ECAC AIR ACCIDENT AND INCIDENT INVESTIGATION GROUP OF EXPERTS (ACC)

WORKSHOP ON GENERAL AVIATION ACCIDENT INVESTIGATION

VALLETTA (MALTA) — 13 NOVEMBER 2018

SUMMARY PAPER AND BEST PRACTICES

EXECUTIVE SUMMARY

This one-day ECAC ACC Workshop was arranged as part of the series of bi-annual workshops, on different topics, within the ACC Group of Experts. This one, on 'general aviation' (GA) investigation, was well attended by delegates from the ACC SIAs (Safety Investigation Authorities) and a number of the ACC Observers. The content was divided into sessions on: '***What GA accidents do we investigate, why and how do we report them?***' and '***How do we investigate, what are the problems and where do we find help when we need it?***'. There were a number of high quality presentations and the majority of these are attached to this document as Attachments.

The presentations illustrated that all the ACC SIAs present were keen to investigate GA accidents but resource and workload are often limiting factors on the extent and number of investigations that can be undertaken. There was also a wide range in the scope of investigation activity, from light aircraft certified to international standards (CS/FAR 23 (fixed wing) and CS/FAR 27 (rotary wing)) down to the very lightweight and deregulated forms of aviation.

A set of 'Best practice' suggestions concludes the paper, based on the discussions within the Workshop.

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Attachments

Note: Attachments are available on the ACC restricted site on the ECAC Web site:

https://www.ecac-ceac.org/group/accidents/

Introduction

On 13 November 2018, the ACC ('Group of Experts in Accident Investigation) of ECAC held a one-day workshop at the Mediterranean Conference Centre in Valletta, Malta, on 'General Aviation Accident Investigation'. The event ran the day before a regular ACC meeting (ACC 49), all generously hosted by the Malta investigation authority, BAAI.

Programme

A copy of the Provisional Programme developed for the Workshop on 13 November is attached. Time constraints meant that some material was presented at the regular ACC/49 meeting the following day. The format was of 15-20 minute presentations by selected delegates followed by discussion, in plenary and smaller groups.

Topics

The morning session '***What GA accidents do we investigate, why and how do we report them?***' concentrated on the 'process' of safety investigation. This included how different States define the GA task, how they resource and manage the investigations and how they report the results.

The afternoon session '***How do we investigate, what are the problems and where do we find help when we need it?***' focussed on particular topics, such as emerging technologies (including electrical power for primary propulsion), recorded data, flight testing and human performance.

Papers & discussion – morning session

'***What GA accidents do we investigate, why and how do we report them?***'

This session consisted of 5 presentations and discussion in groups and in plenary session.

It opened with a review of '***EASA legal framework for continued airworthiness***'. This proceeded from the Basic Regulation and included, for general aviation (GA), a review of accidents & serious incidents over the period 2007-2017, showing a slight decline for non-commercial operations. EASA analysis highlighted the five most significant GA issues as being' Stall/Spin', 'Handling of Technical Failure', 'Airborne Conflict', 'Loss of Control' and 'Flight Planning and Preparation'. The EASA provisions and processes of continued airworthiness for GA certificated types (FAR and CS.23 & CS.27) were shown as very similar to those of larger commercial aeroplanes and rotorcraft, with similar processes for Airworthiness Directives and Safety Recommendations. However, it was noted in discussion that there are very large numbers of non-commercial GA aircraft in European states that fall below the CS.23/CS.27 categories.

There followed presentations by three Safety Investigation Authorities (SIAs) on how GA investigation strategy is carried out in their respective States. These were the **BEA** (France), **ANSV** (Italy) and **AAIB** (United Kingdom). This provided interesting similarities and contrasts between these SIAs. In general, the approach to accidents to EASA CS.23-level aircraft was similar, guided by the provisions of EU996/2010, with its obligations to investigate, and the adherence by these States to the principles of ICAO Annex 13 and Regulation EU 996/2010, particularly for commercial transport aviation. It was at the lower levels of weight and regulation that there were distinct differences in approach and these States had each adopted a 'flexible and case-by-case' approach for allocating the investigation resource, and final reporting. To a large extent this appears to reflect the different ways in which States categorise and regulate the lightweight types within GA.

Within the **BEA**, for instance, there had been a change of policy in 2015 to go beyond the limited requirements of Regulation EU 996/2010 and now to investigate **all** fatal accidents, including those involving 'Annex II' aircraft (this 'Annex II' categorisation has since changed to 'Annex I of the EASA Basic Regulation 2018/1139'). This reflects the very significant levels of microlight activity in France, that the BEA is able to access accident sites and other evidence and that it is recognised that proper investigation of a fatal accident requires substantial technical means, possessed by BEA. However, this highlights the need to balance workload and resources and the need to concentrate resource on the 'certified aircraft' accident categories which generally cause injury.

In Italy (**ANSV**) the category for recreation and sport flight are 'VDS' (Volo da Diporto o Sportivo), originating in 1985 and modified in 2010. The allocation of resource for investigation by ANSV requires discretion in the selection of occurrences, with a priority on accidents on training flights and where there is a corresponding design with a type certificate (such as the Tecnam) to the non-certificated VDS design. ANSV will generally **not** investigate non-powered VDS (hang-gliders, paragliders), powered hang-gliders & trikes.

The UK (**AAIB**) presentation covered the range of investigation activity below the EU requirements in Regulation EU996/2010. This includes the rapidly developing Drones/UAS area where the principle is to investigate all accidents above 20 kg and those below being used in commercial operations; the AAIB 'decision tree' for determining response is shown in Attachment 5. The principles for gliders and non-commercial balloons are similar; AAIB investigates where there are fatalities or special technical interest, otherwise an investigation is generally done by the relevant sporting body, such as the British Ballooning & Airship Club or the British Gliding Association.

For registered microlights, homebuilt/amateur-built aircraft and single-seat deregulated aircraft the AAIB will investigate all accidents, with flexibility on the extent of the investigation and its reporting. The areas in which there is generally no AAIB investigation are the 'non-registered' forms, such as parachuting where a registered aircraft is not involved, parasailing and paragliding, hang-gliding and powered paragliders (paramotors). A part of the rationale for this approach is that without an established 'regulator' for these activities, there is no effective structure for processing Safety Recommendations and is therefore a poor use of resource..

The Workshop was assisted by a dedicated Cranfield University MSc academic thesis on this topic completed by an **AIBN** (Norway) investigator – '*Strategies for Non-Commercial General Aviation (GA NCO) Accident Investigations*' (Attachment 12). The thesis postulated that major airline accidents are investigated and reported in much the same (ICAO Annex 13) way worldwide and are generally the rationale for the existence of SIAs. However, GA accidents occur more often and make up a sizable portion of SIAs' activities.

The aim of this project was to examine how SIAs prioritize GA NCO investigations, and to explore the background and underlying rationale for ten SIAs:

Transportation Safety Board of Canada – **TSB**, Canada

Accident Investigation Board – **HCLJ**, Denmark

Safety Investigation Authority - **OTKES**, Finland

Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile - **BEA**, France

German Federal Bureau of Aircraft Accident Investigation – **BFU**, Germany

Icelandic Transportation Safety Board - **ITSB**, Iceland

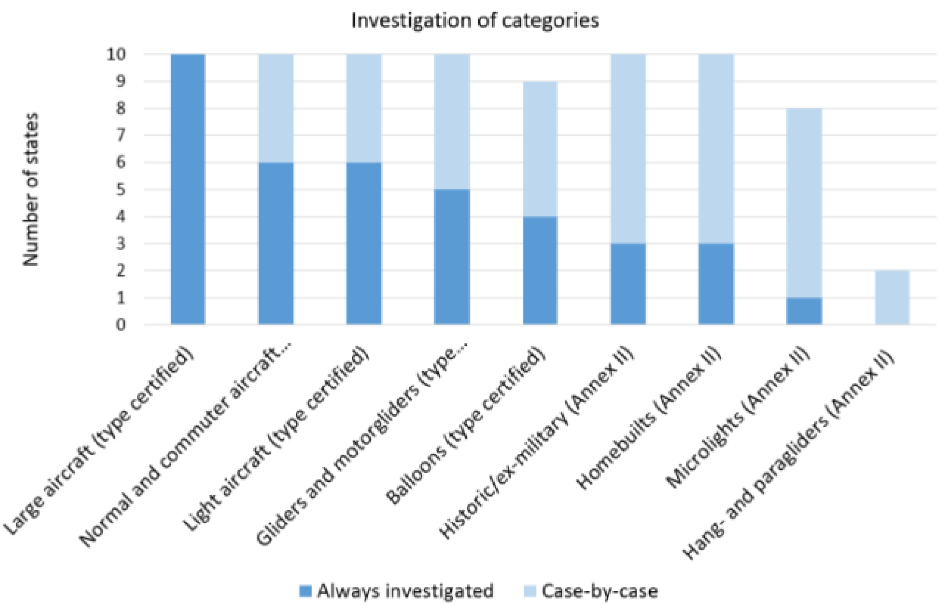
Transport Accident Investigation Commission - **TAIC**, New Zealand

Accident Investigation Board Norway – **SHT**, Norway

Swedish Accident Investigation Authority – **SHK**, Sweden

Air Accidents Investigation Branch - **AAIB**, United Kingdom.

Of particular interest was a figure showing how many states investigate each of the nine different aircraft categories, 'always' (in dark blue) and 'case-by-case' (light blue). These ranged from all 10 SIAs 'always' investigating 'large aircraft (type-certified)' to much more variation in the lighter GA categories, often depending on SIA workload and resource.



The project confirmed that the SIAs have differing processes and reporting and GA NCO priorities. The author considered whether these differences signal 'a need for benchmarking' and a need for better international guidelines. Although considering that better alignment may be beneficial in the long run, the author cautions against a rushed development and implementation of common 'one size fits all' GA NCO strategies, particularly considering individual societal and SIA internal considerations.

Group discussions

Delegates were split into 3 groups. Reporting back, their conclusions on the theme ***What GA accidents do we investigate, why and how do we report them?***' were broadly similar. The following points were made:

> In many cases, even in ECAC States with larger GA industries and activities, accidents and serious incidents tend to be less well reported to the SIAs than AOC events. In general, events involving fatality or serious injury will be adequately reported to the SIAs through Police and ATC process.
>
> For GA accidents involving fatalities or serious injury, ECAC States would generally investigate at some level. This extends to microlights, registered or de-registered, but not in all States. This is < 50% for hang-gliders and paragliders. For parachute accidents, most would investigate if an aircraft were involved, very few if it were only the parachutist after leaving the aircraft.

In some states, other organisations may also investigate accidents; these may include the Police and recreational aviation bodies.

All SIAs find that they need to be flexible in allocating investigation resource to GA investigations, given the importance of prioritising public transport ('AOC') investigations. This includes whether to do an investigation 'in the field' or remotely, by correspondence. It is a common experience within ACC States that their SIAs particularly struggle with resource allocation for GA investigations during the summer months, due to the increased volume of GA activity.

There was one comment that, in general, GA investigations are more necessary, and are undertaken more seriously, in territories with higher population density. There was discussion on the diversity of the approaches taken by SIAs to GA investigations in comparison to AOC investigation. The conclusion of the group was that this diversity is an inevitable outcome of the variation in resource available and trying to standardise, at this stage, would not be productive.

There was a very wide agreement that investigating GA accidents is very valuable in the training and development of investigators within SIAs, for them to be able to tackle larger and more high-profile accident cases in AOC/public transport aviation.

Papers & discussion – afternoon session

'***How do we investigate, what are the problems and where do we find help when we need it?'***

This afternoon session consisted of five presentations and discussion, looking at practical means for investigating GA accidents, including novel technologies, and how this knowledge might be propagated.

'Full composite aerobatic airplane in-flight break-up' from **BEA** looked in detail at the break-up of a single-seat aerobatic aircraft, with a 100% carbon-fiber airframe. This should give an acceptable load of +/- 12g; the BEA calculated the failure occurred at +8g at 200 kts. The pilot escaped by parachute. The onsite phase was challenging with a spread of wreckage (including the right wing) in cropped fields. There were witnesses but they were evenly split on whether the engine mountings failed first or the right wing.

Structural analysis work was split between the DGA/BEA laboratories (propeller and engine mounts – metallic) and a commercial laboratory, CETIM, because of their greater experience of composites and their failures. The detailed wing examination built up a pattern of the failure mechanism and fractography revealed 'porosity' of typically 3-4%, locally to 9%. However, this was generally within manufacturing limits. By contrast, the upper right engine bracket (composite) showed evidence under laboratory examination of fatigue striations, indicating that the engine separated initially, followed by the right wing. A lesson from this investigation was that the laboratory examination was essential to understand what happened and to implement corrective actions.

'Your evidence up in smoke – investigating a Lithium battery fire' from the **AAIB** stemmed from a battery fire in an HPH Glasflugel 304 eS sport glider, with a battery-powered forward sustainer brushless motor. During a normal touchdown the glider's forward FES lithium polymer battery ignited, due to an electrical arcing event. The pilot was unaware that the glider was on fire and the battery continued to burn, generating smoke and fumes which entered the cockpit during the landing roll. The pilot was not injured but the glider's fuselage battery box and surrounding structure were extensively damaged by the fire.

At the time, as there was no injury, the AAIB did not launch an investigation and this was left to the BGA (British Gliding Association). However, it soon became evident this was a significant and complex case, and the AAIB initiated a full investigation, with three safety recommendations relating to the provision of fire warning systems in FES-equipped sailplanes.

The technical examination was complex and involved a range of laboratory work, including CT-scanning, and reconstruction (with spectacular pyrotechnic display). Two similar events were identified – useful in seeing similarities and disparities in precursor and successor events. These showed that with these high-energy batteries, once one cell burns, the others will too, that the battery compartment is unlikely to contain the fire and that there is a large question on the appropriate qualification level for battery assembly.

'Accident investigation – a manufacturer's perspective' was presented by the Chief of Airworthiness for **Diamond Aircraft** and **Austro Engine** and provided insights into the perspective of an active GA airframe and engine manufacturer, with some 500 aeroplanes in service, some 3,000 engines and more than 600 employees in Austria. The presentation showed the natural balance between the obligations and assets of the SIA (legal obligation to investigate for safety, access to on-site and other data, wide aviation expertise) with the manufacturer (data on occurrences, legal and commercial obligations, product safety programme, access to design data and deep expertise in company products). Thus the manufacturer has strong motivation, for the quality system, product improvement, reputation and reducing future cost, to work closely with an investigating SIA.

A 2017 Q4 accident example demonstrated this, where data from an EECU (electronic engine control unit) showed engine RPM loss with oil temperature up. The engine was shipped to the plant in Austria in early 2018 and inspection showed a cracked and holed piston, with heat damage, and this was traced to defective fuel injectors and an eroded control valve. Corrective measures were defined, spare parts organised and an initial Service Bulletin (SB) was issued in October 2018, with an EASA Airworthiness Directive (AD) following.

This clarified into clear 'Do's and Don'ts' for an engine manufacturer:

Do: communicate via Annex 13 procedures,

"Involve us" – ask before disassembly

Record condition and environment before sending engine

Don't: disassemble engine or components without co-ordination

Energise the EECU without connecting to an aircraft

The presentation concluded with a description of the ASTM Committee F44, in which this manufacturer is actively engaged, seeking to reduce the number of engine-related GA accidents. One interesting aspect is how frequently power loss accidents reflect fuel mismanagement issues, including fuel exhaustion, and how this may be alleviated by requiring 'low fuel' alerting systems for all GA aircraft.

'Occurrences involving aircraft during sport parachuting in Italy' reflected a period in which the **ANSV** had investigated a significant number of accidents involving aircraft during sport parachuting in Italy. This included a number of differing scenarios, some involving the aircraft, some involving the interaction between the aircraft and skydivers/parachutists – but there were a number of common features pointing towards underlying significant systemic issues. The presentation also made a point, noted by a number of SIAs involved in the light end of GA activity – that it is very difficult for an SIA to make effective Safety Recommendations in a deregulated environment and where there is not a national parachute or sport aviation association providing best practices.

A number of the common features were that these were generally 'club' (so non-Commercial Operations); that many of the aircraft were OTC dry-leased and foreign registered (mixed single-engine piston and turbine), with a corresponding lack of immediate oversight and with maintenance performed away from the operating base. In the nature of the operations there tended to be a lack of an effective Operating Manual (OM) and Standard Operating Procedures (SOPs) and, frequently, 'sub-optimal' compliance of the carrying aircraft to proper standards.

'Challenges and new investigation methods and techniques in general aviation accidents' was presented by the **Romanian SIAA**, reviewing this SIA's equipment and techniques available got GA investigations and then giving a brief account of a typical GA case. The equipment includes deployable padded travelling cases and toolboxes, with quality inspection and photographic tools, sampling and measuring equipment, such as an infra-red thermometer, and personal protective equipment. In common with other SIAs the SIAA has invested in drone/UAS technology for site survey and capture and has also invested in deployable hand-held lasers and the related software for 3-D analysis.

The GA case presented by the SIAA involved a two-seat motorised ultralight aircraft, a B&F FK9 Mark IV. The aircraft suffered a power loss very shortly after takeoff and struck the ground with an increasing bank angle. Extensive analysis of the powerplant established that the probable cause of the power loss was vapour lock; the probability was exacerbated by the nature of the fuel and by the configuration of the aircraft's fuel system. The SIAA made a total of five Safety Recommendations; two to the engine manufacturer and three to the Romanian Airclub, who act as the Certifying Authority.

Discussion

In the afternoon session, the main point of continued discussion was how ACC States might assist and learn from each other in the investigation of GA accidents. It was agreed that this is in many ways less easy than for the larger forms of public transport/AOC aviation, where international structures and processes are grounded more securely in, for instance, the agreed practices of ICAO Annex 13 and Regulation EU 996/2010.

That said, there was general agreement that there is great scope for increased mutual assistance between SIAs in GA investigation – "we all want to learn". For GA this is less likely to be in the form of shared personnel than in the sharing of technical expertise and experience. This was demonstrated in the BEA and AAIB technical presentations, where the technical expertise may be shared between SIAs. Although GA accidents are logistically smaller than public transport/AOC, for full investigation they often require an equivalent level of specialist laboratory investigation, as shown in the 'structures composite failure' and 'battery fire' examples.

There is also a need to identify similarities and disparities in precursor and successor events; this is generally more difficult in GA because of the lack of general databases that exist for AOC/public transport aviation. However, this can be compensated by good communications between SIAs and good relations with GA manufacturers.

Summary of 'best practices'

The following are simple guidelines drawn from the experience of SIA investigators within the ACC group:

Recognise that for any publicly-funded SIA, the first priority personnel and other investigation resource will always be AOC/public transport accidents and serious incidents. The resource available for GA investigations will always, therefore, be variable and unpredictable.

Recognise the diversity of General Aviation, especially at the lightweight sport and recreational end of the activity aviation, that not all forms of aviation have formal regulation at the NAA level and the value of GA investigation providing safety information feedback to regulatory authorities and sport aviation bodies.

There are significant training and developmental benefits in conducting investigations into GA accidents; allowing investigators to 'learn the trade' and prepare them for more complex and high profile accident cases in AOC/public transport aviation arena. Recognise the added value of GA investigations for the development of competencies within SIAs, helping them to get prepared to handle less frequent commercial transport accidents.

Be willing to seek advice from other SIAs in particular technical areas, such as material failures and fire.

Wherever possible, involve within the investigation safety professionals from airframe and engine manufacturers. They have deep expert knowledge of their product and have legitimate product improvement interests in assisting an SIA investigation.

If an airframe or engine manufacturer is involved, attempt to co-ordinate with them before disassembling critical components.

In accidents involving parachutists, it can be very useful to download the non-volatile memory carried now in many parachutes, especially reserve parachutes. Parameters recorded may include altitudes and time (hence vertical speeds), chute and reserve openings. The recordings are generally proprietary so the kit manufacturer will need to be involved.

Safety Recommendations are always important. In the less-regulated forms of GA Safety Recommendations on design and construction may be better **not** directed to the NAA (National Aviation Authority) but to the most effective body to implement, such as a national sport aviation body.

- END -