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POINT OF VIEW OF A HELICOPTER MANUFACTURER ON AIRWORTHINESS REGULATIONS

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NEED FOR AIRWORTHINESS REGULATIONS

In spite of the constraint airworthiness regulations impose on manufacturers, their existence obviously cannot be questioned. In fact, it is only proper that governments should protect helicopter passengers and people on the ground through issuing minimum safety requirements.

Therefore, both governments and manufacturers agree on the need for airworthiness regulations whose main purpose, as J.Claude Wanner a brilliant French Official Services engineer puts it, is to «guarantee an overall safety level deemed adequate.»

DIFFERENCE IN OPINION BETWEEN MANUFACTURERS AND OFFICIAL SERVICES

The opinion of manufacturers may substantially differ from that of certification authorities when it comes to interpreting such vague texts.

Obviously the main concern of the manufacturer is safety both for reasons of moral responsibility and of good reputation of his products.

Another major concern to him is that of the competitiveness of his helicopters vis-a-vis competitors and vis-a-vis any other means capable of taking the place of the helicopter for a given job.

The main objective of certification authorities is the cancellation of any risk of accident.

They cannot ignore the competition aspect as their objective is not to hinder manufacturers unduly in their work, but of course this is not as much a concern to them as it is to manufacturers.

Another reason for their difference in opinion is that the expertise of manufacturers on any new aircraft type or any technological innovation is way ahead of that of Official Services.

How can these differing opinions be reconciled ? Well, it takes both consultation when drafting and amending regulations and an attempt to write more precise texts.

NEED FOR CONCERTED ACTION

Regulations are drafted by Civil Aviation Authorities after having, normally, consulted the manufacturers and operators. Depending on the country and the personality of the people in charge, this consultation is more or less effective.

Historically speaking, the first Airworthiness Regulation for helicopters in the world is the American regulation.

Joe Mashman, a test pilot at Bell's, who was in charge of conducting the certification program for the BELL 47 in 1946 told me just how it happened. And I quote :

«The interesting thing was that the FAA didn't have any helicopter certification regulations, so they tried to use the airplane certification rules, but of course the helicopter was not as stable as an airplane and could not meet the airplane stability requirements, but the FAA test pilot was satisfied that it could be flown, even though it was unstable.

. . . The FAA was very cooperative and whenever we could not meet a fixed wing standard, they just changed the standard, and made a helicopter standard, because they knew the helicopter at least could fly, and they were encouraging the development and the production of helicopters.»

Therefore the fixed wing aircraft regulation was adopted and modified as little as possible for its adaptation to the helicopter, on the basis of the remarks made by manufacturers who knew well the particularities of their aircraft. This was a case of true consultation.

Conversely I can affirm that the French manufacturer had not been consulted when the French Civil Aviation Authorities wrote the text below in a 1958 issue of the Règles de l'Air.

«Helicopter flights must follow VFR rules».The French manufacturer knew perfectly that advances in aerodynamics and electronics would affect stability characteristics in such a manner that they would no longer constitute an obstacle to instrument flying.

Nowadays, regulations are modified only after full and systematic consultation with manufacturers. As an example the FAA issued an Airworthiness Review in 1979 based on an extensive consultation. However, consultation considerably slows down the modification process. Furthermore the reduction in operating funds decided upon by the Reagan administration defers to an undefined date the introduction into the regulations of the modifications envisaged.

HOW CAN MORE PRECISE TEXTS BE DRAFTED

If one wants to try to clarify what an adequate safety level means, one is bound to speak of probabilities Absolute air safety does not exist or rather it can only exist if no aircraft is permitted to fly. Therefore one must accept a certain risk of accident and speak of the probability of such a risk whereas, curiously enough, Official Services had always until recently refused to introduce the concept of probability into certification regulations, as if they thought that these could guarantee absolute safety.

It is therefore necessary to try and define the maximum permissible value of probability P of a lethal accident. I will quote again Jean-Claude Wanner's words on transportation aircraft : «The order of magnitude of probability P must be identical with that of competitive transportations means. Anyway, the accident probability of previous generation aircraft gives a maximum value that must not be exceeded»

This concept makes it possible to define precisely the « overall safety level deemed adequate» as it rests on statistics of recent years.

They show that, as regards helicopters, serious accidents due to a mechanical failure of the aircraft, other than an engine failure, have a probability ranging between 1.10^{-5} and 1.10^{-6} per flying hour.

It seems logical to set the probability permissible for a serious accident (an accident that in all likelihood will only lead to material damage) at 1.10^{-6}. The value of P, maximum probability per flying hour, for a lethal accident to happen following a mechanical failure can be set at 10^{-7}. This figure means that one must wait 3 years to have a 50-50 chance of having a lethal accident due to a mechanical failure (total flying time per year for all types of helicopters in the world is 3 million hours).

When the failure probability increases, the acceptable consequence must be less and less serious as suggested by the following table :

Probability	Acceptable consequence
$\leqslant 1.10^{-7}$	lethal accident
1.10^{-6}	good survival probability
1.10^{-5}	*good probability for minor damage* upon landing
1.10^{-4}	flight can be continued

I am fully aware that it is shocking to write : «Acceptable consequence : lethal accident» but one must keep in mind that a probability below 1.10^{-7} is very nearly impossible.

It must be noted that the last line implies that one should prohibit single-engine aircraft from flying as their statistics show over 1 in-flight engine failure per 10,000 flying hours.

I will now illustrate these views on probability with three examples.

1) Engine failures on single-engine aircraft

Turbines of Artouste and Astazou series which have logged millions of flying hours, show a statistical engine failure probability of 1.10^{-5} per flying hour (one failure every 100,000 hrs). Obviously, not all turbines have the same reliability level but this shows that it can be achieved.

Under the regulation, a manufacturer must demonstrate that, in case of an engine failure at take-off, autorotation landing is possible whatever the flight path point where the failure occurs.

Now there is a critical phase with an approximate duration of 10 seconds, when the aircraft is still flying at low speed and height.

With an average of 3 take-offs per hour the engine failure probability during this critical phase is :

$$\frac{1}{100{,}000} \times \frac{3 \times 10}{3{,}600} \# 1.10^{-7} \text{ per flying hour.}$$

For a significantly less reliable turbine (failure probability per flying hour : 10^{-4}) the figure becomes 1.10^{-6}. One should therefore admit that it leads to the wreckage of the aircraft and the crew would generally escape unharmed from a missed autorotation on a flat and clear ground.

Now Official Services demand a demonstration of failure under full load at the most critical moment, which has led to the wreckage of a certain number of prototypes. We have been requesting for a long time already the cancellation of this demonstration and it seems that the new US administration is willing to make this requirement less stringent.

2) Engine failure on multi-engine aircraft

One of the important requests that manufacturers (and users) would like to have implemented deals with the super emergency rpm of the type of turbines used on multi-engine aircraft.

One of the characteristics of a helicopter is that the maximum power used for taking off is needed only during about 10 seconds, until the machine reaches the safety speed. Therefore in case of failure occurring immediately after take off, the pilot will only need the emergency power for a few seconds.

Presently, in case of a category A take-off *from a helipad*, one must impose an often drastic limit on the take-off weight in order to cover the occurrence of a failure.

Now one characteristic of turboshaft engines is that they are capable of delivering, during a brief moment, a power substantially higher than the take-off power at the cost of turbine blade overheating. We would like to have the possibility to use this power for the very unlikely case of a failure at take-off during the critical phase (see calculation above). Obviously resorting to this power would entail the overhaul of the engine after the flight.

Whatever the probability level of this failure, Official Authorities require that the feasability of a recovery be demonstrated after a 3-second wait before touching the controls

although such a failure leads to a change in load factor that the pilot feels throughout his body and according to which he instinctively reacts in the right direction.

About 15 years ago we found ourselves in an absurd situation where we had an Alouette III fitted with an autostabilizer which, undoubtedly, improved the overall safety by reducing the pilot's workload, but whose use was prohibited by French Official Services since it did not entirely meet recovery time criteria. French Official Services were of the opinion that this equipment created an additional risk while neglecting the improvement in safety obtained otherwise.

It should be possible to find a solution to the problems that this super-emergency power brings along (especially the fact that the pilot cannot test it).

3) Another example : « hard-over failure» on a stabilizer or an automatic pilot.

On high-performance aircraft, only through the use of duplex systems is it possible to meet the hard-over requirement. This complication is accepted for aircraft intended to fly in IFR configuration as it leads to a duplication of the stabilization system. However, this complication is useless for aircraft that only fly VFR.

NEED FOR INTERNATIONAL REGULATIONS

We ask for regulations in closer touch with reality thanks to the introduction of the probability concept with a view to avoiding complications that are burdensome when they are not useful.

But we also ask that Civil Aviation Authorities of various countries agree on an international set of regulations and that reciprocity agreements make possible the automatic validation of an airworthiness certificate from one country to another. Presently we are forced to go through the certification procedures several times and to have several manuals in order to take account of the difference in regulations from one country to another.

This is a costly procedure and finally the operator ends up paying the bill.

SURVEY OF PRESENT EFFORTS

In the field of transportation aircraft, AECMA has been making a big effort for the past 10 years, as they have tried to make all European countries adopt a common set of regulations, the JAR 25, based on the FAR 25.

However, national peculiarities are such that it was necessary to allow each country to add special clauses to the JAR 25 which, consequently, only represents the joint basis for the various national regulations in Europe.

In addition national Civil Aviation Authorities have warned AECMA that the existence of joint regulations does not relieve manufacturers of the need to demonstrate successively to each national authority that they comply with the regulations : «we cannot possibly recognize the validity of an airworthiness certificate issued by a small country with no aeronautical experience».

This may be justified in this extreme case. Yet we think that many countries do have sufficiently experienced Civil Aviation Authorities and should therefore trust one another and automatically validate an airworthiness certificate obtained in one of them.

As regards helicopter airworthiness regulations, requests for modification to FAR 27 and 29 were sent to the FAA by AECMA for their incorporation in the Airworthiness Review. If they are accepted (will this ever happen ?) the FAR 27 and 29 modified in this way could become the international airworthiness regulation.

CONCLUSION

To summarize this exposé, I would like to say that :

- airworthiness regulations must be drafted and modified through a process of constant consultation between Civil Aviation Authorities and manufacturers.
- it is necessary to introduce the concept of probability to be able to come closer to the actual risks and to avoid penalizing aircraft with useless systems and demonstration requirements,
- these regulations should tend toward one single international set of regulations and one single demonstration of compliance with the regulations should be sufficient.

In this manner it will be possible to reconcile a continuously improved safety level and a progressive reduction in helicopter costs.