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# 7. HELICOPTER SIMULATOR QUALIFICATION

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I think the one thing that all of us have in common here today, and I believe I am quite safe in saying this, is that we are all supporters of the view that simulators are an acceptable, if not essential, method of training and checking aircrew, and that includes helicopter aircrew as well. After all, I believe that is the reason we are here this week, to discuss how the use of simulation may be defined in respect to the training events for which it is deemed appropriate, the level of the technology to be used, and the criteria that will enable us to get the simulator approved. From these bases will fall out the design of the simulator, and this will in turn be constrained by the technology available, which in turn will perhaps lead us to modify the use and the criteria baselines.

So as you will see, to some extent we are going to go around in circles. I think this is to be expected at this phase of our deliberations, but I believe there are some things we all should understand from the outset which will help reduce the number of circles we are going to describe this week. I base my comments on my experience in a similar type of exercise for fixed-wing aircraft in which I participated both on the international and national levels and also as a result of the knowledge I have of the difficulties faced by the simulator manufacturers in building and designing a simulator for any aircraft.

We are fortunate in having a pattern in the fixed-wing training and evaluation criteria from which we may start. AC 120-40B is a well-debated and currently used document known to most of us. However, as most of you who have reviewed the draft AC 120-XX prepared for this study can attest, slavish adherence to 40B will not produce a good helicopter document. And I am not leveling any criticism at the FAA in this area.

For example, in attempting to get a direct read-across, but also by taking note of the unique situation of rotary-wing aircraft, the objective tests defined in this draft circular total over 800. And that is quite an impractical number for any operator to attempt to run, either on an ongoing basis or at the time of initial or recurrent inspection.

I suggest, therefore, that we must begin by using the format of 40B, perhaps, but then, by analyzing the important aspects of helicopter training and competency checking, define the set of objective tests to ensure that the device is capable of meeting these training requirements. To the objective test must be added, as in 40B and its predecessors, both functional and subjective tests to ensure the necessary realism. We found in the international forum that we had to modify our baseline document to take into account specific training requirements of other national operators. A good example I think was the Australians, who have a requirement that their pilots demonstrate they can do a rejected takeoff of maximal outweight. They naturally said if we are going to check somebody on a simulator doing this, we have to ensure that the simulator correctly represents a rejected takeoff of maximal outweight. I think that gives us a pattern of what we should be doing here later in the week.

If we agree on this, then we must take a closer look at these objective, functional, and subjectives tests. Each test will consist of a description of the test, a statement of the acceptable tolerance between the flown data and the simulator's response, that is, the validation, the flight condition or conditions under which the test is to be conducted, and finally, perhaps, some indication as to the method of proving that compliance. For instance, is a time-history necessary or will a snapshot do? You may think that this is a simple enough matter, but those of us who have been involved in the fixed-wing regulatory criteria discussions know only too well that the method of actually carrying out the test is as important as all the other aspects of that test. Again, to give an example, insistence on totally integrated or end-to-end tests where the control input is applied without tolerance, and the output, that is, the result of the input on the aircraft, is measured to be accurate within a given tolerance, is rarely practical within currently available technology.

The greatest problem is the manner in which the aircraft data are collected or presented. To again use an example from the fixed-wing area, if the data are obtained by plotting, say, the force or displacement of the control column and its effect on the surface, and if then a second plot is obtained by taking a displacement of the control surface and plotting its effect on the aircraft path, it will be quite impossible to match the simulator's results by putting an input to the simulator control column and measuring the effect upon the simulator's flight path, unless the tolerances are generous. That is, it's quite impossible if you are going to apply the same sort of tolerances as those that are now specified. To be fair, this is not the manner in which rotary-wing checkout data have been presented in the past, but the accumulation of tolerances on the aircraft owing to differences in manufacture, maintenance, age, ambient conditions, and indeed even the data-measuring equipment, would ensure that the end result is very much less accurate than that usually permitted by the defined tolerances of the simulator. What is essential is a practical realization of the problems involved and the manner in which the data have been provided. In the fixed-wing world where aircraft manufacturers have been collecting this type of data for many years now, it has been generally accepted that without spending huge sums of money, the currently available data-gathering equipment and instrumentation are capable of an accuracy that is satisfactory for aircraft certification purposes and even for its intelligent use in performing checking. However, it is often not accurate enough to validate total end-to-end system operation in a simulator.

To many of us in the study group, the use of the term "application of good engineering judgment" is an essential part of understanding how a simulator may be said to meet the approval criteria.

For the last few minutes I have addressed a particular issue which in part concerns data and how they are used. I believe a much more fundamental problem in the simulation of a helicopter is the amount and the type of the design and checkout data which are available. For many years now the operators of simulators, the bodies representing them, and the manufacturers of simulators for fixed-wing aircraft have been trying to define a minimum standard for the data that are to be supplied for these purposes. The third edition of the IATA Data Document was published in 1990. It is the result of several years of effort by people very experienced in the manufacture, testing, and use of fixed-wing simulators. And it enabled some progress to be made in defining acceptable criteria for the fixed-wing simulator. Few, if any, rotary-wing aircraft manufacturers come anywhere close to meeting similar standards which may have been defined, but I do note with pleasure that the data analysis document provided by Augusta for the A-109 simulator indicates that they may be an exception to this criticism. Cost is only one of the reasons given for the failings of the aircraft manufacturers. Because helicopter simulator approvals have not been such a prominent item as the fixed-wing ones until now, it is easy to understand why the scope and accuracy of helicopter data packages have been inferior to even the mediocre fixed-wing packages. What must be accepted is that any move toward defining higher criteria for evaluation, testing, and improvement in the training obtained from helicopter simulators will require an order of magnitude of improvement in the data being supplied.

It has been said that the average helicopter data package is the equivalent now of what the fixed-wing data package was 15 years ago; some would even say 20 years ago. A continuation of this approach is not commensurate with the building and evaluation by a regulatory authority of a helicopter simulator equivalent to even Phase 2, Level C standards. The success of the FAA's Advanced Simulation Plan for fixed-wing aircraft is well-known, but I hazard a guess that it would not have been so effective in reaching its goal of zero flight-time training were it not for the work put in by the IATA Flight Simulation Committee in defining the required level of data.

Unfortunately, IATA has not, to my knowledge, convened a committee to set up similar data standards for rotary-wing aircraft, although the "Aircraft Data and Support Requirements Document for Aircrew Training Devices," produced in 1988 by the Naval Training Systems Center, does address some of the issues, including those of the data requirement for rotor-map and blade-element models. This general deficiency must, in my view, be rectified as part of the exercise on which we are about to embark.

I would now like to give some examples of the areas that I believe are insufficiently addressed in current data packages. First, helicopter data packages frequently do not include any models at all and, hence, no proof-of-match document. It is left to the simulator manufacturer to design these. This is not the most efficient way of solving this problem and may lead to greater variations in the simulation of one manufacturer's product and another's than is now the case for fixed-wing aircraft.

Second, the inherent instability of the helicopter is known to all those who attempt to fly it. Most modern types have stability augmentation systems which are used full time. The data covering operations without the systems in use are sparse, yet this is an area of prime importance to training.

Third, vibration is likewise a fact of life in helicopters. Indeed, operation is frequently constrained by the need to avoid and suppress critical vibration frequencies. But the data provided on those vibrations are rarely comprehensive.

Fourth, flying operations of helicopters, especially operations close to the ground or to the surface of water, require accurate modeling of the downwash and knowledge of the prevailing conditions. This in turn requires very accurate recording of ambient conditions with a larger number of parameters being recorded at a higher frequency than is now common.

Based on the analysis document provided by Augusta, which I mentioned previously, it would seem that they at least accept that none of these difficulties is insurmountable. It is this recognition of the need for a level of data commensurate with modern techniques and technology that is required. However, it is unfortunate that this is in exact contravention to the view I have heard expressed here today and in many other forums of this sort, that is, the matter of reducing cost.

You cannot get this level of data and this level of simulation without spending a lot of money. Some of the issues of cost have been raised this morning and indeed in the last paper. Something like 60% of the cost of a fixed-wing Phase 3 simulator goes not to the building of the simulator but to providing the data package and the aircraft parts and avionics that go into that simulator. And that is a problem I don't see any way of overcoming simply, if we are to provide the degree of simulation that is expected of a Phase 3 device. So we are faced with a $12 million or more bill for a Phase 3 helicopter simulator. That's not to say we cannot produce Phase 2, Phase 1, or even flight-training devices at less cost. It is a matter of, as the last speaker said, looking at the return you are going to get.

To put this in context, we heard some figures mentioned earlier about the price of operating a simulator. If you take the cost of operating an airplane and compare it with the cost of operating a simulator, it is a ratio of about 10-to-1. To give you the top-end example, if you look at the cost of ownership of a 747 simulator on a per-hour flying basis, which includes the amortization, the cost of the device, and the building in which it is housed and all the utilities it needs, you come up with an operating cost of about $450 to $500 an hour. If you go to the airplane and use the same criteria, that is, cost of purchasing the airplane, cost of the crew, the increased cost of maintenance caused by the effects of the repeated landing cycles on the engine, the wheels, the brakes, and the undercarriage, and the additional insurance costs, it is an accepted fact in the fixed-wing world that the cost of operating a Boeing 747 for 1 hour of training is $16,000. As I say, that is a top-end one. On an average we are talking about a cost ratio of 10-to-1 in operating the airplane over the simulator.

Now, obviously for somebody who is only operating two or three airplanes, they have a problem. And I think we need to get the thing into proper perspective. Unless you think I am being unduly pessimistic, let me hasten to reassure you, we believe the manufacturers have proved their ability to provide highly accurate simulations of some of the most advanced helicopters currently in operation. These have, almost without exception, been built as military programs and have been successful because additional data have been provided through simulator data-gathering exercises on the aircraft and by a large investment of pilot and design engineer time in tuning the models or final results to meet the objective assessments of the pilots. Such expensive methods will probably not be acceptable to the average civil helicopter operator, who in most cases will not have the resources of the military nor of the large fixed-wing aircraft operators.

Yet despite holding this view, I can also add that because of the special circumstances surrounding some of the training problems for helicopters, there may be no other alternatives. For example, in the relatively high speeds encountered even in large transport airplanes, the human vestibular system is easily fooled into believing that the onset cues or short-term changes produced by the motion platform are being sustained. With the helicopter's low-speed operations, the combination of visual cuing and motion cuing may not have such a good effect.

I believe the motion cues become more important in a relative sense, because the rate-of-change cues from the visual scene at low speeds are small. Not all of my colleagues will agree with this point of view and that, in itself, is sufficient reason for raising the subject now.

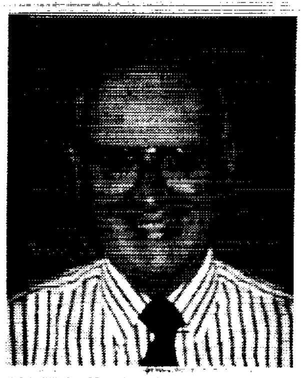
The adoption of an advisory circular to control the evaluation and approval of helicopter simulators is specifically designed to remove all but the smallest amount of subjectivity and to permit recurrent inspections to be carried out from an objective baseline. The first of these aims may be impossible to obtain until better data are available. And the the second may prove impractical and probably unacceptable to the regulatory authorities.

My point in raising the issues I have addressed in this presentation is to warn against falling into the trap of thinking that all that is necessary as an outcome of this workshop and the ensuing working group for the advisory circular is the definition of the training events and the evaluation criteria. Both of these items are essential to the task at hand, but they will be negated unless we also address the problem of the data and how they are to be used.

It has taken some 12 years to reach that conclusion in the fixed-wing world. I submit we cannot afford to give the same amount of time to helicopter simulators. Thank you very much.

MR. CARVER: Brian, is not today's problem with helicopter data collection and the construction of the document similar to the one which has been sent out here by Ed [Boothe] and his compatriots and the same situation we were in with fixed-wing where actually we have all managed working together to achieve everything that is required. Are we not, by using your suggestion, choking off development for the future?

MR. HAMPSON: I think there is some value in what you said, Paddy. My only comment really on what you have said is that we have a different group of players here. And what I was trying to do in my paper, and I am sure you support the view, is to try and read across some of the experience we got in the fixed-wing world so we do not have to spend 12 years in the helicopter case, as we did in reaching the conclusion we reached in the fixed-wing case. And I certainly would not want to choke off anything, but there are some exercises, were we to go back 12 years, in the fixed-wing case that we would almost certainly do differently. I do not think any of us who have been involved in it would disagree with that.



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