

Safety Investigation Following the Accident on 1ST June 2009 to the Airbus A300-203, Flight AF 447

New Recommendations

SAR coordination plans over maritime and remote areas

Those responsible for Brazilian SAR stated that they did not know what means were available in the neighbouring SAR areas and had not tried to obtain information on the subject. Contrary to ICAO standards and recommended practices, there is no SAR coordination plan between Brazil and Senegal. This lack of a plan caused a considerable delay in the start of SAR operations.

Consequently, the BEA recommends that:

- **ICAO ensure the implementation of SAR coordination plans or regional protocols covering all of the maritime or remote areas for which international coordination would be required in the application of SAR procedures, including in the South Atlantic area. [Recommendation FRAN-2012-032]**

Training of SAR operators

The practices observed in the MRCC showed that any doubt induces a formalised SAR response. Although informed by the operator, the French ARCC did not take adequate steps to formalise the implementation of SAR, restricting itself to their zone of responsibility. The training courses undertaken by the ARCC and MRCC personnel rely heavily on the experience within these centres. There is no formalised and common training specific to the SAR mission.

Consequently, the BEA recommends that:

- **the DGAC, in concert with the other services responsible, develop a homogeneous framework for training and for approval of operators responsible for search and rescue activities in France; [Recommendation FRAN-2012-033]**
- **ICAO define the framework for the training of SAR operators in its standards and recommended practices. [Recommendation FRAN-2012-034]**

Organisation of SAR in France

The investigation showed a lack of coordination within the French ARCC. In addition, the absence of a central ARCC in France led the operator to contact several organisations and to provide key information to organisations not competent in SAR. The latter did not pass on this information (in particular the last known position of the aeroplane contained in an ACARS message).

Further, the MRCC have documents listing the MRCC's of all countries, their national points of contact with their coordinates, as well as the ARCC's and JRCC's.

Consequently, the BEA recommends that:

- **the DGAC designate a point of contact at ICAO for the ARCC that has adequate means to accomplish his/her missions; [Recommendation FRAN-2012-035]**
- **ICAO ensure each Member State has a national point of contact and makes his/her contact information available. [Recommendation FRAN-2012-036]**

Air Traffic Control

The investigation showed that the use of HF as a means of communication between ground and aeroplane is limited. Link outages were frequent in this area, especially on the day of the accident. A simulation of the use of ADS-C and CPDLC functions showed that the loss of altitude would have generated an alert on the DAKAR controller's screen. There are numerous areas in the world where HF remains the only means of communication between ground and aeroplane, though more reliable means are available today.

Consequently, the BEA recommends that:

- **the Brazilian and Senegalese authorities make mandatory the utilisation, by aeroplanes so equipped, of ADS-C and CPDLC functions in the zones in question; [Recommendation FRAN-2012-037]**
- **ICAO request the involved States to accelerate the operational implementation of air traffic control and communication systems that allow a permanent and reliable link to be made between ground and aeroplane in all of the areas where HF remains the only means of communication between the ground and aeroplanes. [Recommendation FRAN-2012-038]**

Initial and recurrent training of pilots

Aeroplane handling in the longitudinal axis in a reconfigured law is in general very similar in sensations and responses to flying in normal law. Nevertheless, exiting the flight envelope can be made possible, without longitudinal pilot inputs, by the total loss of the protections and the absence of positive longitudinal stability. The possible related loss of associated speed references doubtless constitutes an aeroplane handling difficulty for crews that are not prepared. Training does not adequately draw attention of crews to the precise identification of the type of reconfiguration and of the level of protection and on the necessity to monitor the trajectory and the primary parameters. In general, the complexity of modern aeroplanes and their particularities require appropriate initial and recurrent training courses.

Consequently, the BEA recommends that:

- **EASA ensure the integration, in type rating and recurrent training programmes, of exercises that take into account all of the reconfiguration laws. The objective sought is to make its recognition and understanding easier for crews especially when dealing with the level of protection available and the possible differences in handling characteristics, including at the limits of the flight envelope; [Recommendation FRAN-2012-039]**

- **More generally, EASA ensure that type rating and recurrent training programmes take into account the specificities of the aircraft for which they are designed. [Recommendation FRAN-2012-040]**

After the autopilot disconnection, while the aeroplane was stable in cruise, several pilot inputs significantly degraded the aeroplane's kinetic energy. The rapid exit from the flight envelope was not anticipated by the pilots, nor as it understood. In the absence of any reliable speed indications, understanding of the overall physics of flight at high altitude could have considerably helped the pilots to anticipate the rapid degradation of the situation. The same applies to the overspeed phenomena that have evolved with modern aeroplanes.

Consequently, the BEA recommends that:

- **EASA define recurrent training programme requirements to make sure, through practical exercises, that the theoretical knowledge, particularly on flight mechanics, is well understood. [Recommendation FRAN-2012-041]**

The startle effect played a major role in the destabilisation of the flight path and in the two pilots understanding the situation. Initial and recurrent training as delivered today do not promote and test the capacity to react to the unexpected. Indeed the exercises are repetitive, well known to crews and do not enable skills in resource management to be tested outside of this context. All of the effort invested in anticipation and predetermination of procedural responses does not exclude the possibility of situations with a "fundamental surprise" for which the current system does not generate the indispensable capacity to react.

The rapid increase in crew workload in an unusual and unexpected situation led to the degradation of the quality of communication and coordination between the pilots.

Consequently, the BEA recommends that:

- **EASA review the requirements for initial, recurrent and type rating training for pilots in order to develop and maintain a capacity to manage crew resources when faced with the surprise generated by unexpected situations; [Recommendation FRAN-2012-042]**
- **EASA ensure that operators reinforce CRM training to enable acquisition and maintenance of adequate behavioural automatic responses in unexpected and unusual situations with a highly charged emotional factor. [Recommendation FRAN-2012-043]**

The lack of any reference system and of homogeneity in the instruction methods and evaluation criteria for instructors does not allow an objective evaluation and comparison of CRM skills among crews. This lack could however be compensated for by the existence of a standards for instruction that would allow the implementation of an objective evaluation and comparison of the level of CRM among crews.

Consequently, the BEA recommends that:

- **EASA define criteria for selection and recurrent training among instructors that would allow a high and standardized level of instruction to be reached. [Recommendation FRAN-2012-044]**

Improving flight simulators and exercises

The crew of flight AF 447 did not associate the disappearance of the speed information and the ECAM messages associated with the “Unreliable IAS” procedure. The three crew members had undertaken their training according to a known scenario on the simulator, though the technical limitations of the simulator, whose fidelity is satisfactory in most cases, do not allow certain unusual situations to be simulated.

The demonstrative context of the pedagogical approach does not allow the crew to realize the influence of the startle effect generated by the warnings nor, where applicable, of the inappropriate reflex actions on the controls that can occur as a consequence.

These technical limitations, combined with the absence of specific pedagogical tools, do not guarantee assimilation and maintenance of adequate knowledge making it possible to avoid, identify and recover from such a situation.

Consequently, the BEA recommends that:

- **EASA modify the basis of the regulations in order to ensure better fidelity for simulators in reproducing realistic scenarios of abnormal situations; [Recommendation FRAN-2012-045]**
- **EASA ensure the introduction into the training scenarios of the effects of surprise in order to train pilots to face these phenomena and to work in situations with a highly charged emotional factor. [Recommendation FRAN-2012-046]**

Ergonomics

The crew did not de-activate the flight directors and did not call out any changes in FMA mode. It is not sure that they noticed the appearances and disappearances of the flight director crossbars. It is likely that the crew did not know of the mode changes when the flight director became active again, reading and assimilating the displays on the FMA in dynamic and stressful conditions not being instinctive or natural. It seems that requiring an action from the crew to re-engage this automatic system would, on the one hand, lead to a consistency with the autopilot and the autothrust, and on the other hand stimulate a check on the modes and the consistency of the commands presented at the time of the re-engagement.

Consequently, the BEA recommends that:

- **EASA require a review of the re-display and reconnection logic of the flight directors after their disappearance, in particular to review the conditions in which an action by the crew would be necessary to re-engage them; [Recommendation FRAN-2012-047]**

Further, even if it is not sure that the crew followed the orders from the flight director while the stall warning was active, the orders from the crossbars were in contradiction with the inputs to make in this situation and thus may have troubled the crew.

Consequently, the BEA recommends that:

- **EASA require a review of the functional or display logic of the flight director so that it disappears or presents appropriate orders when the stall warning is triggered. [Recommendation FRAN-2012-048]**

The failure messages successively displayed on the ECAM did not allow the crew to make a rapid and effective diagnosis of the situation the aeroplane was in, in particular of the blockage of the Pitot probes. They were never in a position to make the connection between the messages that appeared and the procedure to apply, although reading the ECAM and messages should facilitate the analysis of the situation and allow failures to be handled. Several systems had however identified the origin of the problem but only generated failure messages related to the consequences on themselves.

Consequently, the BEA recommends that:

- **EASA study the relevance of having a dedicated warning provided to the crew when specific monitoring is triggered, in order to facilitate comprehension of the situation. [Recommendation FRAN-2012-049]**

The stall warning is described as being a combination of the aural warning, the illumination of the Master Warning light on the FCU and an indication on the red and black speed tape (VSW). However, the illumination of the Master Warning is generally of a different origin. In the absence of the red and black Vsw on the speed tape, the only element that presents the characteristics of clarity and absence of ambiguity on approach to stall is the aural warning. Symbolic visual information combined with an aural warning on an aeroplane on which sight is highly demanded would doubtless improve its perception.

Consequently, the BEA recommends that:

- **EASA determine the conditions in which, on approach to stall, the presence of a dedicated visual indications, combined with an aural warning should be made mandatory. [Recommendation FRAN-2012-050]**

When airspeeds are below 60 kt, the stall warning is no longer available, even though it may be beneficial for it to be available at all times.

Consequently, the BEA recommends that:

- **EASA require a review of the conditions for the functioning of the stall warning in flight when speed measurements are very low. [Recommendation FRAN-2012-051]**

Operational and Technical Feedback

The investigation showed that the certification of an aeroplane does not make it possible to identify all of the operational risks, and that in addition there is no mandatory operational and human factors analysis of in-service events (as with continuing airworthiness). EASA is currently undertaking work (OSD) aimed at having the holder of the aeroplane type certificate define its minimum associated training programme, based on the operational risks identified by operators and the manufacturer following in-service events.

In-service feedback is an essential prerequisite in the process of improving flight safety. It is notable that the reports written by crews after events do not always reveal their severity or all of the elements of an operational appreciation. This makes somewhat random the preservation of the indispensable elements needed for an investigation and thus difficult for the operator, the manufacturer and the authorities

to evaluate the associated risks and threats and to undertake an exhaustive analysis that makes it possible to take appropriate measures.

Consequently, the BEA recommends that:

- **EASA improve the feedback process by making mandatory the operational and human factors analysis of in-service events in order to improve procedures and the content of training programmes; [Recommendation FRAN-2012-052]**

and specifically,

- **that the DGAC take steps aimed at improving the relevance and the quality of incident reports written by flight crews and their distribution, in particular to manufacturers. [Recommendation FRAN-2012-053]**

Oversight of the Operator

In-flight and ground inspections by the Authority within the airline never brought to light any major deviations, whether in relation to the operator's conformity to the regulatory provisions, to the ECP's or in flight. Thus, the whole range of inspections did not bring to light the fragile nature of the CRM nor the weaknesses of the two copilots in manual aeroplane handling. Though respecting the regulatory requirements applicable to oversight, it appears that the organisation, methods and means deployed by the authority were not adequate to detect the weaknesses of an operator and impose the necessary corrective measures.

Consequently, the BEA recommends that:

- **the DGAC review the organisation of its oversight so as to improve its cohesion and effectiveness; [Recommendation FRAN-2012-054]**
- **the DGAC ensure the adequacy of the conditions of recruitment and training so that all of its inspectors have the skills required to exercise their functions. [Recommendation FRAN-2012-055]**

Release of Drift Measuring Buoys

The release of drift measuring buoys by the first aircraft to arrive over the zone would have made it possible to better understand the drift of floating debris in the first few hours. This would have facilitated modelling of the currents and thus the reverse-drift calculations to estimate more precisely the localisation of the site.

Consequently, the BEA recommends that:

- **ICAO amend Annex 12 on search and rescue operations so as to encourage Contracting States to equip their search aircraft with buoys to measure drift and to drop them, when these units are involved in the search for persons lost at sea. [Recommendation FRAN-2012-056]**

Note: In accordance with Article 17.3 of European Regulation (EU) 996/2010 of the European Parliament and Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation shall in no case create a presumption of blame or liability for an accident, a serious incident or an incident. The addressee of a safety recommendation shall inform the safety investigation authority which issued the recommendation of the actions taken or under consideration, under the conditions described in Article 18 of the aforementioned Regulation.