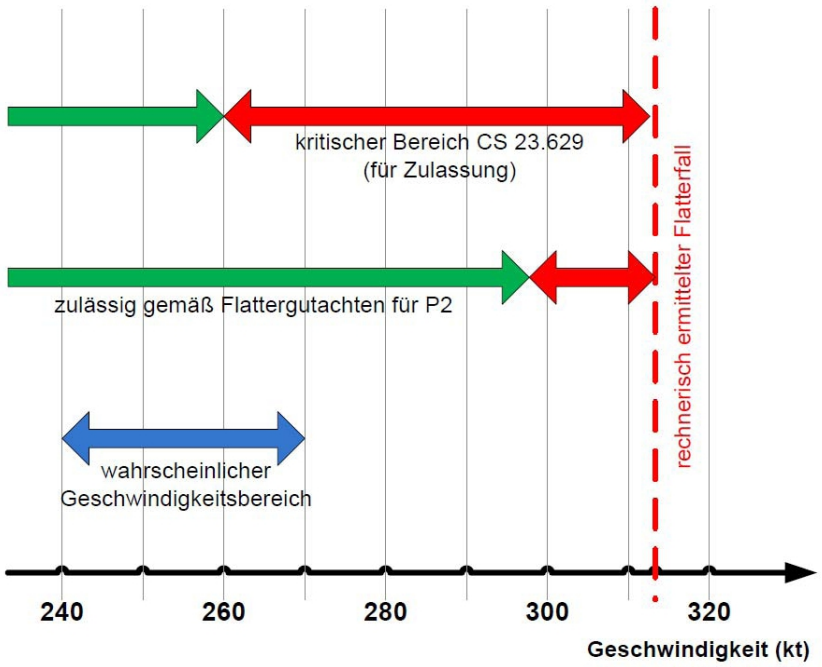


Figure 3: Speed Range [2]

Gérard had the reputation in the flight test community to be very conscious about safety. He was the type of person aware of the risks of his profession and he would constantly strive to improve flight test methods and even design systems, which would reduce the risks associated with the business of flight test. For example, Gérard developed a rocket powered seat, which would slide back and catapult the test pilot under distress next to the aircraft exit, so that the pilot could bail out more quickly when things go wrong during high-risk testing.

I knew Gérard in person and I do not know, how many in this room have lost friends or fellow pilots due to tragic accidents in the display arena. When you read Des Barker´s Book “Zero Error Margin”, you quickly learn that in the world of display flying the accidents hardly ever happen to the rookies – it is the highly respected, extremely experienced pilots who get caught.

The tragic accident on November 29, 2006, however, had three spin-offs.

- Spin-Off 1: An annual European Flight Test Safety Workshop is being organized since by the Flight Test Safety Committee. The first such workshop was held in London in 2007, followed by Amsterdam in 2008, Vienna 2009, again London 2010 and finally Salzburg in 2011.

- Spin-Off 2: For the Salzburg event, we chose "Displaying Prototype Aircraft – Risks and Preparation" as the grand theme. This topic was readily accepted and as the organizer I had immediately full support from the test pilot community. Some individuals who contributed to the workshop are in this room and I would like to thank them wholeheartedly for making the workshop such a success. This workshop is actually the reason why I am here: I was asked by Bob Dixon to summarize the results and draw conclusions. I am very happy to do this and feel privileged to be allowed to present.

- Spin-Off 3: A third spin-off is the creation of the European Flight Test Safety Award, sponsored by the financier of late Gérard, Ms. Heidi Biermeier from "Stiftung Mayday", which supports the victims of such tragic accidents. The award is intended to not only acknowledge an individual´s contribution to flight test safety, but also to encourage and to promote work in this field (Figure 4).

Figure 4: European Flight Test Safety Award (Source: Author)

2 Results of Flight Test Safety Workshop – Salzburg 2011

As the name implies, the three-day-event held in Salzburg from November 8 until November 10, 2011 was a workhop. Workshop contains the word “work” and we decided to include the audience and distribute work packages. With a group of thirty-plus people, half of them very experienced test pilots with a strong background in demonstrating prototype or highly modified aircraft, the number of attendees stayed below expectations but nevertheless, the event was a big success (often “small is beautiful”).

2.1 Outcome 1 – Lets do something

One of the perhaps most astonishing results was the fact that the problems associated with product demonstration flying are a problem of the industry, not an individual company or pilot.

- Having to squeeze in a demonstration flight in an otherwise busy certification program is one of the problems.
- Getting insufficient time to prepare for the preparation another.

2.2 Outcome 2 – Lets work together

Demonstration of flying machines started very early on. After all, demonstration flights are a marketing tool.

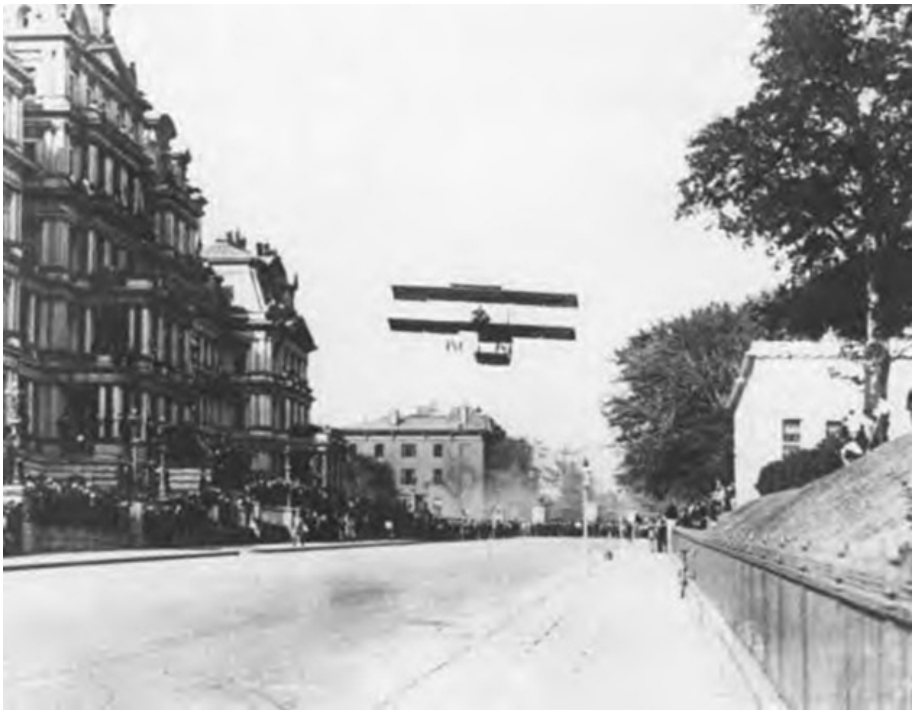
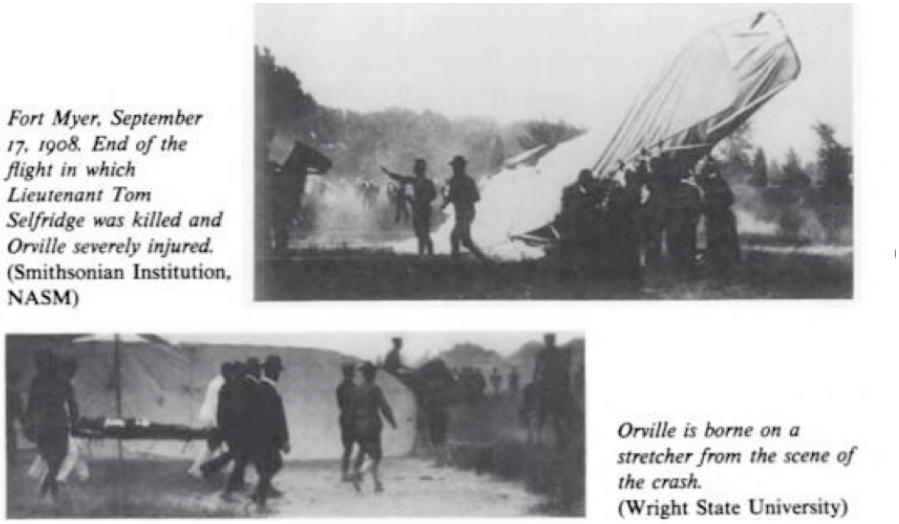


Figure 5: First Air Meet in Reims, France, 1909 (Source: unknown)

In Des Barker´s book “Zero Error Margin”, the famous accident of the Wright Flyer on September 17, 1908 is mentioned. Remember, this was exactly three months prior to the five-year anniversary of the first powered flight and one year prior to the first official airshow, the “air meet” in Reims, France! In these early days the aircraft turned from a solely experimental machine into a useful tool.

On the day of the accident Wright had his so far heaviest passenger on board, young Lt. Selfridge. The lieutenant became the first passenger ever killed in recorded aviation (Figure 6).



Fort Myer, September 17, 1908. End of the flight in which Lieutenant Tom Selfridge was killed and Orville severely injured. (Smithsonian Institution, NASM)

Orville is borne on a stretcher from the scene of the crash. (Wright State University)

Figure 6: Wright Flyer Accident in Ft. Myers, December 1908 (Source: Smithsonian, Wright State University)

The accident is particularly interesting because just prior to the accident the propeller was changed to one with a larger diameter, never tested before. In modern words, we would talk about a significant modification and this flight would rather be considered a test flight instead of a routine passenger-carrying flight.

The early demonstration pilots were inventors, engineers, builders and test pilots all in one person. With the advances in aviation technology, the profession of the flight test pilot developed and demonstrating an aircraft would be part of his job.

In the course of the years the tight link between demonstration of aircraft and the flight test world was lost. These days, demonstrations are routinely flown by all sorts of pilots, operational pilots or professional aerobatic pilots, owners of vintage fighters and others.

We decided in Salzburg that the test pilot community with their specific approach to designing manoeuvres, planning the demonstration, flying the airplane should again get more involved in the business of demonstration. This is not meant to say that today´s professional display pilots are not adequately trained or do not do a fantastic job. This simply says that different groups should cooperate more closely and use their combined wits. Experimental test pilots are individuals who are actually flying and developing new aircraft types. They are organised in the “Society of Experimental Test Pilots”.

2.3 Outcome 3 – A Demonstration is not A Demonstration

Have you ever asked yourself the question what the presentation of a barnstormer and the presentation of a company test pilot, showing the latest product, have in common? The answer is – not very much (Figure 7).

Figure 7: Wing Walker (Source: Werner Horvath)

Being in the flying circus environment and thrilling crowds is one thing, demonstrating the latest piece of technology, which at that stage might not even be cleared in the entire envelope, is another.

Why do I mention this? As Ricardo Traven pointed out several times in Salzburg, you – as a demonstration pilot – **must not cross the border**. At least not, until you are fully trained and qualified and understand that you are now in a different segment of the display flying arena.

- If you are a military pilot, trying to show precision and discipline in a multi-ship formation, do not try to be an aerobatic world champion
- If you demonstrate the latest piece of technology, with 5 hours on type and the envelope hardly expanded, do not seek to thrill the crowds by planning spectacular manoeuvers. A simple fly-by might be just enough.
- If you are an operational military pilot do not copy the show of the company test pilot who exactly knews his gates, has trained the contingencies in a simulator and above all, has done an engineering analysis on how to perform the manoeuvres.

Traven pointed out that one of the most lethal things a demonstration pilot can do is to cross the border – to change from one area of expertise into another is the cause of many display flying accidents. A highly sophisticated military jet should not fly manoeuvres that might be quite normal for a single piston aircraft. A company test pilot would be ill-advised to ask the world champion in the unlimited class to orchestrate his demonstration. Downline rolls are nice to watch

in an aerobatic competition but there is absolutely no military use for such a manoeuvre in a fighter aircraft.

Crossing the line is worsened, if the pilot decides to cross the lines during the display, improvises his display.

	Product Demonstration	Airshow Circuit
Objective	Strictly marketing and sales	Specator entertainment:
Focus	Commercial focus flight test product demonstration - exhibiting the aircraft's performance and handling qualities to the prospective customer	Airshow pilots 'thrill seeking' audiences – high risk maneuvers (inverted ribbon cut at night
Role of Pilot	Test pilots not necessarily airshow 'literates'. Only one of many skills.	Emphasis is on the skills of the pilot in providing entertainment to fee-paying spectators
Aishow Display Area	Flight test is in restricted areas, but not necessarily in "the box. Flight test demo invariably within a confined 'airshow box' at international expo's"	Practices in the box most of his time

Table 1

2.4 Outcome 4 – Pick brains through a Questionnaire

Part of the effort in Salzburg was to turn the workshop into a workshop – it is already difficult to get good presenters and let them speak to the audience. To get the audience involved is somewhat even more difficult, but that is what workshops are for.

We had three groups

- Group 1: focus on database
- Group 2: focus on the development of a questionnaire
- Group 3: focus on the development of a handbook

There are some key questions to be asked (Figure 8):

- What guidelines should the demonstration pilot consider in best exhibiting the air vehicle to a prospective customer?
- What are the requirements for the selection of demonstration pilots?
- What are the guidelines regarding the target audience?
- What are the demonstration pilot's responsibilities toward the company?
- What are the roles and responsibilities of management?
- What are the demonstration pilot's responsibilities to the prospective buyer's team and pilots, briefings, and reporting?
- What are typically the focus areas for aircraft manufacturers when developing their marketing strategies through product demonstrations?
- Test pilots involved in product demonstration flights need to regularly revisit the safety elements governing the objectives, sequence design and risk management involved.
- What are the threats to test pilot demonstration flights?
- What attributes are required to be a successful flight test demonstration pilot?

Figure 8: Some key questions to be asked (Source:Des Barker)

Figure 9 shows you the background of the individuals who answered the questionnaire in Salzburg. If you are interested in contributing to this questionnaire, please use the following link:

https://www.surveymonkey.com/s/SurveyDisplayFlying2012

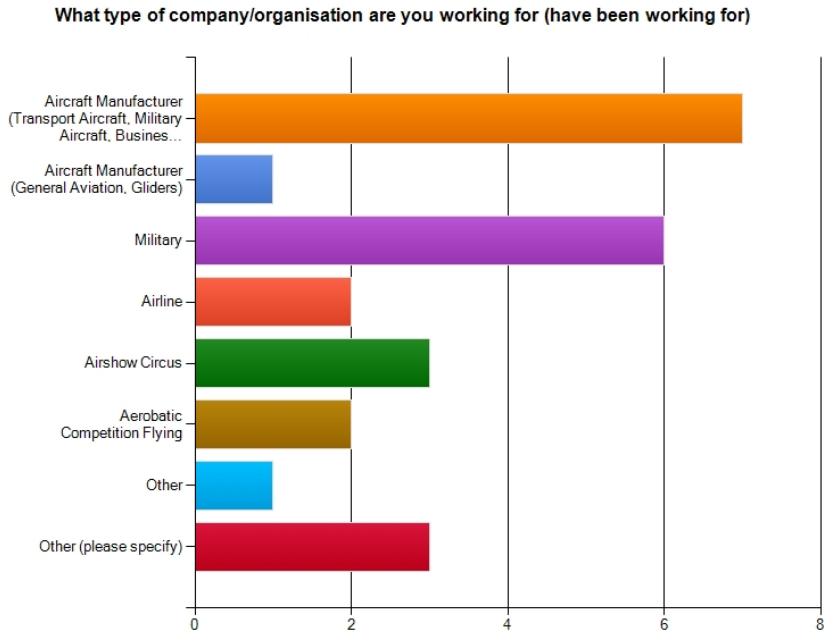


Figure 9: Background of Pilots who answered the questionnaire at the Salzburg EFTSW 2011 (Source: Author)

Figure 10 shows the field of expertise of the pilots who attended EFTSW 2011 and have answered the questionnaire. The above two picture should therefore set the stage so that you understand who the people were who gave the answers which are presented in the following charts.

The results are actually self-explanatory and are shown, without further comments, from Figure 10 to Figure 16. You are encouraged to draw your own conclusions.

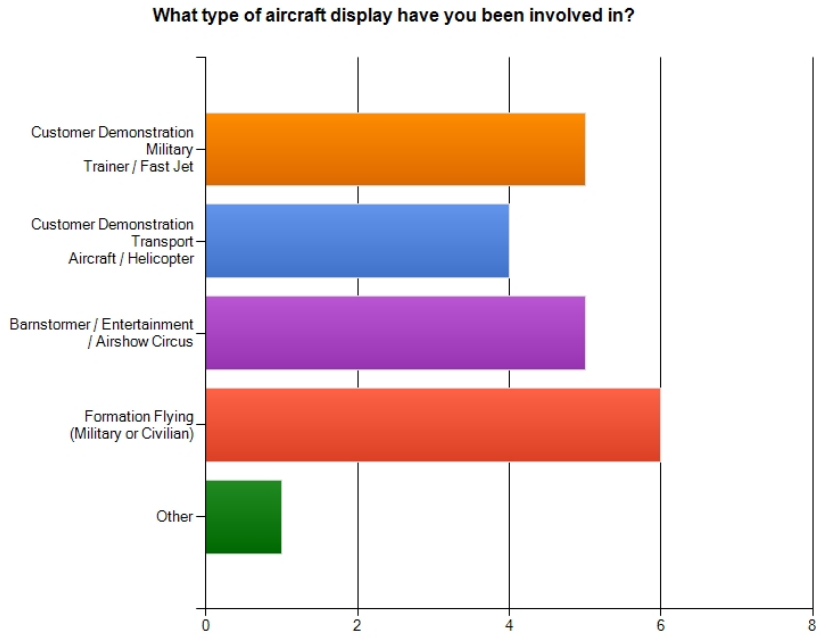


Figure 10: Involvement of pilots in different display flying disciplines- answers from Salzburg EFTSW 2011 (Source: Author)

9. How many practice runs would you recommend for re-training after a prolonged break (e. g. winter)? Create Chart Download

	Response Percent	Response Count
1 – 3	21.4%	3
4 – 9	50.0%	7
10 - 20	14.3%	2
21 – 40	7.1%	1
more than that	7.1%	1
	answered question	14
	skipped question	16

Figure 11: Recommended number of practice runs for first time display pilots - answers from Salzburg EFTSW 2011 (Source: Author)

10. How many practice runs would you recommend to an experienced display pilot prior to the first demonstration of a new routine? Create Chart Download

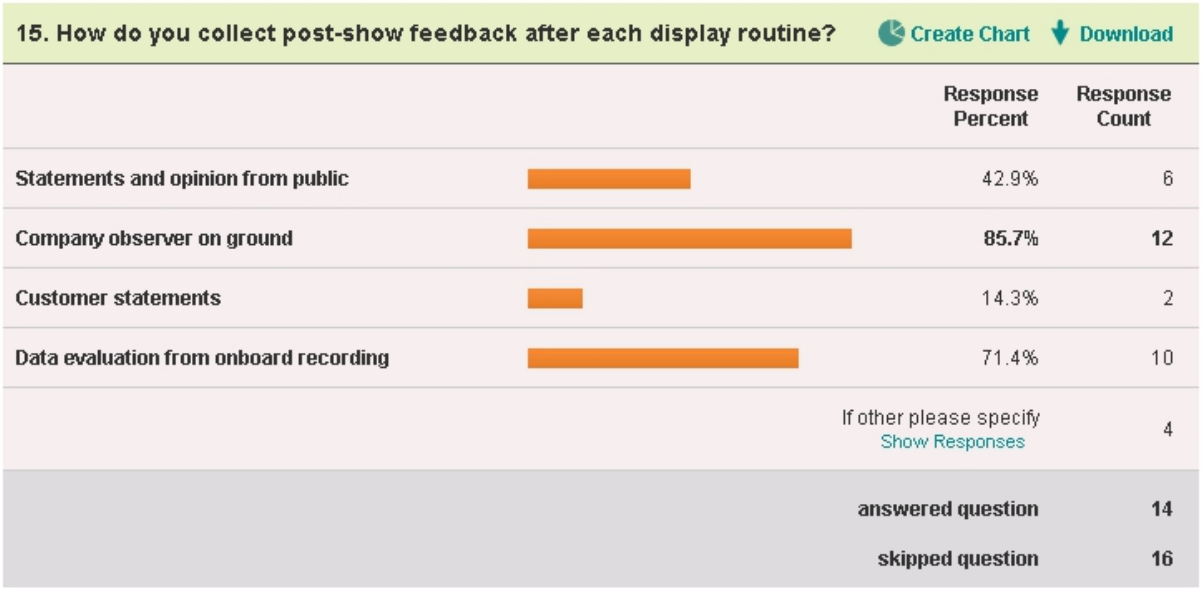
	Response Percent	Response Count
1 – 3	0.0%	0
4 – 9	**50.0%**	**7**
10 - 20	28.6%	4
21 – 40	14.3%	2
more than that	7.1%	1
	answered question	**14**
	skipped question	**16**

Figure 12: Recommended number of practice runs for experienced display pilots - answers from Salzburg EFTSW 2011 (Source: Author)

18. What tools do you use to prepare for malfunctions during the flight? Create Chart Download

	Response Percent	Response Count
Simulator	28.6%	4
Additional Checklists	28.6%	4
Tabeltop Simulation	**42.9%**	**6**
Other	28.6%	4
	If other please specify Show Responses	4
	answered question	**14**
	skipped question	**16**

Figure 13: Tools used to prepare for malfunctions - answers from Salzburg EFTSW 2011 (Source: Author)



15. How do you collect post-show feedback after each display routine? Create Chart Download

	Response Percent	Response Count
Statements and opinion from public	42.9%	6
Company observer on ground	**85.7%**	**12**
Customer statements	14.3%	2
Data evaluation from onboard recording	71.4%	10
If other please specify Show Responses		4
answered question		**14**
skipped question		**16**

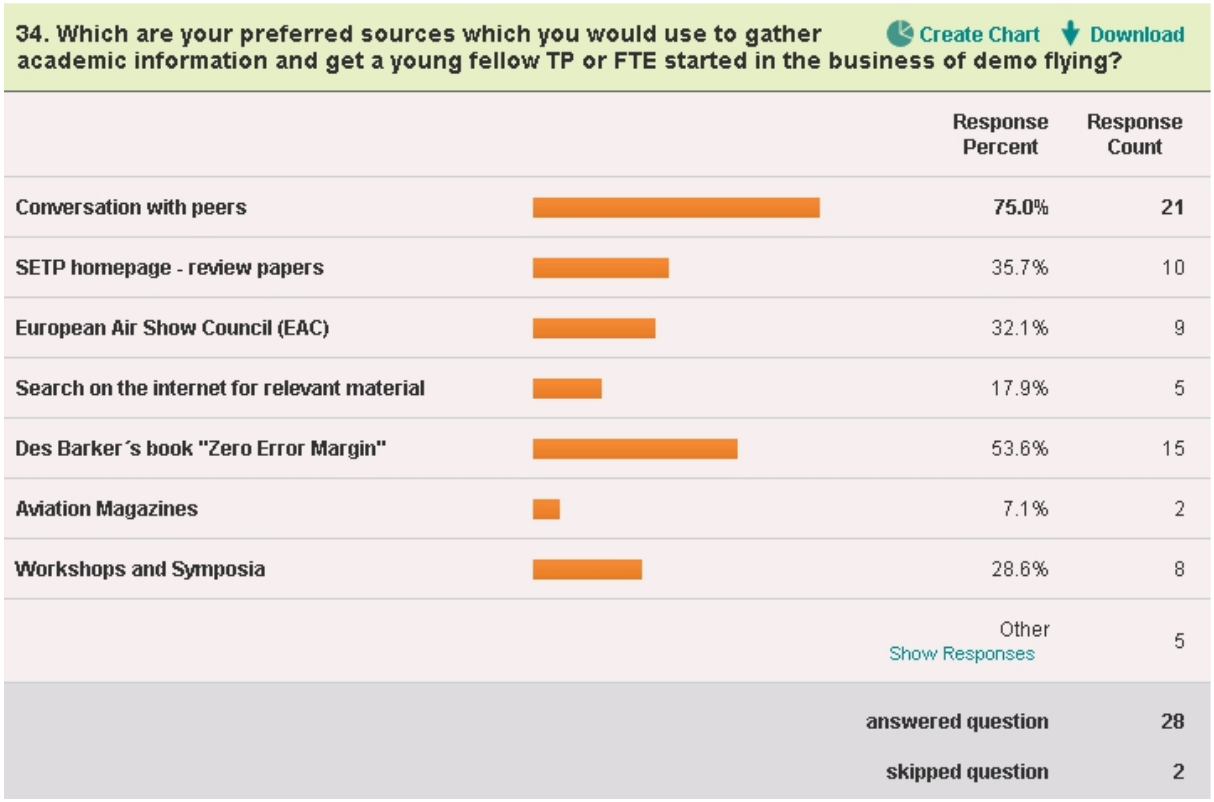
Figure 14: Post-show-feedback - answers from Salzburg EFTSW 2011 (Source: Author)

31. Demonstrating prototype or heavily modified aircraft: amidst all your other flight test activities, how much opportunity did you typically get to prepare for your display (e.g. at Le Bourget, Farnbourough etc.) Create Chart Download

	Response Percent	Response Count
Almost nil	14.3%	4
1 practice run per week	10.7%	3
2-3 practice runs per week	25.0%	7
more than that	7.1%	2
n/a	**42.9%**	**12**
Additional comment: Show Responses		2
answered question		**28**
skipped question		**2**

Figure 15: Opportunities to prepare for display - answers from Salzburg EFTSW 2011 (Source: Author)

Figure 16 is of particular importance – which sources do demonstration pilots consider? The conversation with peers is considered the most valuable. This implies that ideally, in a company you have a team of two pilots and learn from each other. This also implies that the organisation of an event such as this, the EAC Annual Council, should be encouraged and supported.



34. Which are your preferred sources which you would use to gather academic information and get a young fellow TP or FTE started in the business of demo flying?

Create Chart | Download

	Response Percent	Response Count
Conversation with peers	75.0%	21
SETP homepage - review papers	35.7%	10
European Air Show Council (EAC)	32.1%	9
Search on the internet for relevant material	17.9%	5
Des Barker´s book "Zero Error Margin"	53.6%	15
Aviation Magazines	7.1%	2
Workshops and Symposia	28.6%	8
Other Show Responses		5
answered question		28
skipped question		2

Figure 16: Preferred Sources of Information. - answers from Salzburg EFTSW 2011 (Source: Author)

In Table 2 some questions with percentage of YES and NO-answers are given. It stands out that sensitivity studies on individual manoeuvres to determine entry/exit gates are conducted by the vast majority of the pilots (84,6%). In other words, a novice display pilot would be ill-advised if he did not do such studies.

Question	YES	NO
Do you perform sensitivity studies on individual maneuvers to determine entry/exit gates taking into account the specific environmental conditions at the display airfield?	84,6%	15,4%
Do you have an independent evaluation or review of your display program?	78,6%	21,4%
Do you have an independent evaluation of your flying skills?	57,1%	42,9%
Does your company have a fixed set of display regulations covering topics like min. pilot qualification, initial training/currency training, weather limits, min. onboard crew, crew rest)?	57,1%	42,9%
Do you conduct a shakedown flight before starting your display training?	76,9%	23,1%
Do you know your personal and company/aircraft/3rd party insurance?	78,6%	21,4%

Table 2

What are the requirements for the selection of demonstration pilots? Here are some of the answers to this question, given at EFTSW 2011:

- Current on type, high hours,
- Experience, maturity, discipline,
- Experience, attitude, public relations/media interface abilities,
- Experience, capability, willingness, sober mindedness,
- Experienced, safe, level-headed, not apt to suddenly want to impress, good stick pilot on type in the display,
- Maturity, instructor experience, above average flying skills, understanding of customer needs,
- Experience, dedication, safety orientated,
- That the pilot can handle pressure (ignore) parameters that could be destructive to his display programme (such as marketing economic pressure),
- Experience and demonstration of sound judgement, ego under control, knowledgeable about the aircraft, mission and intended customer,
- Mature Integrity, self-confidence,
- Mental strength, maturity to stand up against pressure discipline,
- Flying/display experience, personality,
- Systems knowledge, controlled confidence,
- Experience, discipline, skill (in that order),
- Demonstrated skill and knowledge of the aircraft, leadership, sound decision making, abides by the rules, strong ethical character.

Note that the words "maturity*", "discipline", "ego under control"* or similar are words used quite often.

It was also stated that *"It is good to have a pair to share the flying and support each other"*. Remember, in Figure 16 it was stated that two-thirds of the pilots prefer the conversation with a peer when it comes to learning about display flying.

One participant stated that one should *"Look for a guy whose hands sweat."* Another participant stated that *"I would suggest selection includes appreciation of Human Factors issues and safety management. Certainly display teams that rigorously select with high standards have fewer issues."*

Here are some more interesting results, which I would like to share. These are the answers when asked *"What are the worst things, company management can do to you during preparation and execution of your display flying?"*

- Any type of applying pressure,
- Delay decision for participation and thus time for practise until the last moment,
- Criticising safe manoeuvres which appear hazardous from their "amateur" standpoint,
- Granting the go-ahead for participation in a show too late for optimal preparation,
- Not calculating in the cost of adequate preparation training,
- Late warning of upcoming display allowing insufficeint time to work up.
- Interfere real time,
- Poor briefings, lack of discipline control and timetable slippage,

- Changes in display programme due to financial issues,
- Cut down on practise flights,
- Last minute changes,
- Demands which stretch safety limits,
- Change the timescales,
- Prioritising a culture of 'must arrive and display' over and above risk assessment,
- Preaching safety without actualising it,
- Request deviations from approved limits, routines etc
- Change to timing, display requirements.

2.5 Outcome 5 – Develop a Display Flying Handbook

We are all used to power point presentations and perhaps you have run into the same problem that I did: you listen to a presentation, you like it, you understand it – but when you look at the PP slides three weeks later, you cannot make the connections any more. What seemed to be easy to comprehend, entirely useful and logical in the way it was presented, is now a bunch of pictures with hardly any text left. If you wonder, why I bothered to write a formal paper – this is why. A powerpoint presentation, as useful as it might be in many cases is not a substitute for a full-blown handbook, scientific article, or even your notes that you might take right now.

Therefore, it was decided to conserve knowledge for future generations by developing a handbook. Takskforce #2 developped an outline. Since we are all busy with our daily lives, at this stage, I cannot yet present a book.

Actually, if you remember outcome #XX “Cooperation” – I hope that the two organisations SETP and EAC work together and use their combined wits to develop such a book. I have a strong feeling that some excellent material is already available and circulating. All it takes is some leadership and coordination and bring these efforts together.

Ideally, in today´s electronic media driven world I see the need for

- A pdf-version of a “Display Flying Handbook”,
- An online version, and
- A print version.

Just one or the other means of publication is not enough. The book should go beyond checklist format and actually serve as a useful training material.

A handbook could contain very useful statements from those who survived the business (Figure 17, Figure 18).

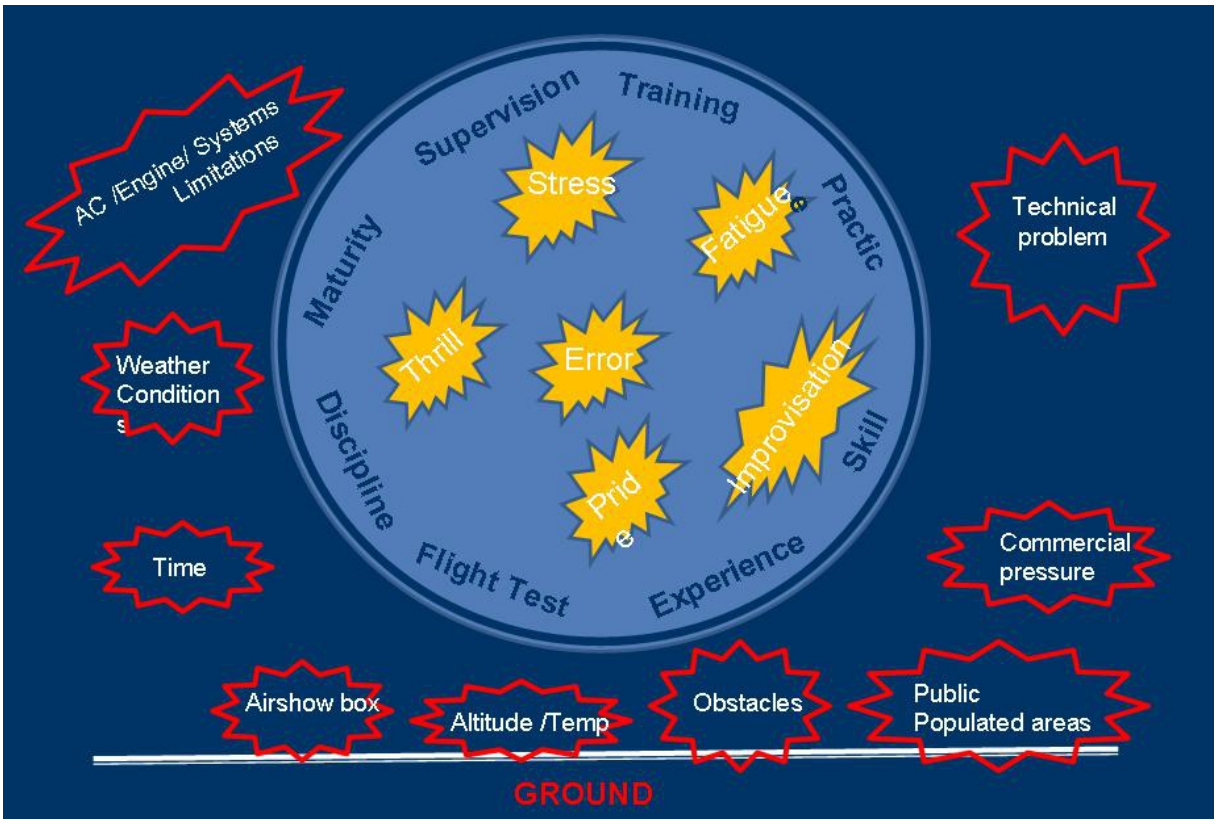


Figure 17: Experton´s Bubble (Source: Patrik Experton)

1. Disrespecting the 'energy gate'. (LOC + FIT)
2. Sloppy attitude control. (FIT)
3. Impromptu, 'gap filling' unpracticed sequences/displays.
4. Loss of visual during formation flying.
5. Ignoring the insidious effects of DENSITY ALTITUDE.
6. Disregarding weather i.e. cloudbase, wind, turbulence effects.
7. Disregarding the structural limitations of the aircraft.
8. Disregarding the placarded flight restrictions of the aircraft.
9. Disregarding waiver height limitations.
10. Disregarding minimum spectator enclosure distance
11. Disregarding positive feedback from a peer´s group
12. Believing that this list is complete

Figure 18: Twelve Deadly Sins (Source: Des Barker)

1. Knowledge of aircraft handling and performance characteristics.
2. Knowledge of own practiced psychomotor skills.
3. Holistic understanding of:
   a. Each manoeuvre.
   b. Energy Management, the 'Energy Gate'.
   c. Positive Attitude Control.
   d. Preplanned 24/7 Exit Manoeuvre.
4. Visual contact.
5. NO 'Impromptu Displays!!!!
6. Never introduce 'Impromptu Manoeuvres' in the sequence.
7. 'Judgement' to know the difference between success and failure

Figure 19: Display Survival Rules (Source: Des Barker)

2.6 Outcome 6 – Develop an Accident/Incident - Database

A friend of mine who is an accomplished test pilot and aerobatic pilot recently answered my new year´s wishes with a statement that he *"had opened a bottle of Champaign just at the end of the old year and is happy to have survived into the new year 2012!"* What had happened? During one of his practice sessions, when pulling out from a manoeuvre, his control stick (yes – the one with which you control pitch attitude and roll angles) broke. Wow – there was probably a great deal of luck, besides skills, involved in making the event survivable.

This brings me to perhaps the most important point of all – sharing information and in particular, sharing information about incidents, not only accidents.

A man by the name "Heinrich" developed what is now called the "Heinrich pyramid" (Figure 15). Heinrich worked for an insurance company and found out that every one major injury is preceded by 29 minor injuries and these minor injuries were preceded by 300 minor events with no injuries. Heinrich talks about "similar accidents" – so perhaps in the above example an accident/incident related to a problem with the control stick. In other words, neither accidents nor incidents should really surprise us. There are usually some warning flags on the path to an accident. Unfortunately, these flags are not always obvious and often entirely unknown to the individual who gets involved in the accident. In the example above, let us assume that some other pilot has had a similar problem with the control stick, except that the control stick did not fully fracture. Assume that because of fatigue it developed a huge crack which was found during a pre-flight inspection. How would my friend have known about such an event? How would his attention be drawn to the problem? Only, and only if, that information is shared.

"The basis of any improvement in accident numbers is sharing of incidents"

Do pilots usually share that information? Yes and no. The answers from the Salzburg-Group are shown in Figure 21. This chart says that slightly more than half of the pilots attending the workshop were not willing to talk about their incidents, at least not in front of their peers during the workshop. These numbers hopefully change if the question was, if they were willing to share information on a de-identified basis.

The problem with data-bases is that there are too many of them which contain too little information. Just search the web and you find numerous individuals who take pride in maintaining a data base. The factual information (When, Where, What) can usually be easily retrieved. When it comes to root causes, one would actually have to dig into the accident report. For incidents, root causes are hardly ever analyzed and therefore not available. Factors leading to the cause are even less obvious. In particular latent hazards which turned into risks are usually not mentioned.

In this respect commercial aviation is more advanced, although not perfect. Across economic interests and boundaries, safety pilots of airlines frequently meet and talk about incidents behind closed doors. At the beginning of these meetings, the participants agree to not disclose any of the information, other than for their own (company) use. That´s all – the rest is mutual thrust. What helps is the fact that the community is small and after several such meetings, people know each other on a personal level (and perhaps are therefore more willing to exchange).

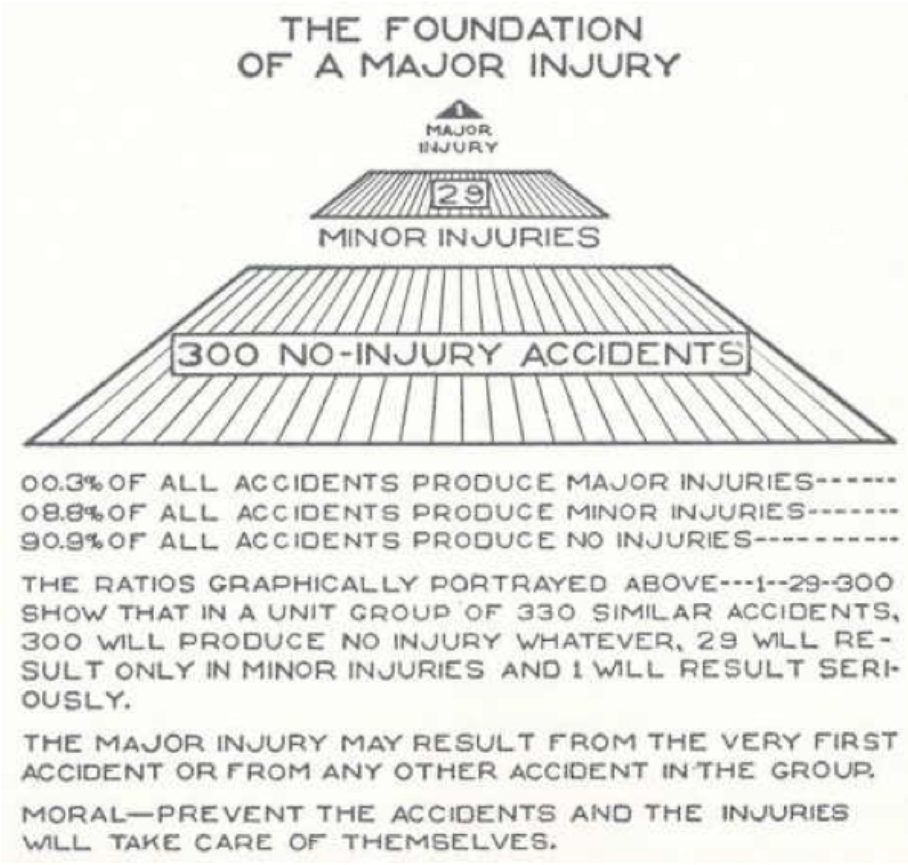


Figure 20: Heinrich-Pyramid (Source: [3])

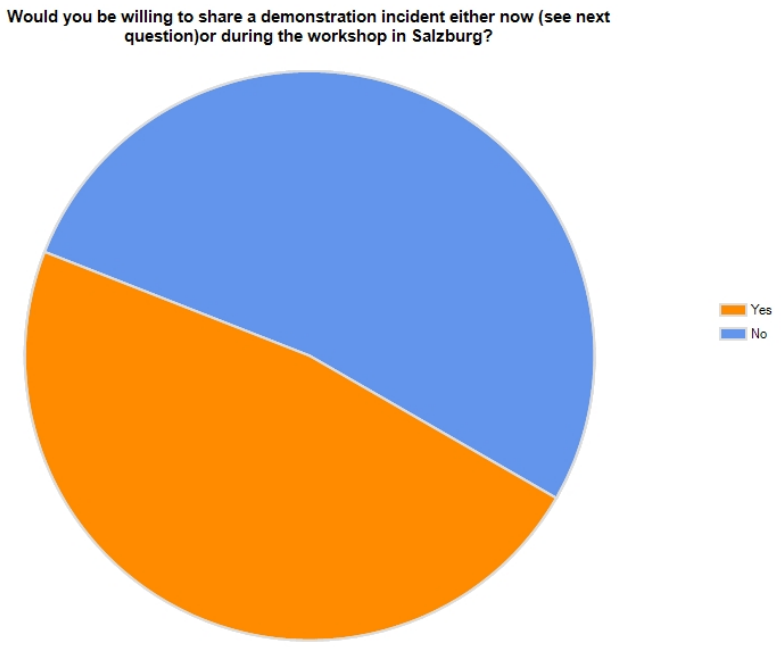


Figure 21: Willing to share information on incidents - answers from Salzburg EFTSW 2011 (Source: Author)

I feel very privileged that I got into the field of analyzing commercial aviation accidents and have spent the last 10 years doing this with a small group of dedicated experts.[1] This is how it works:

- A recognised international organisation, in our case IATA, collects accident data throughout the year and maintains a central data base. The data comes from several sources, insurance companies, accident reports, manufacturers, research from the internet.
- About twenty experts, pilots with a strong safety background, accident investigators from manufacturers, air navigation service providers, a union member, etc. meet twice a year.
- The group meets twice a year – three days in mid-year and four days in second week of January.
- The accidents of the previous years are now analysed, using a specialised taxonomy which we developed for this purpose. I can talk in detail about the taxonomy, but in short: it follows the "Threat and Error Management Model"
- We first classify the accident type, or "end state" as we call it. This is the last unrecoverable event.
- We then look for causal factors, without going too much in detail, but it always follows the same structure: undesired aircraft state, human errors, threats not managed properly, latent conditions.
- We also look in a structured way – and this is very important – into what could have prevented the accident.

[1] I am talking about the IATA Accident Classification Task Force which does the basic work for the annual IATA Safety Report. The task force – back then under a different name – was established in 1955 with the advent of the first jet aircraft in commercial aviation.

The outcomes of the accident classification task force meeting are:

- Accident rates, in our case hull losses and severe damages per 1 Mio departures. The data can be shown by geography, to point out areas which need to be improved (Figure 22)
- Information on specific types of accident. I chose “Loss-of-Control-Inflight” as an example. This is the number one killer these days and has cost more than 2000 lives over the past ten years. This type of accident includes stalled aircraft with pilots unable to recover from a stall (Figure 23).
- Correlations
- Recommendations

Here are my conclusions from these 10 years of accident classification – all you need is three things:

- First, you need one good, centralised data base.
- Second, you need a taxonomy that goes beyond factual information – the trick question is always the “why did the accident happen”, i.e come up with contributing factors.
- Third, you need a small team of experts, not more than twenty, who meet once or twice a year and do an accident classification in a standardized way year after year.

The great thing about this effort is that you produce numbers and numbers are a good tool to steer in the industry in the right direction.

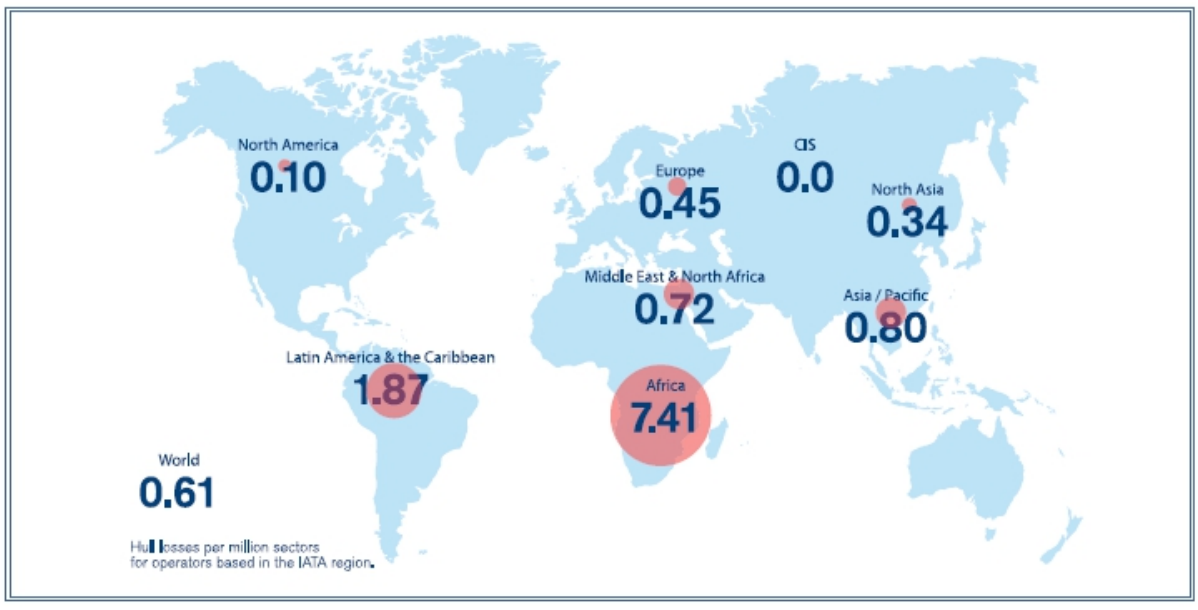


Figure 22: Example accident rate by region 2010 [4]

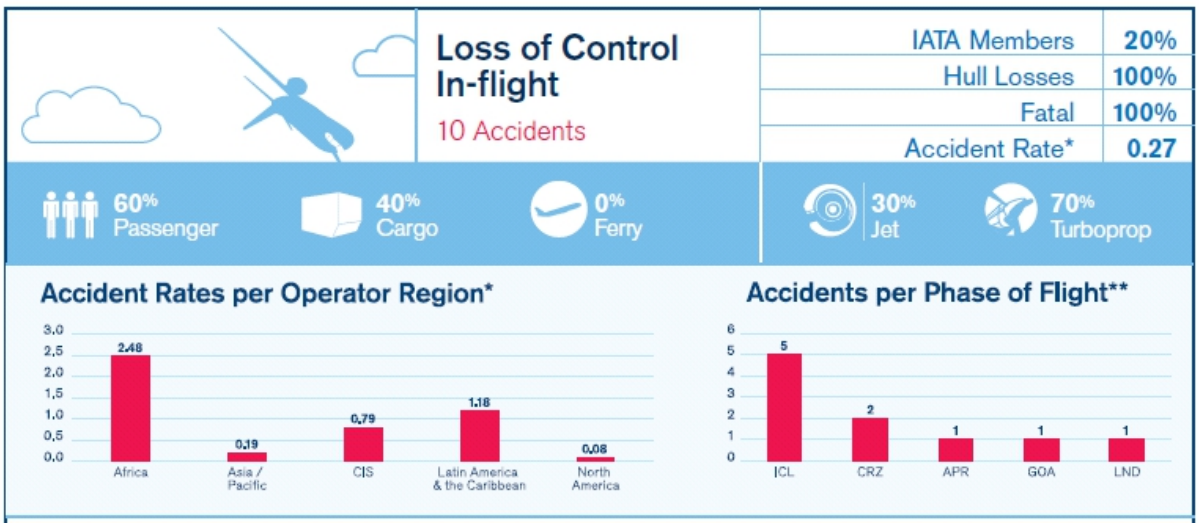


Figure 23: Example Loss-of-Control In-flight Accidents 2010 [4]

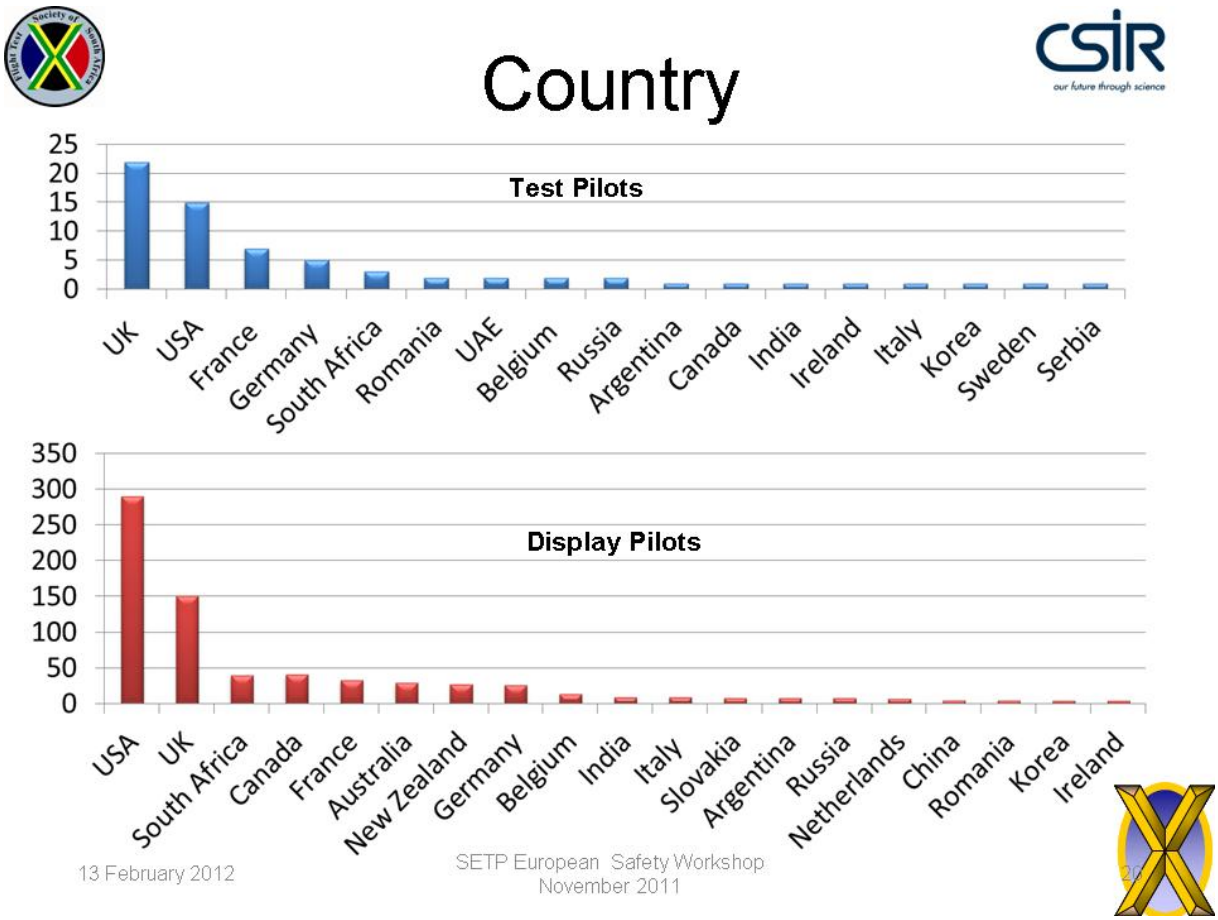


Figure 24: Accidents by Country [Source: Des Barker]

With an incident you can follow the exact same scheme – the only difference between an accident and an incident is the outcome, the severity. All the causal factors leading to an accident, you can find in an incident investigation. The problem here is that pilots tend to forget – the might be briefly in a state of shock, but have to continue fly the airplane and go on.

Here are some important questions:

1. Where should such a database be hosted?

For incidents related to “product demonstration” I think SETP is a great organisation. For Air Show accidents and incidents in Europe, your organisation would be a great option. Nevertheless, the presidents of these organisations should sit together and make the decision for

- A single database with a single taxonomy
- Maintained by one organisation but
- gives access to multiple organisations, including academia and qualified individuals
- There must be a quality control process to ensure that data on “why” is also entered (e.g through a gate keeper that is allowed to de-identifiy and talk to a pilot)

2. Who should be in the group of experts, analyzing accidents

I would recommend that you take pilots with experience in the business, an organiser and perhaps investigators, perhaps from manufacturers which actually do the accident investigation

3. Which taxonomy should be used?

There are several taxonomies, e.g. ADREP 2000, the HFACS classification, IATA Taxonomy. To my knowledge, no dedicated taxonomy for display flying yet exists. I would encourage to develop your own taxonomy, based on the IATA Taxonomy. For those of you who are interested I can go into more detail perhaps after this event.

4. What should be the goal of doing that work?

The goal of accident and incident investigation is

- To come up with statistics which help identify the main areas of concern
- The statistics should be continued over the years and published in a report, preferably on an annual basis
- The expert group should, based on the analysis of the previous year´s accidents, come up with recommendations.

3 Future Research Requirements

Flying is about energy management – Lockheed´s Wayne Roberts pointed out that in a typical display routine, even for a large transport category aircraft, the entire envelope from low energy to high energy and back is transgressed in a matter of seconds.

Des Barker had (and still has) interesting email conversation running, were he asks the question on how to best determine the “energy loss” in certain manoeuvres (e.g. snapped rolls). This is an important question and in my opinion the question should be forwarded to graduates of test pilots schools, flight test pilot instructors and academia. After all, the amount of energy you loose or gain in a display can be the difference between life and death.

4 Summary

The “European Flight Test Safety Workshop 2011” held in Salzburg was a great success. With a small number of experts from different parts of the world, all of them flight test pilots and engineers, some initiatives were launched, which will hopefully be continued and which will have an impact on risk reduction.

The main initiatives are the creation of an accident database, the creation of a “Display Flying Handbook” and the creation of a questionnaire. Above all the test pilot community decided to cooperate with other organisations with the goal to share knowledge.

A somewhat personal satisfaction of having organized EFTSW 2011 lies in the fact that people from across the continents, from competing companies, have actually worked together. It became clear that these people all share the same passion – display flying, but being safe.

The author hopes that the work continues and future workshops will be held to specifically address the challenges related to display flying. The author also hopes that at some stage funding is made available to answer current and future questions.

5 Literature

[1] http://aviation-safety.net

[2] BFU, Accident Investigation Report 3X181-0/06, April 2010

[3] Heinrich: “Industrial Accident Prevention: A Scientific Approach”, 1931

[4] IATA Safety Report, 47th edition, Montreal, 2010

6 Acknowledgement

I wholeheartedly thank all the individuals who contributed to EFTSW 2011 – either as presenters or as audience. It is a privilege to be part of such a dedicated group. I also thank EAC Board for giving me the opportunity to deliver this paper at the EAC convention 2012 in Brussels.