APPENDIX F

Simulator Features and Capabilities Added to Support the 767 Elevator Dual Failure Simulation Tests

Simulator Support of 767 Dual Elevator PCU Input Failure Testin

Overview

ASL has been requested to modify the flight controls model contained within the simulation of the 767-300ER aircraft in order to support Simulator testing of various split elevator failure scenarios. These failure scenarios are described in C/S B-E326-C99-149 Rev B, and were explained to ASL personnel by Pete VanLeynseele at a follow-up meeting on 3-2-2000. At this time, changes to the flight controls model will be limited to those necessary to support testing of the three specific failure conditions associated with the "Dual Actuator Input Failure" scenario described in detail in the above C/S.

This document provides the following information related to the above task:

- A brief summary of each of the three failure conditions and the response that will be provided by the simulation when a specific failure is invoked. Note that the responses provided by the simulation will be somewhat simplified compared to the C/S description.
- A summary of the specific features and capabilities that will be added to the simulation in order to produce the response for each of the failure conditions.
- A list of caveats and limitations that must be understood when using the modified simulation to test these failure conditions.

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Dual Actuator Input Failure - Case #1 :

Failure Condition -

The control valve jams TED on two separate PCUs, on the same elevator surface, at the same time, causing a TED hardover of that surface.

Simulation Response -

A constant force bias of 30 Ibs will be applied to the column in the forward direction. This will cause a corresponding shift in the column position, and the non-failed elevator surface, as the feel and centering unit reacts to the force bias. Pilot control of the non-failed elevator through the column will be unaffected, except that the normal feel force profile will be altered by the additional force bias.

If the aircraft flight condition exceeds an aerodynamic impact pressure of 400 psf the force bias will be gradually reduced to ensure that the “hands-off” position of the non-failed elevator surface does not exceed that of the failed elevator surface.

The failed elevator surface will move to a TED position equivalent to 80% of the single PCU blowdown limit, and then track this limit position as it varies with changes in flight condition,

The non-failed elevator surface will continue to respond to column inputs normally.

Dual Actuator Input Failure - Case #2:

Failure Condition -

The input linkage to two different PCUs disconnects, on the same elevator surface, at the same time (one could be latent), causing a TED hardover of that surface.

Simulation Response -

The normal feel force profile for the column will remain unchanged. Pilot control of the non-failed elevator through the column will be unaffected.

The failed elevator surface will move to a TED position equivalent to 80% of the single PCU blowdown limit, and then track this limit position as it varies with changes in flight condition.

The non-failed elevator surface will continue to respond to column inputs normally.

Dual Actuator Input Failure - Case #3:

Failure Condition -

The control valve jams TED on one PCU, and the input linkage to another PCU disconnects (could be latent), on the same elevator surface, at the same time, causing a TED hardover of that surface.

Simulation Response -

A constant force bias of 15 Ibs will be applied to the column in the forward direction. This will cause a corresponding shift in the column position, and the non-failed elevator surface, as the feel and centering unit reacts to the force bias. Pilot control of the non-failed elevator through the column will be unaffected, except that the normal feel force profile will be altered by the additional force bias.

The failed elevator surface will move to a TED position equivalent to 80% of the single PCU blowdown limit, and then track this limit position as it varies with changes in flight condition.

The non-failed elevator surface will continue to respond to column inputs normally.

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Simulation Requirements:

The Flight Controls model (FTC) for the 767-300ER aircraft simulation used in the 757/767 Simulator Cab shall be modified to incorporate the following features:

1) The capability to individually select and invoke each of the three Dual Actuator Input Failure conditions, and to apply the fault to either the left or right elevator surface.

2) The ability to apply an external force bias to the column to emulate the force bias applied by PCU input pogo(s) during a hardover condition caused by a valve jam. The force bias will be 30 Ibs for the dual PCU Jam case, with provisions to automatically decrease this bias at flight conditions where aerodynamic impact pressure exceeds 400 psi. The force bias will be 15 Ibs for the single PCU jam case.

3) The ability to position the left and right elevator surfaces independently, with the failed surface following the 80% single PCU blow-down position (which varies with changes in flight condition), and the non-failed surface following the column input command, limited only by the standard three PCU blowdown range.

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Simulation Caveats and Limitations:

1) The Simulator Cab does not support independent or differential movement of the two control columns; they are rigidly coupled together.

2) The Simulator Cab will not support Dual Actuator Input Failure conditions with the autopilot engaged.

3) The primary failure effects, including elevator surface hardover, and application of column force bias, will occur instantaneously when the failure is introduced; normal PCU rate limits and air load damping effects will be ignored.

4) For the PCU Input Jam cases, the PCU pogo force bias will be applied at the column, rather than at the aft quadrant, to simplify implementation. This will result in a slight increase in actual column position bias due to the cable stretch effect.

5) For the Dual PCU Input Jam case, the adjustment to the applied force bias for flight conditions with aerodynamic impact pressure greater than 400 psi is approximate, and is only intended to provide a good match to the actual response for a specific flight condition.

6) For the Dual PCU Input Jam case, the effect of PCU input pogo travel limits and shear outs will not be modeled in the simulation.

7) For the Dual PCU Input Jam case, the change in feel force gradient above 70 Ibs at the column on the side opposite the failed elevator, due to breakout effects, will not be modeled in the simulation.

8) For the Dual PCU Input Disconnect case, the additional force gradient introduced by the slave cable lost motion device will not be modeled in the simulation.

9) Limitations on elevator control system asymmetry, and differential elevator travel, will not be modeled in the simulation.

Simulation Overview - 767 Elevator PCU Failure Effects Demo