A New Approach to Improved Rotorcraft Safety

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1. ABSTRACT

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Data in every corner of the world indicates that “pilot error” (pilot judgment & actions, safety culture/management, etc.) is by far the leading contributor to fatal rotorcraft accidents (EHEST Analysis of 2000-2005 European Helicopter Accidents - 2010). As such, notable safety efforts have aimed at producing better pilots through training and organisational culture. This is a completely rational and sensible approach; perhaps, in addition, there are technologies that can come into play that can effectively reduce pilot error and that could provide greater safety benefit if they were more attainable. Often these candidate technologies are ruled out early in the process because the airworthiness codes are not written in a manner that is conducive to the introduction of new technology.

Cautiousness and conservatism in the initial airworthiness codes is not a new condition but there might be another way. Over the last decade, the global small aeroplane community has been traveling a bold new path to dramatically improve safety, while simultaneously reducing the cost and effort required to certify new products and retrofittable technologies. The differences between the rotorcraft world and the fixed wing world are great but there is a powerful example of how attainable technology can save lives in the aeroplane world. As with rotorcraft, controlled flight into terrain (CFIT) was the second highest cause of fatal accidents over the last decade. This is where the similarity ends however. When looking at the U.S. fatal, fixed wing accident rate for CFIT accidents one sees a dramatic reduction – one which is not linked to any new regulation.

2. BACKGROUND

2.1. CS-23 Reorganisation

Over the last several years the world’s leading aviation regulators, including the European Aviation Safety Agency (EASA), have been working to organise and streamline the design certification requirements for small airplanes (CS-23). This evolution of CS-23 represents a significant change in format and structure but it maintains or improves the current level of safety while reducing the certification burden. The key to achieving these results resides in assuring the certification specifications contain only the true safety objectives while the technological solutions and test procedures are contained in the methods of compliance. Through the work of the global team, led by the U.S. Federal Aviation Administration (FAA) Part 23 Reorganization Aviation Rulemaking Committee (ARC), soon EASA, FAA, National Civil Aviation Agency of Brazil (ANAC), Transport Canada Civil Aviation (TCCA), Civil Aviation Authority China (CAAC) and other global regulators will share a common set of requirements and methods of compliance for small airplanes.

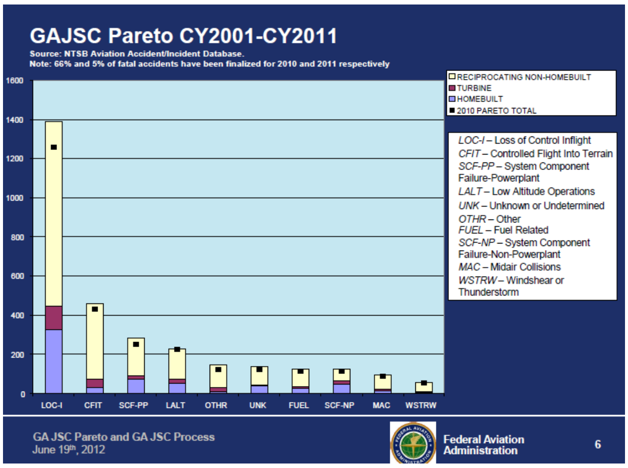
The goal of this effort is to assemble an internationally accepted set of design requirements for the range of airplanes that are regulated by CS-23 with a methods of compliance that are contained in globally harmonised consensus standards. By assuring the design regulations (CS-23, part 23, etc.) contain only the safety requirements, they are more appropriate for the range of aircraft governed by CS-23 and they will withstand the test of time as technology continues to evolve. The future format of CS-23 will result in far fewer special conditions and exemptions and international validation will be vastly improved as the requirements in the major markets around the world are identical.

The global regulators continue to determine which methods of compliance are acceptable by working together and with the global aviation community to develop internationally acceptable consensus standards. As standards are developed in this joint fashion, the regulators then adopt these standards into their regulatory structure as acceptable means of compliance. The process of continually updating and keeping these methods of compliance current occurs through standards organisation meetings and close international coordination of the key regulators.

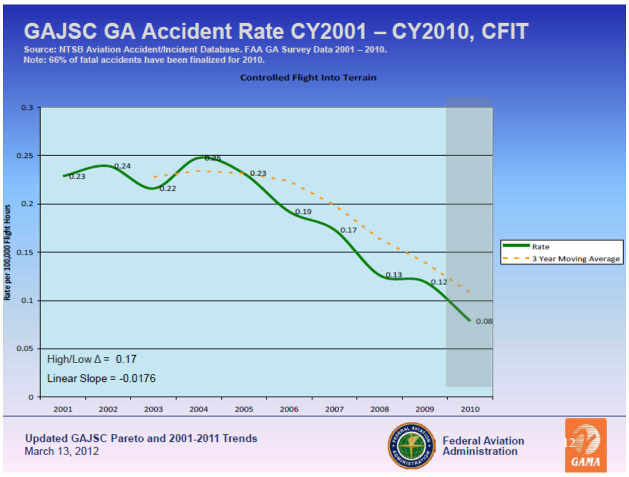
CS-23 currently applies to fixed wing aircraft weighing 8.618 kg (19.000 lb) or less. This weight limit includes a tremendous range of airplanes from simple single piston engine, one occupant, in private use up to 19 seat, multi-engine turbine powered vehicles in commercial service. As a result of this tremendous range in design complexity, aircraft performance and level of risk, today’s detailed requirements in CS-23 over regulate the simplest vehicles and don’t capture all of the needs of the most complex. The system of project specific special conditions and exemptions has served as a stop gap measure in these cases but the time and effort needed to develop these means many designs and changes are never developed.

The goal of this effort has been to assure the requirements of CS-23 clearly articulate the safety requirements for the full range of airplanes while affording the flexibility to incentivise investment in new safety technologies. In the small airplane community, there are numerous examples where the cost and time required for certification has resulted in a lack of new safety technologies. Further, there are examples of carry on, uncertified safety equipment that becomes widely adopted and successful because of the affordability.

One of the key examples of a totally uncertified technology that is saving lives in the small airplane world is moving map technology. According to the U.S. General Aviation Joint Steering Committee (GA-JSC), over ten years, the second most cause of fatal accidents for fixed wing aircraft is controlled flight into terrain (CFIT).



When looking at this rate based data on an annual basis, something remarkable is evident. Over the last six years of the study, fatal accidents as a result of CFIT dropped to a level that almost immeasurable.



According to the FAA Small Airplane Directorate, the significant drop in CFIT accidents in small airplanes is a direct result of moving map technology becoming cost effective. Key to this improvement is uncertified, handheld GPS moving map technology. As a result of an affordable price and utility of handheld GPS, a large number of pilots made the personal decision to purchase and use this technology and it saved lives in significant numbers.

While a dramatic reduction in CFIT is a phenomenal result, by far the leading cause of fatal accidents in fixed wing flying comes from loss of control (LOC). Through deeper study of LOC accidents, it becomes evident that the majority of these occur as the result of a stall/spin during day, VFR conditions while manoeuvring around the traffic pattern.

A primary focus during initial pilot training is the recognition and avoidance of the stall/spin accident but despite this, loss of control remains the key fatal cause. Traditionally airplanes have been designed to recover from a spin but around the traffic pattern there isn't sufficient height for the recovery. Today technology exists to prevent or mitigate these accidents but under the existing regulations, they cannot be developed in an affordable fashion to allow wide adoption. The newly organised CS-23 will provide incentives that will make new loss of control preventing technologies far more easy to bring to market.

The new CS-23 will not only address loss of control accidents by incentivising new technologies, it will take the same approach in all safety areas. There is bold new work to come up with simple and cost effective crashworthiness improvements, more flexible and clearer pilot interface methods, electric propulsion and the list will continue to grow and evolve with time. Instead of spending time promulgating rule changes, the industry and regulators will spend their time developing new and clever methods to comply with the broader safety requirements. Instead of paperwork, the aviation community will obtain results.

2.2. Restructure CS-27 & 29

In the February of 2013, the FAA posted a question to the U.S. Federal Register (Docket FAA-2013-0259) to determine if the rotorcraft community thought the current regulations governing the design of small and large rotorcraft (part 27 & 29/CS-27 & 29) were appropriate for the future. Recently, the FAA indicated that there was international support for a review of both part 27 & 29. Further the FAA indicated that to succeed a review must include key international regulators, such as EASA, and the global rotorcraft community.

As the opportunity for the review of the regulations governing the design of rotorcraft becomes evident. EASA & FAA are actively discussing the need for the development of a study to guide the future structure of CS-27 & 29. It will be important to assure that the global rotorcraft community works together so that future developments will be suitable for all stakeholders. The construct of such a study must obviously consider the certification environment but also the key operational and maintenance issues.

3. A FUTURE CS-27 & 29

Would the international rotorcraft community determine that adopting a model similar to that of CS-23 is appropriate, many differences that exist would have to be considered. The most significant difference between small airplanes and the rotorcraft environment involves the level of price sensitivity.

While there is certainly strong price sensitivity at the entry levels of rotorcraft, many of these vehicles are used for revenue generation in more complex organisations and as a result different issues are at play. A thorough review of the unique rotorcraft environment from certification, production, operation and maintenance must be conducted as part of any study.

The global regulators have traditionally used surrogate measures for risk, performance and complexity. Items such as passenger load, maximum weight and engine type may no longer hold true as measures of these characteristics. Looking forward, future aircraft will continue to contain more complex systems at lower and lower weights and electric propulsion is just around the corner. A review of the regulations would allow for a thorough review of these facets and direct measures of the critical characteristics could be established.

International harmonisation of any changes would remain a critical facet. Differences in safety performance, operational needs and market characteristics should be well understood on a global basis. To assure these issues are well understood, ahead of any rulemaking program, the international rotorcraft community should assure that a properly organised certification process study (CPS) is created to capture the key issues, considerations and potential solutions.

4. SAFETY STUDY

Statistically relevant safety data is critical to assuring that any changes to the future rotorcraft environment are developed in the most effective direction. The International Helicopter Safety Team (IHST) has done a good job of capturing the available safety data and by drawing conclusions based on that data. It will be incumbent upon EASA in the coming years to improve the operational and safety data for the European rotorcraft community.

Once there is established a common set of European rotorcraft safety data, including accident information and operational exposure, the work of determining where technological interventions can be beneficial. The European Helicopter Safety Team (EHeST) has become a repository for European rotorcraft safety data and analysis and the work of this group will be key to assuring any international solutions to rotorcraft certification are applicable to the European community.

The current findings of the IHST and the EHEST indicate that, similarly to the fixed wing world, loss of control, controlled flight into terrain are the leading causes of fatal accidents. The loss of control accidents in rotorcraft are related to power mis-management rather than speed management in the fixed wing environment. The differences include higher lethality related to systems failures and higher incidence of mid-air collisions. It will be important, to delve deeper into the full set of European safety data to fully understand the causes of fatal accidents.

5. KEY TECHNOLOGIES

The EHEST Specialist Team on Technology recently presented the results of their study that compared over three hundred potential safety technologies to a set of accident scenarios (*European Helicopter Safety Team (EHEST): Technological Solutions Alleviating Helicopter Safety Concerns)*). This study provides a tremendous opportunity for deeper review of how these technologies could be brought to market in a faster and more reasonable fashion. Examples of these technologies from the study include:

- All-electric rotorcraft (e.g. avoiding hydraulic systems)
- Integrated three-function valve, simplifying hydraulic system lay-out
- Ultrasonic ice protection system
- Engine backup system to aid auto-rotational flight
- Improved Flight Management Systems, Attitude-Heading Reference Systems and Air
- Data Systems
- Self-monitoring smart electro-mechanical actuators
- Traffic collision awareness equipment
- Ground collision avoidance system
- Automatic Dependent Surveillance Broadcast
- Flight envelope protection system
- Analysis of flight characteristics and prevention of PIO (Pilot Involved Oscillations)
- Energy absorbing materials in construction and seats
- Self-healing, crashworthy fuel tanks

- Seat attenuator and slide system
- Airbags and harness restraint systems
- Light helicopter HOMP systems
- Full Authority Digital Engine Control with vibration and condition monitoring
- Flight data acquisition and monitoring system (can also be used for training and fleet management)
- Cockpit information recorder (audio, video and GPS)
- Miniature or deployable voice and flight data recorder
- Flight data evaluation and processing tool for accident and incident investigation
- Various new-technology types of blade lag dampers, such as fluid-elastic inertial or magneto-rheological fluid–elastomeric dampers
- Active vibration, noise or load reduction through piezo-electric actuators that correct unwanted blade behaviour by making small tab deflections
- Helicopter sling load stabilisation using a flight director to guide the pilot, thereby
- reducing the load instability
- New rotor concepts with increased blade number to ease vibration and noise reduction
- Use of RFID (Radio Frequency Identification) tags on helicopter parts
- Helicopter usage spectrum development (monitoring individual helicopter usage)
- Health and Usage Monitoring System (HUMS)
- Rotor blade corrosion coating
- New diagnostic techniques
- Digital ground navigation database for predictive ground collision avoidance; this may be coupled to an intelligent flight path guidance system
- Ways of combining information from various visual sources (sensors)
- Novel display techniques to minimise the risk of spatial disorientation
- Advanced symbology injection in night vision systems
- Combining real-time imagery (video) with 3D vision
- Weather uplink and flight safety program, linking and unifying all sorts of weather
- observation and prediction techniques
- Various types of obstacle detection and terrain avoidance systems (using laser, radar, laser radar or millimetre-wave imaging)
- Adaptive helicopter seat mount concept for aircrew vibration mitigation applications
- Hydraulic lag dampers that reduce vibration levels
- Composite helicopter blades, also to reduce vibration levels
- Advanced alerting system - capabilities for part time display of vehicle parameters (includes a sophisticated monitoring of aircraft parameters)
- 3D audio for enhanced cockpit communication to reduce workload
- New fire detection system for engine and main gear box compartment using UV-IR optical flame detector
- Autorotation training display on a flight training device, showing optimized autorotation trajectory for the actual flight condition

It became evident from this comparison that many of the potential safety technologies are infeasible as a result of cost while they could provide great safety benefit. This study could act as a key guiding document to the early analysis of potential safety benefits that could be enabled by changes to the certification environment for rotorcraft.

6. EASA RESOURCES

There are a number of pressures on EASA resources that will continue into the future. Agencies of the EU are currently subject to staff reductions and these conditions are likely to persist into the future. To assure the European rotorcraft community can continue to grow, it is important that the available certification and rulemaking resources can be used in the areas of greatest need.

Through the elimination of many special conditions and exemptions, which are only applicable to a single project, in favour of globally accepted standards, the work of EASA staff can be reduced. Further, European validation projects would require fewer EASA resources if global certification standards were more harmonised and methods of compliance identical. Finally, be allowing EASA standardisation resources to work with other global authorities and the international community as globally acceptable consensus standards are developed, there would be an expectation of better results with fewer resources.

7. SUMMARY

Taking advantage of the opportunity for an organised and on purpose review of CS-27 & 29 could be valuable provided the exercise is conducted in a global fashion. As so much of the world's rotorcraft fleet is designed and certified in Europe, it only makes sense that the European rotorcraft community play a significant role in deciding on any potential changes.