

Response to comments on NPA-E-20

1 - Justification of the NPA

This NPA represents the culmination of extensive co-operative work carried out by JAA, FAA, AIA and AECMA. The work commenced in 1989 and was managed by the Engine Harmonisation Working Group.

Analysis of service experience of bird ingestion indicated that the achieved safety level would not be satisfactory in the long term. The requirements needed to be increased in severity.

Lengthy negotiations produced an internationally agreed definition of the bird threat and considerable effort was expended in an attempt to agree a harmonised requirement together with acceptable means of compliance. At a late stage in the process a problem was identified with intermediate sized birds.

Agreement was eventually reached on the issues of medium and large birds, but the JAA position on intermediate bird sizes was not supported by all members of the harmonisation group, and consensus or compromise proved impossible at time of issuance of this NPA. Current data and forecasts indicate a necessity to re-assess the bird threat. This will likely lead to further rulemaking activity. It was agreed to review the JAA proposed rule (as shown in the proposed JAR-E 800 (b)(3)) as part of this re-assessment.

Principle changes introduced by the NPA are as follows :

1. The new bird threat introduces a 1.15 kg flocking bird. The engine inlet area will determine the number and mix of 0.35 kg, 0.45 kg, 0.70 kg and 1.15 kg birds to be used for the test demonstration. The engine must have thrust and run-on capability after the ingestion. The schedule of the 20 minute run-on test received minor improvements.
2. The single large bird test will be conducted using a 1.85 kg, 2.75 kg or 3.65 kg bird dependant upon the engine inlet area. A safe shutdown is acceptable after the ingestion.
3. A more realistic bird threat is identified for engines having small intakes, including all likely turbopropeller engines.

The JAA's concerns with intermediate sized birds arose as a result of its involvement in the validation of a large turbofan engine which featured fan blades of novel material and construction. The failure characteristics of these fan blades were markedly dissimilar from those of metallic construction, such that the engine readily met the proposed single 3.65 kg large bird and multiple 1.15 kg medium bird standards, but the 1.85 kg bird capability was only marginally equivalent to earlier metallic designs.

This led the JAA to the view that it was possible for fans to be designed for certification test success with 1.15 kg medium birds (continuing safe operation) and with 2.75 kg or 3.65 kg large birds (safe shutdown), but with an inferior level of robustness when faced

with intermediate sizes. Such fans would not present the level of robustness which earlier engines had typically demonstrated in the 1.85 kg large bird test.

The harmonised portion of the proposed requirements would permit a fan to be produced such that shut down would result from ingestion of any size of bird greater than 1.15 kg. The JAA was unable to tolerate this potential for reduction in safety levels compared to designs currently in service.

The deficiency with respect to intermediate sized birds has made it necessary for the JAA to introduce an integrity requirement the criterion for which is fan unbalance following ingestion of a 1.85 kg bird. This will help to ensure a more linear capability with increasing bird weight as was the case with previous conventional designs. This is the basis for the proposed JAR-E 800 (b)(3).

In the engine test of JAR-E 800 (c) [see ACJ E 800 paragraph (4)(b)], any vibration resonance may be cleared by small throttle movements [within ± 3 % of the specified level] since this test is not the means for testing the engine endurance in a vibration mode (this is done under JAR-E 740 or other paragraphs) and because this action is usually allowed in the engine operating instructions. The ± 3 % value has been chosen for covering the test facility thrust / power measurement accuracy as well as the tolerance on power / thrust setting at the specified levels or the necessary margin for clearing vibration resonance.

The text on the inlet protection devices was simplified in JAR-E 800 (e)(2).

Based on a probability assessment, the One Engine Inoperative (OEI) ratings were excluded when determining the take-off power / thrust.

The question of the possibility of one blade being struck by more than one medium bird has been considered. While such an event is frequent during the certification tests with multiple medium birds, an analysis of the field experience showed that this is very unlikely on more than one engine in-service. This is probably due to the fact that the number of birds used for the certification testing is significantly larger than the number of birds likely encountered in service. Consequently no specific requirement has been introduced into this proposal. If it happens during any certification test and if there is blade failure, then the case should be carefully analysed in relation with the requested safety level.

The format of FAR 33.76 (as proposed in the FAA NPRM) and JAR-E 540 / JAR-E 800 are different, but the two sets of requirements and their interpretation are considered equivalent for the requirements which are proposed in this NPA, with the following exceptions :

- the proposed JAR-E 800 (e)(1) provides alternatives to tests. These provisions are contained in the advisory material to the equivalent FAR rule.
- there is no FAR equivalent to the intermediate bird provisions detailed in the proposed JAR-E 800 (b)(3).

2 - Economic impact analysis

The safety benefits resulting from these changes to the rules are largely achieved by more rigorous standards and testing than has been the case in the past. This will probably result in an increase in engine unit cost.

Currently JAA have no means to quantify the economic impact of such rules.

3 - Comments received during the circulation of the NPA

Comments or approval were received from the following organisations :

- Authorities of Denmark, France and United Kingdom.
- General Electric, Pratt and Whitney, Rolls Royce, Snecma and a member of the JAA RAP.
- ALPA (Airline Pilot Association).

4 - Response to comments

One commenter, although noting that the proposed standard would be an improvement over current standards, suggested to address a perceived increased bird threat due to larger flocking birds. It was agreed that this should be subject of a new study and possible new rulemaking but it was considered that this was outside of the scope of the current effort and that this would delay the publication of the new rules which represent an improvement over current ones.

One commenter considered that the bird speed of 200 knots specified in the proposal for the large bird test would not represent the most severe conditions. This very question has been debated for years when preparing the proposal and this speed was confirmed to be very close to the most severe condition for rotating blades on a general basis. A highest speed would be more significant for fixed structure for which the kinetic energy is the only parameter. It was agreed that this should be subject of a new study and possible new rulemaking.

One commenter questioned the 10% tolerance on critical test parameters. The comment was agreed in principle and the advisory material was clarified.

One commenter questioned the overall lay out of the proposal which was considered as not being clear enough for the people supposed to apply it. This was agreed and the rule and the ACJ were re-formatted for clarity. Other editorial comments, which are not detailed in this response, were embodied at the same time.

One commenter suggested to delete the word « containment » in the proposed JAR-E 800 (a) (5) and instead to make reference to JAR-E 810 (a). This was agreed [see JAR-E 800 (c)(1)]

One commenter suggested a change to the proposed JAE-E 800 (c)(2) so that it would read « ... a second bird must be aimed at the most critical exposed location outboard of the primary core flow path, .. ». This was not agreed. The proposal did not adequately address

all designs, in particular large low by-pass designs where the critical location on the fan blade could be inside the core flow path.

One commenter suggested to delete the word « approximately » in JAR-E 800 (c)(3) and (4). This was accepted. This is consistent with current JAR-E 800 in JAR-E Change 10.

One commenter suggested to include an assessment of the engine condition following the 20 minute run-on test to establish that hazardous conditions are unlikely to develop over the maximum flight duration of the aircraft. This is the concept of « no imminent failure » after a certification test. This was discussed during the development of the proposal and was rejected on the basis that such conditions would be unlikely to affect multiple engines after a bird encounter. The comment was therefore rejected and it was suggested that the current JAR 21.21 (c)(3) would be a means to discuss the situation between the applicant and its authority should the case arise.

One commenter considered that the wording in the ACJ on the use of artificial birds was not sufficiently robust in the context of acceptance of artificial birds because this technology is not currently mature and is not presently an adequate substitute. This commenter requested to specify that this means must be acceptable to the authority. Another commenter insisted on the need to be cautious when considering artificial birds. This was agreed in principle and the wording was improved.

The proposed JAR-E 800 (b)(2) received many comments of differing opinions. One commenter stated that the principle had some merit. Another proposed to apply it only to unconventional designs of fan blades. One commenter proposed a demonstration by test or analysis of a run-on capability of 50 % thrust for 5 minutes. One commenter disagreed with the proposal. Many commenters, however, questioned the proposed 12 % figure and its origin. JAA authorities concluded that there would be a rule to address the legitimate safety concern. The 12 % unbalance figure came from a review of some available certification reports for large fan engines currently in service. In the absence of an acceptable better criteria, the comments were rejected and the text kept [see JAR-E 800 (b)(3)]. It was agreed that this should be subject of a new study and possible new rulemaking.

One commenter questioned the fact that it is not specified if the large bird must be completely ingested or not by the primary flow as this might be important with regard to the criteria of maintaining the thrust. The comment was irrelevant as there is no thrust criteria for the large bird.

One commenter suggested to specify if the birds should be aimed simultaneously or in sequence and addressed the case of more than one bird hitting the same blade. The comment was not understood as this information is either given in the rule itself or in the justification of the NPA.

One commenter questioned the « minimum engine » and suggested that an engine corresponding to a mean time in operation would be more representative. It appears that the commenter was not aware of JAR 21.33 and certification procedures : the certification tests are made on engine conforming to the type design.

One commenter noted that the use of analysis for certification must be dealt with caution. This was agreed : this was clearly specified in the proposed ACJ.

One commenter noted that the bird ingestion is a critical case for the engine and is not fully controlled at the moment. The basis of such a statement is not known. All certifications have been made in accordance with the rules.

One commenter criticised the text of the economic impact analysis (particularly the words « globally favourable »). The wording was improved but it should be realised that currently JAA have no formal means to perform valid economic analysis of the impact of new rules.