

ATTACHMENT H

Correspondence from Airplane Manufacturers to American Airlines and Response

(10 pages)

August 20, 1997

Captain Cecil D. Ewell
Chief Pilot and Vice President of Flight
American Airlines
American Airlines Flight Academy
P.O. Box 619617
Dallas-Fort Worth Airport, Texas 75261-9617

Dear Captain Ewell:

After your AAMP conference Tom Melody, Larry Rockliff, Tom Imrich and Ken Higgins committed to provide you a coordinated package of recommendations for improving your already excellent program. This is our coordinated response. Our intent is to give you additional and corrected technical information as well as the benefit of our experience in unusual areas of the flight envelope for training pilots in various airplane models. We hope you accept this as part of growing industry-wide effort of working together on common training and flight safety issues.

Our inputs are organized into the following subjects:

- Aerodynamic Explanations
- The Use of Rudder
- Airplane Recovery from Upsets
- Use of Simulators
- Angle of Attack Indicators
- Technology Aversion
- Factual Errors

Aerodynamic Explanations

It is important that commonly accepted aeronautical terminology and notations be used. The AAMP does an excellent job in presenting many ideas in a short time span while keeping the technical information at a line pilot's level of understanding. The risk in doing this is that some terms may not always be used in the technically correct context. This could become misleading or in some cases, have a negative effect on training. The use of the term "phugoid" when describing speed stability is an example. Additionally, we believe that consistent and correct short-hand aeronautical notations should be used. We recommend that you refer to a commonly accepted reference such as Perkins and Hage, "Airplane Performance, Stability, and Control" or "Aerodynamics For Naval Aviators" that is issued by the Chief of Naval Operations Aviation Training Division.

The notion and application of corner speed should be revisited. The corner speed concept is not questioned and is entirely appropriate for combat aircraft when

Page 2

optimum combat maneuvering is necessary for achieving a competitive advantage. However, the issue is complex beyond practical use in procedural application for recovering a large transport airplane from an upset. The first limitation in applying corner speed to recovery is the fact that the speed is a function of several variables including airplane weight, and therefore is not a constant. For practicality, this is solved by identifying an average corner speed for the airplane model and accepting the resulting less than optimum turn radius. Additionally, there is the potential that pilots could fixate on obtaining and maintaining corner speed, while delaying or overlooking implementation of other recovery techniques, and result in unnecessary loss of altitude during a nose low recovery. Exposing pilots to the concept of corner speed and radius of turn as a basis for understanding why it may be necessary to increase speed in order to recover from a nose low, low altitude upset is beneficial. However, incorporating a corner speed into recovery procedure, we feel is inappropriate.

Use of Rudder

The excessive emphasis on the superior effectiveness of the rudder for roll control vis-à-vis aileron and spoilers, in high angle of attack, is a concern. Many of the AAMP slides associate high angle of attack with use of rudder. Although rudder usage for turn coordination and yaw control is emphasized and appropriate with improving "hands on" flying skills, modern aircraft have yaw dampers and turn coordinators designed to provide adequate yaw coordination and the manual application of rudder can defeat its purpose. The pilots are left with the impression that it must be used first in all high angle of attack situations. The factors associated with high angle of attack when considering aerodynamic and environmental variables presents the pilot with a technical challenge. When should it be used? How much should be used? How long should it be used? While some of this is touched upon, additional rudder use information should be provided with emphasis on the consequences of inappropriate use of rudder. Although a simple rule about rudder usage cannot be stated, a more appropriate standard is to first use full aileron control, if the airplane is not responding, use rudder as necessary to obtain the desired airplane response. Momentary actuation of spoilers during roll input does not significantly increase drag.

Sideslip angle is a crucial parameter that should be discussed in your program. It is probably not well understood by many line pilots, but has a significant impact on an airplane's stability and control. Large or abrupt rudder usage at high angle of attack can rapidly create large side slip angles and can lead to rapid loss of controlled flight. Rudder reversals such as those that might be involved in dynamic maneuvers created by using too much rudder in a recovery attempt can lead to structural loads that exceed the design strength of the fin and other associated airframe components. The hazard of inappropriate rudder use during windshear encounters, wake turbulence recovery and low airspeed at high angle of attack, for example, stick shaker, should also be included in the discussion. The use of "top rudder" without an explanation of

Page 3

the exact situation may cause pilots to inappropriately use excessive rudder when attempting to use coordinated rudder. In a high angle of attack condition, this could result in a delayed recovery, excessive bank angles or even a rapid roll in the opposite direction.

Airplane Recovery from Upsets

The AAMP recovery procedure for a high angle of attack, nose high upset instructs the pilot to unload and roll (limiting bank angle to approximately 70 degrees) toward the nearest horizon in order to lower the airplane nose. It is important to initially stress unloading the wing through (up to) full down elevator, and down stabilizer trim. Roll should be introduced only after exhausting the use of pitch axis controls and after considering the reduction of thrust (on airplanes with wing mounted engines). Introducing roll angles at extremely high angles of attack creates sideslip and hence has the same concerns as rudder usage. Accident and incident data indicate that many nose high, high angle of attack events are because of inappropriate stabilizer trim. The initial use of elevator and down stabilizer trim will normally be adequate in establishing a nose-down pitch rate. In combination with thrust reduction few failures can be conceived for which these measures would not be sufficient. As with all proposed scenarios, the use of roll to assist in pitch attitude reduction cannot be ruled out, but if the airplane is at high angles of attack, the sideslip introduced by rapid roll may result in departure from controlled flight.

As mentioned above, reducing thrust on underwing mounted engines is another way to assist the pilot in lowering the nose. While the effects of thrust on pitch are emphasized earlier in the presentation, the possibility of reducing thrust during a nose high recovery is not part of the discussion. In fact, the recovery procedure infers an increase in thrust in most nose high recoveries.

We identified our concerns with the use of rudder to generate a roll as a separate subject earlier. Inappropriate use of rudder during a high angle of attack, nose high upset should again be stressed while discussing the nose high recovery.

Use of Simulators

Associated with upset recovery is the ability to train pilots. Simulators have become practical and accurate training tools throughout the evolution of our industry. To that end, they have become accepted by the user community, with a high degree of confidence in the fidelity of their performance. Artificially manipulating a simulator into an environment that is way beyond valid engineering data creates a potential for negative learning. Current simulator limitations also do not permit the replication of linear or lateral load factors. Using a vortex flow in the simulator to induce an upset is a reasonable approach, however, inhibiting aileron inputs as apparently implemented in your training simulators, until the airplane has rolled through 90 degrees of bank will invariably result in large sideslip angles—probably outside the range of valid aero data. Additionally, without any aileron effectiveness during the

Page 4

first 90 degrees of roll, the pilot will probably use rudder in an attempt to roll the airplane erect. This will lead to an increase in sideslip that could invalidate the response of the simulator to any further inputs. Pilots need to be aware that the simulator will not necessarily respond as the airplane will when simulator capabilities are exceeded.

Angle of Attack Indicators

There is a strong recommendation for an analog Angle of Attack indicator. It is implied that this device can be used for a variety of functions, including detection of overweight conditions and as an indicator of critical performance parameters. Although an angle of attack indicator can be used to determine wing angle of attack and therefore be used for recovery from unusual attitudes, its use as a performance tool is limited without the inclusion of corrections such as accurate center of gravity, a parameter not currently available on commercial airplanes. Also, the accuracy of current angle of attack vanes (absent inertial correction) is not sufficient to indicate accurate medium to high-speed performance parameters. Additionally, the human factors such as aircrew performance while using angle of attack indications during recovery of large transport category airplanes have not been studied.

Little information is provided on the vulnerabilities or limitations associated with presenting angle of attack guidance. Factors such as its reliability with wing icing, or airplane configuration anomalies, such as loss or partial loss of a radome, or the additional training required to assure its proper use are overlooked. As you know, manufacturers are working with your company and others to respond to the angle of attack issue. We are defining the technical requirements, ways of displaying the information and associated costs. In the interim, the discussion of this subject should be more balanced.

Technology Aversion

The subject of the proper use of automation is right on target and timely. Airplane accident and incident data validate your concern in this area. Equally, engineering advances incorporated into all modern jetliners in recent years can share in the safety statistics the industry enjoys. The human factors issue associated with the proper use of automation is also excellent information for pilots. Indeed there are likely as many situations where a crew would be well served to use the technology available to them, rather than be primed to eliminate it. The key point is for the user to be situationally aware so they can make rational decisions instead of rote responses. To better balance the discussion, it should include some positive information about why technology was introduced and what it does to assist the pilot.

Factual Errors

Some of the information presented while using actual accident scenarios is incorrect or has been misinterpreted. For example, it was stated that the 737 rudder pedals did not indicate the rudder position if the rudder PCU had certain failures. This is

Page 5

incorrect, the rudder pedals indicate the direction and motion of the rudder except for yaw damper inputs. Information about the A300 Nagoya accident also has some fundamental errors. We recommend you review this information and work with the manufacturers or safety organizations in order to maintain correct information in your program.

The AAMP is an excellent program and we applaud American Airlines for expending the time and money in developing and implementing it. The concerns we identified can easily be mitigated with some modifications. As you know, the industry is working to develop an Airplane Upset Recovery Training Aid that should include many of the AAMP ideas and information. We hope that your staff will continue to provide that industry team with the benefit of American Airlines information and experience. We appreciate the opportunity to make this input.

Sincerely,



J. Kenneth Higgins
Boeing Commercial
Airplane Group
Vice President
Flight Operations and Validation



Tom Imrich
FAA
National Resource Specialist,
Air Carrier,
Operations



Tom McLoody
Boeing Douglas Products Division
Sr. Manager/Chief Test Pilot
Experimental Flight Test
and Customer Service



Larry Rockliff
Airbus Service Company,
Training Center
Flight Training
Director and Chief Pilot

American Airlines

October 6, 1997

Mr. J. Kenneth Higgins, Vice President
Boeing Commercial Airplane Group
Flight Operations and Validation

Mr. Tom Imrich, FAA
National Resource Specialist
Air Carrier, Operations

Mr. Tom Melody, Senior Manager/Chief Test Pilot
Boeing Douglas Products Division
Experimental Flight Test and Customer Service

Mr. Larry Reckliff, Director and Chief Pilot
Airbus Service Company Training Center
Flight Training

Reference: Letter dated August 20, 1997 from the Addressees

Subject: Recommendations for AAMP

Gentlemen:

In response to your August 20, 1997 coordinated package of recommendations regarding our AAMP program, I would submit the following.

Aerodynamic Explanations:

The Aerodynamics section of the program was and is founded on several recognized sources. Perkins and Hage, "Airplane Performance, Stability, and Control" was a primary reference. Additionally, we have been telling pilots for many years that "Aerodynamics for Naval Aviators" by Hugh Hurt is the best single source document available on this subject.

The use of Greek letters and formulas does not play well with pilots. In converting to English letters and modifying words, some technically correct terminology was lost. Tom Imrich and Warren VanderBurgh have worked together over the past three months on this issue. It is my understanding that Tom is satisfied with the modifications we made (although the labeling will continue to differ somewhat from that in Perkins and Hage). These improvements are included in Revision 16 to the AAMP booklet.

Recent accident history highlights the importance of understanding corner speed. We are presenting the corner speed issue correctly and feel that we are applying it appropriately. Our experience with the AAMP simulator sessions over the past two years have very clearly indicated a need for exposure in this arena.

Use of Rudder

Let me say this one more time, we do not advocate the introduction of large sideslip angles when flying at high angle of attack. You seem to be predisposed to the belief that we are using rudder first or rudder only. The workbook is not a stand-alone document and nothing should be inferred without listening carefully to the presentation. In four different sections of the AAMP, emphasis is focused on the fact that when the airplane is not responding to aileron and spoiler control, you should use smooth application of coordinated rudder to obtain the desired roll response. Additionally, let me re-emphasize that AAMP stresses keeping the airplane inside the flight envelope at all times regardless of attitude. Our pilots are taught to always "respect" the stick shaker.

The hazard associated with large or abrupt application of rudder at high angle of attack is clearly exemplified by the NTSB video re-creations of the 737 accidents at Colorado Springs and Pittsburgh. (If you accept the NTSB's conclusion of a hard-over rudder as the most probable cause). Additionally, the Boeing Company developed videos dealing with 'Crossover angle of attack' which are very helpful in emphasizing the rudders' powerful affect on roll control at higher angles of attack.

The proper use of "top rudder" and the low alpha conditions under which it is applied are very clearly explained in the presentation.

Airplane Recovery from Upset

Ken, this is an arena in which we clearly disagree totally with your position. After disconnecting the autopilot and autothrottles, the first two steps of our current nose high recovery procedure are as follows:

Unload with Forward yoke pressure toward zero "G" force
Roll the aircraft toward the nearest horizon -- limit bank angle to approximately 60°

At American Airlines, we teach our pilots to fly the airplane first using primary flight controls. If unloading with elevator does not generate an adequate nose down pitch rate, then we will not hesitate to roll the lift vector off the vertical to generate the required nose down pitch rate. This procedure will work on all of our aircraft. Any delay in initiating the roll (if required) could lead to a very tenuous situation.

We will not teach nose down stabilizer trim as the next step after unloading. There are significant risks associated with running stabilizer trim during an upset recovery. This is not to say that a pilot cannot attempt to trim off excessive stick forces during the recovery process.

Preservation of energy is a primary concern on a nose high recovery. We will not teach the reduction of thrust prior to rolling the lift vector off the vertical. This would be totally counter-productive on more than half of our aircraft. It may also be counter-productive on airplanes with underwing engines, depending upon altitude and kinetic energy levels. Only after we unload and roll will we consider thrust and in most nose high recoveries we will increase thrust. Depending on energy levels (altitude and airspeed), we will consider reducing thrust on airplanes with underwing engines.

We do not understand your concern about high angle of attack maneuvering during nose high recoveries. Regardless of attitude, the action of unloading will lower angle of attack and the airplane should respond normally to its roll controls.

Use of Simulators

The AAMP simulator training models have been in continuous development over the past two years and we continue to refine them. We have come a long way toward representing realistic scenarios. One of our covenants has always been to abide by the control laws in each of our eight fleet type aircraft. Initially, inhibiting aileron input response on the vortex model simulation was a necessary compromise to achieve both realism and the desired learning objective. However, this does not result in large sideslip angles as you suggest. On your next visit to our Flight Academy, we will be pleased to show you the Beta readouts during this event.

The AAMP modeling and training in our simulators focuses on maintaining the airplane inside its flight envelope regardless of attitude. It is our belief that the fidelity of our simulators is reasonably good as long as we remain inside the envelope. We do not accept your statement that we are "manipulating a simulator into an environment that is way beyond valid engineering data".

The simulator training portion of AAMP is proving to be invaluable, with a steep learning curve for a significant percentage of our pilots. They are reporting that the simulator experience is both challenging and rewarding. Obviously, our emphasis is on recognition and basic recovery maneuvers, not fidelity of aircraft performance.

Angle of Attack Indicators

In the process of reviewing catastrophic events resulting from upsets or unusual attitudes we wonder if, in certain circumstances, IAS and attitude are providing sufficient information to the pilot to affect a recovery or extract optimal aerodynamic performance. This situation is, of course, compounded in the case of Pitot and/or static blockage. The

consequences of a corrupted CADC on a highly automated "electric" airplane has gone well beyond mere loss of airspeed and caused numerous unexpected alerts and system failures. These often ambiguous indications can result in the crew becoming task saturated. We are pursuing the installation of some sort of display that will provide *situational awareness relative to the flight envelope at all times.*

I am pleased to hear that progress is being made in the study of an intuitive display on the 737-800 aircraft. Working together with the superb flight deck engineering group at Boeing, I am confident we can find a solution providing this enhanced situational awareness.

Technology Aversion

Let me say first that American Airlines does not have an aversion to technology. It is obvious that we have embraced many of the new technologies and incorporated them into our cockpits.

Automation ~~dependency~~ is the issue we have highlighted in AAMP. The discussion revolves around levels of automation and technology judgment; i.e., what is the appropriate level of automation for a particular task? Over the years, our industry has unwittingly developed a culture that drives us to attempt to operate at the highest levels of automation at all times. It is our opinion automation lacks the ability to create flexible responses to unanticipated changes in flight path requirements.

AAMP Training embodies a cultural change in the way we use the various levels of automation available in each of our aircraft. It takes us back to the precept that the pilot should always "fly the airplane first". It's not that aircraft automation is bad or unreliable, it is just that over the years, we have come to over depend on automation, which has obvious consequences.

In both the AAMP, and in Human Factors and Safety Training, we are attempting to re-establish a proper balance between automation and the maintenance of our pilots flying skills. The guidance is that if immediate direct control is required, then manual control should be applied. If the airplane is departing its intended vertical or lateral path in a threat environment, then the pilot should disconnect the autopilot and autothrottles to regain and maintain the intended flight path. AAMP seeks to reassign the appropriate role of aircraft automation within the cockpit, recognizing that ultimately, it will be the human being who is held responsible for the safety of our passengers and our aircraft.

Factual Errors

We have complete accident reports available through our corporate safety department. The AAMP tries to represent each example correctly. However, the intent of the AAMP is not to analyze accidents in detail, but to capture the essence of the event.

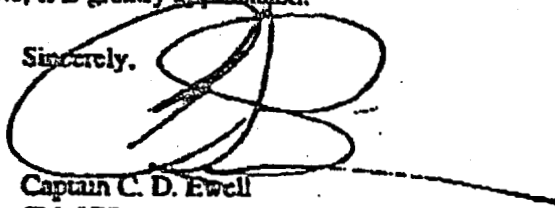
There is not time nor is it appropriate to conduct detailed accident briefings during the AAMP presentation.

The purpose of AAMP is to provide the pilots with the knowledge and skills to recover from any of these upset events and to extract maximum performance from the airplane when required. We also think it important to emphasize the role of the pilot as final arbiter, operator and decision maker.

In closing, your suggestions and recommendations have been carefully analyzed. Ultimately, as you are aware, we are charged with the responsibility of the lives of our passengers and crew in a real life, everyday environment, not one which is technically and optimally controlled, as in a simulator or academia.

We thank you for your input and time, it is greatly appreciated.

Sincerely,

A large, stylized handwritten signature in dark ink, consisting of several loops and a long horizontal stroke extending to the right.

Captain C. D. Ewell
Chief Pilot
and Vice President-Flight

cc: Mr. R. W. Baker
Capt. L. R. Schumacher
Capt. P. W. Railstack
Capt. R. D. Miner
Capt. W. VanderBurgh