69231

Boeing Commercial Airplane Group
P.O. Box 3707
Seattle, WA 98124-2207

DEPT. OF TRANSPORTATION

99 DEC 20 PM 4: 19

December 20, 1999
B-H330-EAK-1999-00296

U.S. Department of Transportation Dockets
Docket No.[FAA-1999-6482] —8
Federal Aviation Administration
400 Seventh Street SW.
Room Plaza 40 1, Washington, DC 20590
Internet address: 9-NPRM-CMTS@faa.gov.

Subject: Docket No. FAA-1999-6482; Notice No. 99-19, Revisions to Digital Flight Data Recorder Regulations for Boeing 737 Airplanes and for Part 125 Operations

The subject Revisions to Digital Flight Data Recorder Regulations was reviewed by The Boeing Company and resulted in the attached comments. The Boeing Company is pleased to be a part of the rulemaking process and hope this cooperative effort will continue into the future. If there are any questions, please feel free to contact this office at any time.

Sincerely,

E. A. Kupcis
Chief Engineer;
Regulatory Requirements
Phone: (425) 237-4304

Subject: **Boeing Comments to the FAA NPRM 99-19,**

"Revisions to Digital Flight Data Recorder Regulations for Boeing 737 Airplanes and for Part 125 Operations", dated November 16, 1999.

Summary

Boeing is supportive and in general agreement with the intent of the subject FAA NPRM. This letter is written to provide the FAA with recommended changes intended on improving the success of the rule as well as the associated adoptive activity required by industry to take place very quickly to meet the proposed compliance timing.

Proposed NPRM Format and Content Change

Boeing suggests specific content and format change to help provide the required clarity and consistency within the proposed rule. Boeing interpreted the rule as indicated in the Proposed NPRM Format and Content Change section of this letter, and all following comments were made based on this interpretation. One significant concern was the revision of requirements associated with parameters (a)12 to (a)1 7. Under the proposal (as written), the exemption allowing older airplanes to record these parameters from a single source was removed. Boeing believes that this exemption may have been removed in error and recommends it is reincorporated.

Compliance Cost

Boeing has identified inaccuracies within the Compliance Costs section. These items are explained in detail in the Compliance Costs section of this letter.

Cost Benefit Analysis

Boeing requests that the FAA re-evaluate the cost benefit analysis performed for this proposal. The existing analysis does not address the incremental costs and benefits of each of the additional requirements separately, or of the different costs for production and retrofit of any given parameter. An itemized cost/benefit analysis would likely have a significant influence resulting in a potential reduction in requirements, particularly for retrofit installations.

Benefits versus Impact of Parameter 88

Boeing provides in this letter a comprehensive review of the existing and proposed flight controls parameter (a) 88 design; including design philosophy, operation, existing installations, possible installations to comply with this proposal, and comments regarding possible future requirements for additional force parameter requirements. The FAA has previously approved the Boeing design for parameter (a) 88; Boeing requests that this design again be considered acceptable for the additional B-737s covered by the proposed revisions to the existing rule.

Scheduled Implementation

Boeing believes the FAA does not fully comprehend the proposed compliance dates are unreasonable, particularly for the retrofit aspects. Boeing suggests a more realistic yet challenging schedule of October 3 1, 2000 for production and retrofit to be accomplished

at the next scheduled heavy maintenance check starting two years after the release of the final rule.

Discussion

Proposed NPRM Format and Content Change

The proposal is structured to allow airplanes built after October 11, 199 1 and before August 18, 2000 to record parameters (a) 12 to (a) 14 from a single source, but requires older airplanes to record each control or surface individually. This is inconsistent and believed to be in error. Also, there are conflicts in the proposal with the compliance times and the number of parameters required to be recorded as follows:

- FAR 12 1.344 (b) - (Recorder only and FDAU equipped airplanes) The proposal exempts the B-737 from this paragraph and applies all of new paragraph (m), requiring parameters (a)1 to (a)22 plus (a)88 to (a)91 to be recorded to the ranges, accuracies, resolutions, and recording intervals specified in Appendix M. Note that this requirement removes the paragraph (b) exemption of recording parameters (a)1 2 to (a) 17 from a single source and now applies the full requirement of Appendix M to the recording of these parameters. It also eliminates the (b)(1) exemption from meeting the resolution and recording intervals specified in Appendix B and the (b)(2) exemption from meeting the resolution specified in Appendix M.
- FAR 12 1.344 (c) - (DFDAU equipped airplanes) This is similar to (b) above. Removes the B-737 from the requirements of paragraph (c) and moves them to paragraph (m). It also removes the paragraph (c) exemption of recording parameters (a) 12 to (a)1 4 from a single source and now applies the full requirement of Appendix M recording.
- FAR 121.344 (d) - The proposal adds paragraph (d)(3) which confirms the requirements of paragraphs (d)(1) and (2) and applies the compliance statements of paragraph (m)(l) and (2). We note that the additional parameter recording of paragraph (m) seems to be overlooked here, indicating that they are not required. Although, it is clear that (m) says "in addition to all other applicable requirements of this section," it is not clear why (d) was not revised like (b) and (c) to say "Exempt the 737". This inconsistency requires resolution. Also note that the recording of parameters (a) 12 to (a) 14 from a single source is still applicable unlike in (b) and (c) above.
- FAR 12 1.344 (e) and (f) are similar to paragraph (d) above.
- FAR 12 1.344 (m) - This paragraph is inconsistent with paragraphs (b), (c) and (d) in that it requires the recording of parameters (a)88 to (a)91 while (b), (c), and (d) does not.
- Appendix M to part 121 and Appendix E to part 125 is amended by revising parameter 88 with a note 14 which reads "For all Boeing B-737 model airplanes, the seconds per sampling interval is 0.5 per control input; remarks do not apply." There is some confusion regarding the intent of the comment "remarks do not apply"; does

this mean all the comments in the remarks column do not apply to the B-737? Boeing believes the note is meant to indicate that the sampling remarks do not apply.

The addition of paragraph (m) has made it unclear what is required for the B-737's. It would be much clearer to include the additional B-737 requirements to the existing applicable paragraphs. The note associated with parameter 88 should be revised to clearly state that only the sampling remarks do not apply.

Compliance Costs

The proposal estimates the total cost of implementation. Though the FAA has identified some of the more costly components such as installing a new FDAU on airplanes that have a recorder only, and the upgrade of the recorders themselves, not all of the issues, detail changes, and associated costs are correctly portrayed and considered. The following items could affect the total costs of implementation:

- The compliance costs for future production airplanes does not account for the change in the control column and wheel force changes. The calculated cost does not include the cost of the two column force transducers, one wheel force transducer, and the revision to the Flight Control Computer (FCC) that would be installed on B-737 airplanes manufactured after August 18, 2000. This proposal accelerates the implementation of these sensors, which were previously not required until August 19, 2002.
- Other items, not identified by the FAA, that will impose substantial added costs to the airlines and increase the complexity of the proposed change is revision to the Engine Accessory Unit (EAU) and to any airplanes that have a pneumatic only air data system. The requirement for Thrust Reverser Positions will require modifications to the Engine Accessory Unit. For the B-737-100 and B-737-200 models, approximately 937 airplanes will require two new PC cards and associated connectors and wiring. For the B-737-300 and B-737-400 models, approximately 250 airplanes will require four new PC cards and associated connectors and wire. Air Data Systems with only pneumatic altitude/airspeed outputs will not be compatible with any FDAU. This may apply to as many as 500 B-737-100's and B-737-200's and 373 B-737-300's. For these airplanes it will be necessary to design and develop some type of conversion module that could convert the pneumatics to analog or digital form to allow acquisition by the FDAU or to replace the Air Data System.
- The third paragraph under One-time Compliance Costs to Retrofit B-737s states "increased number of recorded flight data parameters would require that a solid state FDR (installed to comply with the 1997 DFDR regulations) with a memory capacity of 64 word per second (wps) would need to be increased to 128 wps". The 1997 DFDR regulation did not require a solid state FDR and a B-737 built before October 11, 1991 would only be required to record 1 through 22 plus 88 through 9 1 parameters which could still use a recorder with a memory capacity of 64 wps.
- Through-out the proposed amendment, when the FAA is identifying the cost of implementation between the different B-737 derivatives the B-737-400 is grouped with the B-737-200 and advanced B-737-200. While it is true that the B-737-200's

are “all analog” airplanes, the **B-737-400** is essentially the same as **B-737-300** and **B-737-500’s** utilizing many **ARINC 700** systems which can provide data for recording in a digital form. Therefore the **B-737-400** should be logically grouped with the **B-737–300** and **B-737-500** airplanes.

Cost Benefit **Analysis**

The cost - benefit comparison in the proposed rule does not address the incremental costs and benefits of each of the additional requirements separately. The cost of implementing these changes will vary significantly from one parameter to another. Since the costs of implementing some parameters will be so large compared with the cost of implementing others, it seems reasonable that a cost benefit analysis be done on a parameter by parameter basis. Also the costs will differ greatly between production implementation and retrofit implementation, therefore the cost benefit analysis should be further split to account for these differences.

Boeing requests that the **FAA re-evaluate** the cost benefit analysis performed for this proposal. An itemized by parameter cost-benefit analysis would likely provide additional guidance and justification for reduced requirements, particularly for the retrofit fleet.

For example:

The proposal indicates that the reason for requiring additional parameters on all **B-737’s** is because the rudder has been the subject of some recent aircraft accidents and **incidences**. The benefit of recording parameters associated with the rudder would be much greater than recording parameters which are not associated with the rudder. Thus, recording the yaw damper, standby rudder on/off, and rudder pedal forces, which are related to **B-737** rudder movements, would have a greater benefit than recording control column and wheel forces, as well as other parameters. For the **B-737-100, B-737-200, B-737-300, B-737-400** and **B-737-**500 the addition of control column and wheel forces have a significant associated impact. The **B-737-600, B-737-700** and **B-737-800,** records control column and wheel forces but the existing sensor and FCC would have to be replaced, to meet the proposed range requirement, which also has a significant impact.

On early **B-737** airplane configurations, there will be a huge expense to comply with these requirements. Parameters that would have significant impact, includes the addition of new sensors to provide the new force parameters and the additional cards added to the **EAU** to provide Thrust Reverser Positions. Flight Data Recording Systems with pneumatic air data inputs would require a complete overhaul of the recording system, and changes to the Air Data System, would potentially requiring the development of a new pneumatic-to-electric conversion module. These are very significant and costly modifications for airplanes that are nearing the end of their useful service life. Clearly, the cost benefit analysis on these early **B-737** airplanes is much different than that on new production airplanes.

On newer airplanes currently configured with more modem Flight Data Recording System there are issues as well. A brief review of the current 64 word per second data frames revealed that there is insufficient capacity to allow recording of all the new requirements in a 64 word per second data frame. However, if for example the column and wheel force parameters were not to be added, it may be possible to add the other additional parameters while maintaining the 64 word per second frame. This point serves to illustrate that an incremental method is necessary to truly compare the costs and benefits of any specific additional requirement.

Based on the above examples, Boeing suggests that the FAA re-evaluate the requirement for each additional parameter separately for both production and retrofit impacts, and perform an incremental cost benefit analysis on each parameter.

Boeing Approach to Parameter 88

The most significant improvement that will be realized from the FDR upgrade is included in the existing rule (14 CFR Part 121,125,129,135, "Revisions to Digital Flight Data Recorder Rules; Final Rule", Amendment No. 12 1-266, 125-30, 129-27, and 135-69, effective date August 18, 1997) in requiring direct recording of surface positions and the associated control positions for all B-737 models. The additional requirement to measure force will provide useful information, but is not as significant of an increment in information over the already required control and surface position data.

Boeing Philosophy

The Boeing philosophy toward implementation of parameter 88 assumes that all recorded data will be used to determine control inputs, and not just control force. The use of all available recorded data (surface position, control position and control force data) allows determination of the total control force applied by both pilots in any situation or system failure mode, including jams in the system. The control and surface position sensors show the exact state of the entire system, including actuation of any system breakout device due to a jam or disagreement between pilots. The force transducers simply help determine how the control moved as measured by the position sensors. Boeing considers the sign of applied force to be more vital information than the magnitude of the applied force. Therefore, the combination of all available data allows isolation of system problems and differentiation between system versus pilot input. With this philosophy in mind, the Boeing-approach for measurement of parameter 88 (cockpit flight control input forces) was to use the column and wheel force transducer locations that already exist in the systems.

Column & Wheel Forces

On the B-737, force transducers already exist in the wheel and column control systems and are used by the Autopilot for Control Wheel Steering (CWS) functions. These transducers were designed into the system to measure normal operating forces applied by either or both pilots. Using these existing force transducer locations was considered the most effective design implementation of parameter 88 considering the cost and schedule impact of any other design. Other alternatives to using the existing force transducers are discussed later.

Pedal Forces

Previously, rudder control systems on all Boeing models were designed without force transducers because pedal force was not required for normal system operation. The current design for rudder pedal forces was chosen over a year ago not only to meet all upcoming regulations, but also with retrofit in mind. The single transducer design chosen by Boeing on most models meets all requirements specified by the existing rule, but is also simple to retrofit. Boeing wanted to encourage retrofit of pedal force, which at that time, was over-and-above what was required by the regulations. To this end, Boeing offered the parts to measure pedal force at no cost to encourage operators to retrofit the FDR parameter. The FAA has approved this design as meeting the requirements of the existing rule, as discussed later.

Capability of Boeing "Baseline" Implementation

The design used by Boeing on all axes can differentiate between an input caused by the system or an input by the flight crew. The exception is the rudder system, where pilot versus Nose Wheel Steering input cannot be distinguished (however a Nose Wheel Steering failure is considered extremely improbable and requires four independent faults). In addition, for systems with breakout devices (column and wheel), the force applied by each pilot can be determined if the system is ever broken out due to differential pilot input as shown by the position sensors. For the rudder system where there is no breakout device, individual pilot forces cannot be determined. This approach has been approved on other Boeing models.

Baseline B-737-NG (B-737-600, B-737-700, B-737-800, and B-737-900) Configuration for Parameter 88

The B-737-NG production design implementation of parameter 88 is shown in the enclosure (1). These configurations will be referred to as the "Baseline Configuration" because the FAA has already approved them as being in compliance with the existing rule as discussed further below. The design implementation for parameter 88 for each system is as follows:

Pedal Force (Baseline)

The B-737-NG includes a single rudder pedal force transducer on the push rod between the aft quadrant and input torque tube. At this location, the force transducer measures the total rudder pedal force input by either or both pilots. This design satisfies the parameter 88 requirements defined in the existing rule because no override or breakaway capability between pilots exists in the B-737 rudder system.

Column Force (Baseline)

The B-737-NG includes two column force transducers, one installed in the left cable control path and one installed in the right cable control path. The elevator control system has an override device between the two columns that allows both pilots to operate the controls independently. Since the primary control path from either pilot is via both cable runs, the force measured by both force transducers must be summed to obtain the total force applied to the system.

To comply with the existing rule, the column force transducers will be modified specifically for the DFDR application to achieve the increased force range and new FCC software and hardware will be installed to interface with the new transducers.

Wheel Force (Baseline)
The B-737-NG includes a single wheel force transducer installed in the left cable control path. This configuration was accepted by the FAA even though the lateral control has an override device between the two wheels that allows either pilot to operate the control independently. The primary control path from both pilots is via the left control path only, the right control path is normally not connected and is used only in the event of a failure. Therefore, the single wheel force transducer in the left cable control path records the control force inputs from both pilots. The FAA accepted the single force transducer on the condition that both the left and right control wheel positions were also recorded. Comparison of these two position sensors allows detection of breakout of the override between wheels which allows the right cable control path to become active. The FAA determined that this configuration meets the intent of the existing rule and approved the design.

To comply with the existing rule, the wheel force transducer will be modified specifically for the DFDR application to achieve the increased force range and new FCC software and hardware will be installed to interface with the new transducer. In addition the force transducer stops (airplane hardware) will be modified to allow the additional range.

B-737-NG Column and Wheel Force Retrofit
The retrofit design for the B-737-NG column and wheel force transducers is still in work. The retrofit design that meets the required force range will require modification of the wheel transducer travel stop, replacement of the existing column and wheel force transducers, and the FCC hardware and software which processes these signals and transmits them to the DFDAU for flight data recording. Retrofit component availability is being worked out with the affected suppliers. Since the new force transducers and the modified FCC hardware and software will not be available prior to July 2000, it is anticipated that retrofit of all B-737-NG cannot be achieved by August 18, 2000.

All B-737-NG in-service airplanes currently record ±15 lbs. wheel force and ± 40 lbs. column force. Boeing believes the reduced force range is acceptable for flight data recording purposes because the sign of the applied force is the most important information provided as discussed above in ***"Boeing Philosophy".*** Therefore, the preferred option would be no change of hardware and software and to record the force range described above. Full force range implementation could be made at the airlines earliest opportunity which would require hardware and software changes as described above.

Current FAA Position & Proposed NPRM
The baseline B-737-NG configuration for parameter 88 was found to comply with the

requirements of the existing rule. A meeting was held between Boeing and the FAA on June 24, 1999, with attendees from FAA-SACO, FAA-AEG, and Boeing. In this meeting, Boeing described a design for parameter 88 for all Boeing production models, including the B-737, B-747, B-757, B-767 and B-777. Following this meeting, Boeing submitted a letter to the FAA as a formal certification plan describing the proposed design. The FAA then approved the Boeing proposal (FAA Letter 99-130S-0887, "Intended Function Finding of Compliance for Federal Aviation Regulation (FAR) 12 1.344, Federal Aviation Administration (FAA) Project TD4 1 50SE-T", to BCAG, dated November 10, 1999.)

The B-737 parameter 88 design described above is identical to that presented in the meeting with the FAA. That same design is identical to what was approved for other Boeing models. This design implementation of parameter 88 was approved because it completely complies with the requirements specified by the existing rule which specifically states:

> ***"For airplanes that have a flight control breakaway capability that allows either pilot to operate the controls independently, record both control force inputs."***

There is no breakaway capability in the rudder control system on any Boeing model. Therefore, the existing rule specifically allows the single force transducer installation.

The proposal also states:

> ***"The FAA specifically requests comment on the necessity andfeasibility of instrumenting all four rudder pedals on B- 73 7 airplanes with force sensors as a means of compliance with paragraph (a)(88)."***

To date, neither the existing rule nor the proposal has specified a requirement that would necessitate a change to the current baseline design of pedal force. Specifically, neither regulation requires that individual pilot forces be measured such that parameter 88 alone be able to determine if one pilot was making an input that disagreed with the input of the other pilot. (i.e. there is no requirement to measure disagreement between pilots). Currently the NTSB recommendations and the proposal suggest the only issue is ***"a yaw damper event could be distinguished quickly from a flight crew input or a rudder anomaly".*** The current B-737 design of rudder surface position, pedal position and pedal force meets this intent.

<u>B-737-1 00, B-737-200, B-737-300, B-737-400, and B-737-500 Proposed Retrofit Configuration for Parameter 88</u>

The proposed design of parameter 88 for retrofit on B-737-100, B-737-200, B-737-300, B-737-400, and B-737-500 models is shown in the enclosure (2) and will basically be identical to that described above for the B-737-NG except as noted below:

Pedal Force
The pedal force transducer for the B-737-1 00, B-737-200, B-737-300, B-737-400, and B-737-500 is identical to the single force transducer that is the current baseline on the B-737-NG. This configuration has been delivered on B-737-1 00, B-737-200, B-737-300, B-737-400, and B-737-500 models since August 1998 and retrofit kits are currently available to operators for this installation on airplanes delivered prior to then. Any change to requirements to which this installation complies will require additional retrofit.

Column Force
The B-737-100, B-737-200, B-737-300, B-737-400, and B-737-500 include two column force transducers in the same locations as on the B-737-NG. The output from both force transducers must be summed together to determine the force applied to the system by either or both pilots. However, the elevator control system on the B-737-1 00, B-737-200, B-737-300, B-737-400, and B-737-500 does not have a jam override device between columns. Therefore, it cannot determine the force applied by individual pilots.

Wheel Force
The B-737-100, B-737-200, B-737-300, B-737-400, and B-737-500 include a single wheel force transducer in the same locations as on the B-737-NG. The lateral control system on the B-737-100, B-737-200, B-737-300, B-737-400, and B-737-500 is identical to the lateral control system on the B-737-NG relative to parameter 88 (see discussion under "*B-737-NG Wheel Force* "). However, it should be noted that this single force transducer design was accepted by the FAA on the condition that both the left and right control wheel positions were also recorded. Currently, the existing rule only requires measurement of the Captain's wheel position. To allow continued use of the single force transducer for parameter 88, Boeing would therefore propose that a second (new) wheel position transducer be added to the First Officer's control wheel. This will then allow the B-737-100, B-737-200, B-737-300, B-737-400, and B-737-500 wheel force configuration to be identical to that of the B-737-NG baseline.

B-737-100, B-737-200, B-737-300, B-737-400, and B-737-500 Column and Wheel Force Retrofit
The wheel force transducer currently used by the CWS system on B-737-100, B-737-200, B-737-300, B-737-400, and B-737-500 models does not meet the force range specified by the existing rule. To achieve the required range, accuracy, and resolution, would require a costly retrofit of approximately 3000 CWS wheel force transducers in the B-737 fleet, and there are significant concerns regarding the impact to the normal CWS functions on those airplanes. Boeing has reviewed several design options for retrofit of the wheel force transducer. In addition, discussions with the force transducer supplier indicate that the approximate availability of the force transducers would be 250 units per month, which implies it would be one year before a sufficient number of parts would be available to retrofit the entire B-737 fleet. Boeing is investigating alternate transducer suppliers, but cannot yet commit to a date for a sufficient number of parts available to support retrofit of the entire B-737 fleet.

Boeing is therefore proposing the following design for retrofit of these parameters. The existing installed CWS column and wheel force transducers, which interface with the

FCC, would be retained. The wiring between transducers and the FCC would be tapped into a new signal conditioning unit (installed in an existing or new LRU) which would then provide the force data to the DFDAU in a standard ARINC 717 format. This appears to be the lowest risk and cost option available at this time. The drawback is that the existing wheel force transducer does not have the force range capability required by the existing rule. The recorded control wheel force range would be ± 50 lbs. (±70 lbs. required).

Therefore, Boeing requests that the proposal allow flexibility in compliance to some of the sub-tier requirements (e.g. range, accuracy, etc.) in order to significantly reduce the retrofit impact on the B-737-100, B-737-200, B-737-300, B-737-400, and B-737-500 fleet. Boeing believes the reduced force range is acceptable for flight data recording purposes because the sign of the applied force is the most important information provided as discussed above in ***"Boeing Philosophy".***

Benefit versus Impact of Alternate Implementations of Parameter 88

Below is a discussion of possible alternatives to the baseline configuration described above. As stated before, the baseline configuration meet the currently stated requirements. Only if a new requirement is stated would it need to be changed.

However, the only new requirement that would force a change to the baseline configuration would be a requirement to directly measure forces applied by each individual pilot in order to determine any disagreement between the pilot inputs. This would require moving the force transducers as close as possible to the pilot input point rather than installed in a more accessible location elsewhere. That means adding transducers to the pedals themselves for pedal force, and adding transducers at the top of the control column (yoke) for column and wheel force. The alternative are discussed below:

Alternate Pedal Force Implementations

The proposal states:

> ***"The FAA specifically requests comment on the necessity andfeasibility of instrumenting all four rudder pedals on B- 73 7 airplanes with force sensors as a means of compliance with paragraph (a)(88)."***

The proposed addition of four individual rudder pedal force sensors to record rudder force would require a significant number of design changes in the rudder control mechanisms and to the structure of the cockpit floor. The desired location for installation of these force sensors has severe space limitations on the B-737 which limit the design options. At present, Boeing and our suppliers have not yet been able to identify a design solution that can be implemented without significant structural and system changes. This makes the retrofit task by the operators complex, lengthy and presumably costly. It is also expected that the design definition and implementation of four transducers would take considerably longer than the implementation dates proposed by the proposal.

Boeing believes that the four transducer implementation will provide little to no gain in additional information. Examination of the United 767 incident in Frankfurt will bear this out. The baseline single transducer will determine why the rudder moved in the first place (pilot or system) but cannot determine whether or not a pedal jammed. The four transducers would also determine why the rudder moved in the first place, but ***may*** **also** allow determination of which pedal was jammed or restricted. However the four transducers still could not tell ***why*** the pedal was jammed or restricted, because with either implementation, the jam or restriction is ***upstream*** of the transducers. Therefore, there is no major incremental gain in information from the four transducers.

Alternate Wheel & Column Force Implementations

The only alternate that gives additional data over the baseline would require the location of the force measurement to be moved upstream of the "branch" of the cross-connection to the other control column. That means adding transducers at the top of the control column (yoke) to directly measure applied column and wheel force. B-737-100, B-737-200, B-737-300, B-737-400, and B-737-500 (retrofit required) will also include two column force transducers. This would require significant study by Boeing to determine feasibility. An example of some issues identified: calibration concerns, reliability concerns, could impact CWS operation, could affect instrument vision (over the column), could require replacement of the entire control column assembly, a new column design may require airplane systems re-certification.

Summary of Alternate Implementations of Parameter 88

In summary, the impact of the alternate designs discussed above would be significant and costly to the operators. The incremental gain from the alternate force information does not appear commensurate with the design impacts, airplane down time, and system complexity issues. These alternate designs would take at least 18-24 months to develop and implement which is not in line with the schedule suggested by the proposal. Additionally these alternate designs are impractical to retrofit. Boeing believes its current design for parameter 88 meets the intent of the existing rule.

Yaw Damper Command

The proposal adds the recording of yaw damper command. It is stated that the intent of this requirement is to record the amount of voltage being received by the yaw damper system, which determines how much rudder movement is being commanded. On the B-737-NG airplanes, both the yaw damper command from the SMYD and the yaw damper LVDT position feedback are currently recorded via an ARINC 429 interface. On the B-737-100, B-737-200, B-737-300, B-737-400, and B-737-500 airplanes, Boeing is proposing to record the yaw damper LVDT position feedback from the new Yaw Damper Coupler (YDC) via an ARINC 429 interface, and if FDR capacity allows, the yaw damper command from the YDC via an ARINC 429 interface.

Standby Rudder Status

The proposal adds the recording of standby rudder status. It is stated that the intent of this requirement is to record whether the standby rudder system switch is in the on or off position. The standby rudder may be activated by means other than the switches.

Boeing believes that the intent of this requirement is to determine the actual status of the standby rudder system and not the position of any particular switch. Boeing is planning to record the state of the standby hydraulic system rudder shutoff valve, which is also controlled by both of the standby rudder system switches. Recording the position of this valve will provide a clearer indication of the actual status of the rudder standby system.

Scheduled **Implementation**

In the proposed amendment to Part 12 1.344, paragraph (m)(I) proposes the compliance date of August 18, 2000 for all Boeing B-737 model airplanes equipped with a flight data acquisition unit of any type as of July 16, 1996, or manufactured after July 16, 1996. This is applicable for production airplanes as well as all retrofit airplanes that fit in this category. Boeing believes that the proposed compliance date is unrealistic.

The compliance schedule, imposed by this proposal, is aggressive and presents unacceptable schedule risk. The implementation of the proposed additional parameters will not be an easy or simple task. Implementation of these parameters will require new sensor development, new and revised Avionics outside the recording system, new hardware installations and the installation of a new recording system that requires a DFDAU to process all of the required parameters. Boeing believes that this change could only be implemented during a scheduled heavy maintenance check, and that work outside scheduled checks would force the unnecessary grounding of B-737 airplanes.

Boeing is presently working on programs aimed at bringing the B-737 fleet into compliance with this proposal. Our aggressive plan assumes an aggressive response from our suppliers. Through our best effort, the earliest compliance date Boeing could support would be October 3 1, 2000. Boeing plans on providing a "generic" retrofit service bulletin approximately 1 year after the final rule is published. This generic service bulletin will not provide a specific retrofit installation for each 737 airplane. Therefore, airlines will expend time and resources to custom tailor a "generic" Boeing solution to fit their specific airplane configuration(s). A custom Service Bulletin, Supplemental Type Certification (STC) or equivalent package may take up to an additional year to develop.

Production

Typically, Boeing development of design solutions and commitment follow the final rule release. However, because of the anticipated short implementation flow of this proposed rule, Boeing has **pre-implemented** production design change commitment in an attempt to accommodate the expected FAA imposed schedule constraints. Typical development flow for a program of this magnitude would require a minimum 18 month flow. Boeing has been aggressively developing the required design changes, working closely with our parts suppliers, impacted airlines and the FAA with the intent of supporting the anticipated implementation activity as quickly as possible. Boeing and our suppliers can commit to a compliance date of October 3 1, 2000 for production airplanes.

In-Service Retrofit

Service Bulletins

Retrofit solutions for a significant number of design issues remain in work. The Service Bulletin to incorporate the changes on B-737-NG will be available no earlier than two months following completion of production certification. Boeing plans to develop two additional "generic" service bulletins, one for the B-737- 100 and B-737-200, and another for the B-737-300, B-737-400, and B-737-500. These bulletins will provide the Airlines with identification of new parts, and installation of complex sensors as required by this proposal. Boeing has developed an extremely aggressive plan to have these two Service Bulletins designed, developed, FAA approved, validated and available to the Airlines in the 1st quarter of 200 1. However, because the proposal alludes to alternative designs it is not clear what the final rule will actually require. The difference between this proposal and the release rule could affect the actual release of the bulletins. As discussed above, these bulletins are "generic" and it will be the responsibility of each Airline to complete their unique design, acquire parts and obtain a custom Service Bulletin, STC, or equivalent package. Boeing estimates that this activity could take up to an additional year, depending on the base-line configuration of the airplanes, and the degree of variation between airplanes within a particular airline's fleet. It may be two years before Airlines have a retrofit packages available. Boeing recommends that compliance to the final rule, for airplanes manufactured before October 3 1, 2000, be accomplished at the next scheduled heavy maintenance check starting two years after the release of the final rule.

Transducer Supplier Parts Availability

By August of 2000 there will be over 600 delivered B-737-600, B-737-700, and B-737-800 that will require 3 new force sensors installed on each airplane. There are over 3000 older B-737's in service, which will also require additional force sensors. This means more than 4,000 force sensors need to be produced and installed on all the B-737's (not including parts for production and spares) within the proposed (August 2000 and 2001) time frame. The transducer supplier has indicated that, with their best effort they may be able to produce 250 sensors a month. At that rate it would take the supplier over a year just to produce the parts. Boeing is actively investigating alternate transducer suppliers, but is not yet able to provide a parts flow commitment which could support the proposed stated implementation dates.

Fleet Impact

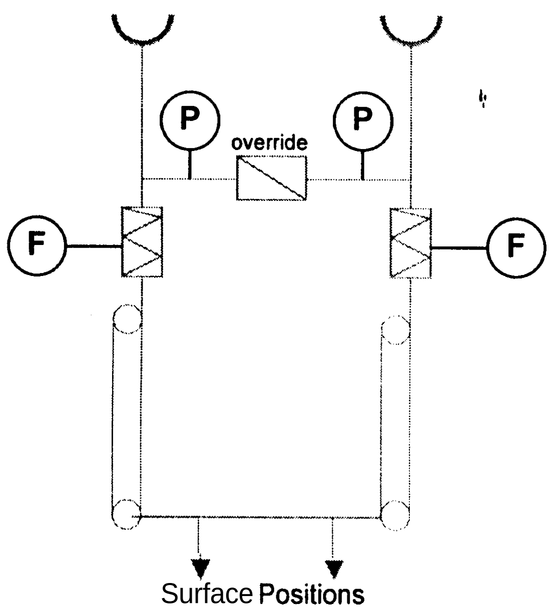
With the current proposal implementation dates, Boeing believes there would be a much higher cost associated with the loss of revenue than what is assumed by the FAA. Many Airlines may be forced to ground airplanes because they cannot get the required parts. Since parts would not be available until August 2000, practically every airplane would have to be taken out of service (not incorporated during a normal maintenance check) to implement these changes. Boeing believes that additional compliance time is required for retrofit airplanes.

FDR Flight Control Force Measurements

737-NG Production and RetrofitImplementation of Parameter 88

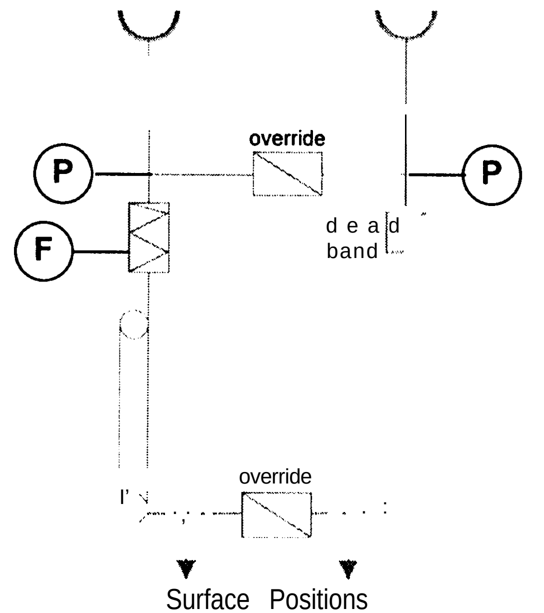
737-NG

Elevator System



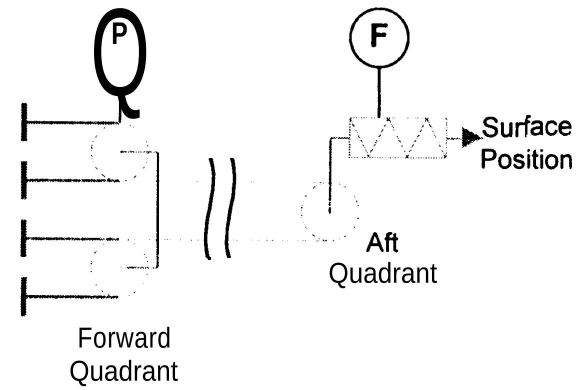
Note: The output from both force transducers must be summed together to determine the force applied to the system by either or both pilots.

Lateral System



Note: The single force transducer measures the force applied to the system by either or both pilots.

Rudder System



Legend

Position Sensor (P)

Force Transducer (F)

99-EAK-296ENC2.doc
01/10/2000

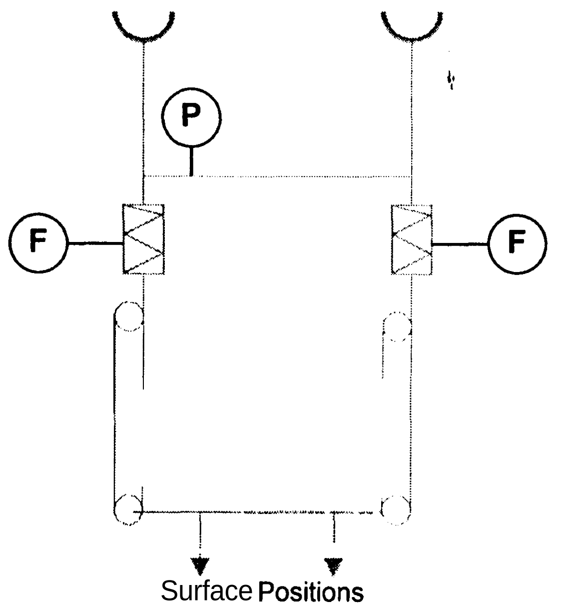
BOEING

FDR Flight Control Force Measurements

737-Classic Retrofit Implementation of Parameter 88

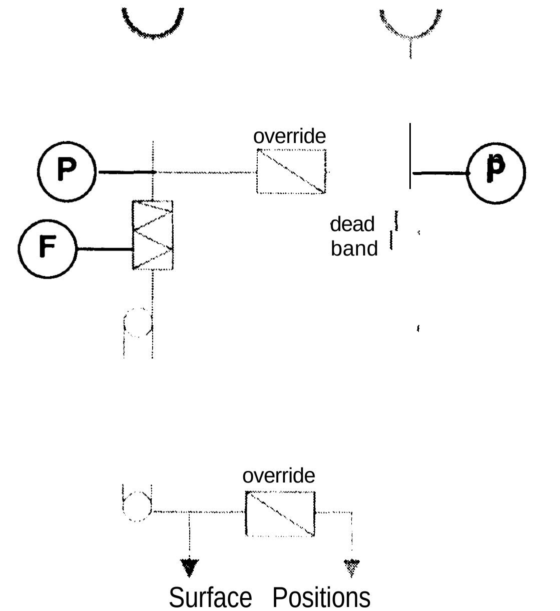
737-Classic (retrofit only)

Elevator System



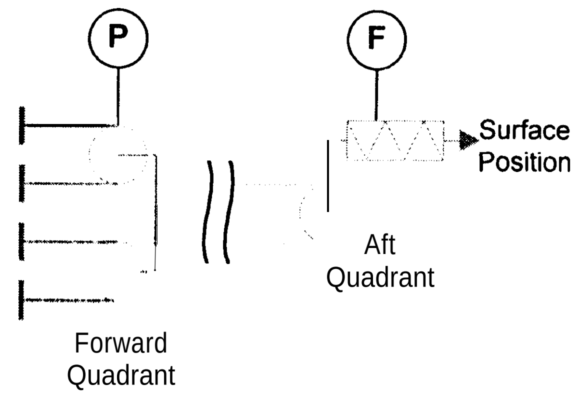
Note: The output from both force transducers must be summed together to determine the force applied to the system by either or both pilots.

Lateral System



Note: The single force transducer measures the force applied to the system by either or both pilots.

Rudder System



Legend

Position Sensor (P)

Force Transducer (F)