CHAPTER 4.4 - RECOMMENDATIONS RELATING TO THE ERGONOMICS OF THE AIRCRAFT-CREW INTERFACE and

RECOMMENDATIONS RELATING TO THE CERTIFICATION OF THE AUTOMATIC PILOTING SYSTEMS

44.1 - Modification of the flight deck ergonomics of the A320

The Investigation has shown that the most probable accident scenarios imply an error in the command of the descent effected by the pilot by means of the FCU. In particular, confusion between the VS and FPA modes appeared probable to the Commission. All the other scenarios imply that the crew did not recognise the very great anomaly of the resultant vertical flight path.

The Commission is fully aware of the part played in the cause of this situation by the shortcomings it has noted in the performance of the crew, notably in the areas of cross-checking and monitoring of automatic devices. At the end of its deliberations, however, the Commission considers that it cannot by any means exclude the possibility of the recurrence of disruptive factors which could reduce the rigorousness of cross-checking among the crew to more or less the same extent, whatever the level of training may be.

Moreover, the Commission's deliberations have led it to consider that the ergonomic conception of the relevant Autopilot control could have contributed to the cause of the accident situation: This concept seems by its very navure to favour some mix-ups which could have catastrophic results if they are not detected, while the PFD symbols do not offer the best chances of detecting such confusion.

The Commission of Investigation therefore confirms and clarifies its preliminary recommendation of 20 February 1992 concerning the conception of the aircraft-crew interface relative to the vertical modes of the Autopilot on the A320.

Consequently, the Commission of Investigation recommends for the A320:

- that the target value of VS or FPA should be displayed on the PFD in order to clarify their coherence with the fundamental utilization philosophy, as taught (order effected with the FCU, control of the order and its result on the PFD);

– that the display of the FCU corresponding to the target values of vertical speed or flight path angle should be changed to a non-ambiguous expression in the current units;

It also recommends that, as far as possible:

– the difference between the respective symbols associated with the HDG-VS and TRK-FPA references and the legibility and alerting ability of the vertical speed information should be reinforced on the PFD.

44.2 Representation of the Autopilot modes of new-generation aircraft

In the process of its analysis of this accident, the Commission has been led to note inadequacies in the effectiveness of the presentation to the crew of the various active modes, the references used, the actions in progress and the targets pursued, with regard to the Autopilot devices, notably in the vertical plane. Most particularly, in the opinion of the Commission, the total information presented is inadequate in terms of its likelihood of alerting a crew, who at a glance, then absorb a wrong mental picture of the state of the automatic devices.

In practice, a good number of the observations made by the Commission apply to one degree or another"to all new-generation aircraft, which all use (if only for reasons of standardisation) the same techniques for displaying information, the same distribution of information, the same ergonomic principles (e.g. indicating the modes using a small-sized alphanumeric display, which has to be read in central vision and requires high-level cognitive decoding). Finally, the Commission has the impression that a scarcely distinguishable series of symbols are associated with functions whose actions and interactions are complex.

Consequently the Commission recommends that for all new generation aircraft:

– consideration should be given by the competent authorities and organisations with a view to improving, in a standardised manner on an international basis, the presentation and the symbols of the displays and information relating to the different active modes of the Autopilot, notably in the vertical plane.

44.3 - Balancing the horizontal and vertical information

The analysis has led the Commission of Investigation to note the crew's strong focus on lateral navigation during the intermediate approach phase, to the detriment of monitoring the vertical flight path. The Commission has analysed the economic factors which might have been the reason for this focus. It has also retained the idea that the very presentation of position information on the cathode ray screens was of such a nature as to encourage or prolong such a focus.

The Commission notes in fact that the abundance and the level of synthesis of the information presented in the horizontal plane on the navigation screen (direct analogue positioning relative to a suitable map of the world) does not have an equivalent in the vertical plane (no representation of the profile of the vertical plane nor of the safety constraints: safety altitude, determining objects, high ground). This phenomenon seems to be characteristic of all aircraft fitted with Cathode Ray Tube (CRT) instrumentation and notably an FMS without vertical profile.

Consequently the Commission recommends:

— that a study should be carried out into how newgeneration aircraft can be provided with a better balance in the presentation of the horizontal and vertical position information, reinforcing the latter (e.g. representation of the vertical plane profile, topographical representation, safety altitudes representation), and developing the associated methods allowing the crew members to be more aware with respect to the vertical situation (e.g. automatic significant height clearance announcements in descent before the final approach phase).

44.4 - Certification of flight deck ergonomics

In studying the certification process of the A320 relating to the ergonomic aspects of the aircraft-crew interface, the Commission has noted that the certification authorities concerned had established a basis for certification, comprising several special conditions and acceptable means of additional conformity to regulations JAR 25 and ACJ 25. It has also noted that particular effort had been devoted to the corresponding evaluations during in-flight or simulated operations carried out for the purposes of certification.

In spite of that, in the course of its analysis of the F-GGED accident, the Commission has come to consider that certain aspects of the ergonomic concept of the FCU and the

aircraft's instruments did represent a contributory factor in the accident, and that this could happen again.

Consequently the Commission of Investigation recommends:

– that a study should be carried out into the methods by which manufacturers should, as far as is possible in the industrial process, obtain the best information on the probable behaviour of the user when considering new ideas in aircraft ergonomics that could have major consequences;

– that the certification authorities undertake a revision of the transport aircraft certification regulations in order to clarify the objectives and certification criteria concerning flight deck ergonomics (in particular the interaction of the crew and the high-level automatic devices) and its impact on the safety of flight, taking into account the associated likelihood of human error;

– that the acceptable means of demonstrating compliance associated with this recommend experimental protocols, taking into account the latest ergonomic experience.

44.5 Recommendations concerning the Autopilot systems

In September 1992, a malfunction of an FCU was identified. It displayed a corrupt instruction value on the FCU when transferring to the Autopilot computer (FMGC). The French certification authorities have informed the French A320 Operators, as well as the supervising authorities of the foreign Operators, asking them to warn their crews against the risk of such malfunctions, and to define an adaptable operational procedure. From the technical point of view, measures have also been taken to make reception tests on suspect electronic components more stringent, and to define a new version of FCU manufactured with more resistant components.

The Commission has analysed this case of corruption of target value displayed on the FCU and has considered that such a scenario was very unlikely in the case of the accident.

However, in arriving at this kind of theory of the circumstances of the accident, and more generally of the context of a "standard" approach, in the framework of the applicable certification criteria, the Commission did

query the probability of the crew overlooking faults that would not have been observed by the Autopilot on approach.

Consequently, the Commission of Investigation recommends for the certification criteria of Autopilots that, in the operational environment of so-called "standard" approaches,

– the probabilities of failure of an Autopilot verticle mode, not detected by the system, as well as their probabilities and delays of detection and correction by the crew, notably in dynamic situations, should be re-evaluated;

– the repercussions of such undetected failures or failures not corrected by the crew in the final approach phase should be re-evaluated, and that their combined effects thus estimated should be verified with the risk level taken into account in the certification process.

44.6 – Quality control of the Collins-700-020 DME Software

In the course of the Investigation relating to the F-GGED accident, the Commission proceeded to examine the non-volatile memories of both pieces of Collins-700-020 Distance Measuring Equipment (DME) of the aircraft. The hypothesis of the occurrence of one of the currently recognized malfunction modes can be refuted by considering the available technical factors.

However, this examination has brought to light some anomalies that could have been avoided by applying software verification and test procedures such as those described as standards RTCA DO 178 A and EUROCAE ED 12 A.

From the results obtained from the software in question, the Accident Investigation Bureau recommended that "whatever means are judged necessary should be put in place to eliminate the bugs of the Collins-700-020 DME". The French and American certification authorities have carried out a quality control procedure. The first conclusions of this test have confirmed the software's inadequacies and the need to overcome them. They have been communicated to the equipment manufacturer, who is committed to pinpointing the necessary corrections before the end of 1993.

Parallel to that, the French certification authority has made it obligatory for all aircraft on the French register

to make specific changes to correct the faults that have been identified in this equipment. For its part, the American certification authority has introduced an identical process.

The Commission notes the measures taken and does not have any recommendations to add