Page 1, 4th paragraph:

"The engineering simulation of the accident flight on the basis of the recorders data, conducted within the interested organization again (the Boeing Company, USA), was performed solely in the line to blame the perished crew without the consideration of the possible malfunctions of the aircraft control system. At the same time even on the basis of the Boeing company flight data readout stated in the report it may be ascertained that the crew throughout the whole flight had been in the control loop and had been trying to take actions to avoid the accident but average elevator nose down deflection was continued in a monotonous systemic way unusual for human actions."

Response: The engineering simulation is used during accident investigations to verify the airplane and its systems responded properly to the atmospheric conditions and recorded control inputs (flight control and thrust). The simulation can be further used to determine atmospheric disturbance or systems' anomalies that may have contributed to an event. In this event, the simulation results show the airplane responded as expected to flight control surface positions, thrust inputs, and atmospheric conditions.

The FDR data show the crew was not in the control loop for the entire flight, as the autopilot had been engaged for the majority of the flight. Further, the statement "…the crew…had been trying to take actions to avoid the accident…" cannot be supported or refuted from the available FDR data. We agree that the crew's actions were "unusual," but as stated in the report, the best explanation for those unusual actions—based on all of the available data—is that the crew lost spatial awareness and had not been properly trained to avoid or recover from that situation.

Page 3, 1st paragraph:

"There is no analysis of the crew actions with the A and B autopilot channels as well as of the reason for their in-flight switching (the Autopilot B was engaged at the beginning of the flight whereas the Autopilot A was engaged after the reaching of the flight level) (p. 1761). There is no analysis why the binary signal about autopilot B engagement appeared just prior the aircraft impacted the ground (T = 4071 sec as per Figure 23)."

Response: Page 176 of the report states: "A/P B was disconnected and A/P A engaged. Likely the PIC was the PF since that moment." Switching of autopilot channels is a crew option that is not usually mandated for operational reasons, but is generally a Standard Operations Procedure (SOP) that suggests the Pilot Flying (PF) alternate between the "A" and "B" autopilot channels. The choice is usually Channel A for the Captain and Channel B for the Copilot. During the incident flight, the change in autopilot channels could reflect a switching of the pilot flying, or a reflection of the possibility the autopilot was not switched earlier in the flight. The draft report states that the pilot flying during the approach was the captain. Typically, the PF will use the autopilot usually associated with the pilot flying; in this case the Captain would use the "A" channel.

Another possibility is the crew chose to utilize the "A" autopilot to examine the flight characteristics of the autopilot. The crew may have chosen to switch autopilot channels in order to exercise the "A" channel.

The change in state of the "B" autopilot channel at the end of the data is believed to have occurred after impact. At the same time as the autopilot discrete change, a rapid drop in computed airspeed and a rapid increase in pitch attitude are present. These are erroneous data points that occurred after impact.

Page 3, paragraph 3:

"On the Report's page 83 the conclusion is stated of the control system normal operation: "…both the values and curve slope are well consistent, which confirms the normal operation of the flight control system without any extra resistance". This correspondence is just the evidence that there had been no control linkage disconnect or its significant extension but in no way proves that there had been no nose down elevator hardover (runaway)."

Response: The data do not show indications of a nose-down elevator hardover. If a nose-down elevator hardover occurred, it would be expected the crew would have applied significant nose-up column force to return the column to neutral or pull in the nose-up direction. The significant force would have resulted in cable stretch leading to a noticeable discrepancy in the column-elevator relationship. Clearly, the data show the elevator deflected linearly with column, and elevator deflections were close to their expected values.

Furthermore, if a hardover existed, it would be expected that the crew would utilize any means available to regain pitch control. This includes the use of horizontal stabilizer trim which, although the data show was functioning as expected throughout the flight, was never commanded in an attempt to regain the desired flight path.

Page 3, paragraph 5:

"According to the available flight data the evaluation of the factual column forces is only possible on the basis of the deformation (extension) of the elevator control linkage. The evaluation of the factual forces with this method would have allowed determining the nature of the nose down elevator deflection. However at the examinations this method was not applied. The report does not contain the basis for the impossibility to use this method (for example due to insufficient accuracy of the source information)."

Response: Figure 26 on page 85 shows calculated force as calculated by the simulation. This force is based on column position and dynamic pressure. Calculated forces were presented in the analysis because column forces were not recorded in the FDR data received by Boeing. Column force data were not available to aid in the analysis of the elevator control system operation. However, the following observations can made from the available FDR data:

- The elevators deflected per design with column deflection throughout the entire flight. All elevator deflection data were consistent with expected values. These data 1) are not consistent with a jam in the elevator system and 2) preclude the existence of a jam in the system.
- The autopilot was not engaged during the final segment of the accident flight. Therefore, the nose-down elevator deflection could not have come from an autopilot input.

These observations 1) are not consistent with an airplane system producing the nose-down elevator deflection and 2) preclude an airplane system source for the nose-down elevator observed during the accident.

Page 3, paragraph 6:

"In the Report the elevator/column relations during go around in FD mode in other flights are not present, the comparative analysis of these relations to the relation, shown during the accident flight, has not been conducted either."

Response: The previous flight's FDR data were provided for analysis. The analysis shows that no go-around was performed in the previous flight; however, other portions of the flight were reviewed and analyzed. The data show the elevator deflected linearly with column, as expected, for the takeoff (Figure 1) and landing (Figure 2) of the flight before the accident flight. Furthermore, the elevators deflected as expected during takeoff of the accident flight (Figure 1).

Page 6, paragraph 5:

"4. Comments on the evaluation of the elevator power control units (PCUs) serviceability

The examinations of the PCUs within Parker Aerospace USA (hereafter referred as Corporation) being their designer and manufacturer have not been fully performed. The elementary principle of the failed technical objects examination implies the check of the assemblies' compliance with the specifications established by the manufacturer (see pp. 119-121) and the matching of the assemblies with the technical documentation and drawings. These examinations have not been performed."

Response: A full and detailed PCU exam was performed. To assess if the PCU was functioning normally, an X-ray Computed Tomography (CT) scan was accomplished, flow testing of the servos performed, and a teardown and a detailed inspection performed to detect any conditions that would prevent normal operation of the PCU. All of these tasks confirmed normally operating PCUs. To assert that the assemblies need to be matched against drawings is incorrect and is not the standard method to determine the functional operation of the PCUs. Any manufacturing anomalies would not have allowed the PCUs to operate normally in service for over 16 years for the left PCU and 31 years for the right PCU. Further, any manufacturing anomalies would not have allowed the PCUs to pass the full and detailed testing performed. These results were documented in the NTSB Airworthiness Group Field Notes and distributed to all investigation parties including the FATA.

Page 6, paragraph 7:

"The following information is not stated in the report:

-the PCU's Designer and Manufacturer certificate;

-the manufacture drawings of PCUs installed on the particular aircraft."

Response: The aileron & elevator PCU designer is Boeing and Parker builds the PCU in accordance to the Boeing requirements. Engineering drawings typically are not reproduced in an accident investigation report and especially when the drawings contain proprietary information. During the examinations the drawings were referenced with the investigation parties.

Page 7, paragraph 3:

"According to the MSNs of the left PCU parts the date of their manufacture was presumably defined as January of 1997. There is no information on the right PCU date and place of manufacture. The Boeing 737-500 (53A) VQ-BBN aircraft as it was claimed by the Boeing Company had been operated "on condition" since 1990. According to the date of production of the left PCU parts it was approximately determined that both PCU had been operated at least for 16 years. The reason for and the place of their installation and the causes of the previously operated assemblies pre-schedule dismantle have not been determined. It should be noted that the PCUs are different from each other in design."

Response: Based on sub-assembly serial numbers observed on the PCUs and cross referenced to the manufacturing documents, the left hand PCU was most likely manufactured in 1997 (~16 years of service) and the right hand PCU in 1982 (~31 years of service). The PCUs have the same design but different configurations since they were originally installed on different aircraft. These differences are described and outlined in the Boeing Overhaul Manual 27-09-21 and Service Letter 737-SL-27-052-B. The PCUs have a different configuration with slight differences in sub-components that does not change the form fit or function.

Page 7, paragraph 5:

"The report presents the results of the performed examinations of the assembled units together with the results of the conducted measurements of the slide-sleeve clearances. As per the presented results of the conducted measurements it follows that there is the increased friction load in the matched elements of the structure. Still the Corporation has not provided the investigation team with any drawings. The same can be attributed to all the other specifications and results of measurements, given in the Report. In all cases the opinion of Corporation is meant, which is not justified by any documents."

Response: The servo was tested in accordance with the Acceptance Test Procedure (ATP) and recorded on the Test Data Sheets which were provided to all attendees and summarized in the NTSB Airworthiness Group Field Notes during the examination. The clearance measurements are not normally performed on in- service units and there is no formal documentation or requirement for this activity. The clearance was measured at the June Irvine examination after the control valves had been disassembled. Since there was no intent to measure the clearance of the valves, they were not properly protected from the environment and most likely formed a raised film of corrosion causing the clearance to be smaller than required. This raised layer of corrosion resulted in a 0.5 to 0.75 lb increase in slide

friction measured when the control valve was reassembled for servo flow ATP testing. This higher than specified friction is expected as a result of a tighter clearance. During normal repair and overhaul activities if the valves are disassembled they would be placed in corrosion preventative oil or protective bags and then wiped on a lathe prior to re-assembly and subsequently re-tested to validate flow and friction requirements.

However, even if this friction is assumed to be present prior to the accident which it likely was not, this only would result in an increase of 0.1 pound for the pilot to move the control column. No pilot would be able to discern this extremely minute force difference and this would not affect normal elevator operation.

This data and drawing information was recorded in the NTSB Airworthiness Group Field Notes and provided to all investigation parties including the FATA.

Page 7, paragraph 6:

"So, for example, the revealed circular marks on the slide surface are considered as insignificant that could not have any serious adverse effect to the friction load increase and assembly serviceability. This expert estimation of the interested party is supported by nothing."

Response: All marks observed on the control valve were the result of manufacturing, normal in service usage, or disassembly marks which do not affect the performance of the control valve. Evidence of these marks does not indicate performance degradation. The performance of the control valve is verified and accomplished by flow testing per the ATP which was accomplished and the results show normally operating control valves. These ATP flow tests were documented on the Test Data Sheets and distributed to all investigation parties including the FATA and summarized in the NTSB Airworthiness Group Field Notes.

Page 7, paragraph 7:

"Furthermore the burrs were discovered on the slide port edge, what is considered, in opinion of the Russian experts, to be unacceptable defect of manufacture. These burrs had got into the clearance between the matched couples, which is proven by the trace present on the surface in the direction of moving. In the Corporation's opinion the burrs had got into the clearance at the moment when the unit was disassembled and left the given mark. This opinion is unsubstantiated because as for such statement the analysis of the matched parts displacement direction along the applied damage should have been conducted with the use of, for example, electron microscope – this has not been done. Only upon the completion of this analysis it is possible to assert unambiguously, whether the single or repeated displacement led to this mark and consequently to answer the question on its origin."

Response: It is not stated which "burr" or slide port edge this is referring to, but an area of the pressure outlet edge of the right hand bypass sleeve ID was noted and discussed during the examination. This edge has an irregular and wavy appearance that in places has a beveled edge. This is attributed to the machining done at manufacture. Since this is a bypass valve that functions as an on-off valve, the metering edges do not have to be as precise as a control valve would be. If the bypass valve passes the flow and friction requirements during flow tests, this machining would be acceptable during

manufacture. As discussed the bypass valve passed these flow tests prior to shipment. The light marks observed were measured and extend for approximately 0.429" and pick up to the right of this port and extend an additional 0.175" for a total travel of over 0.6". Valve travel is ~0.090", so it is not possible these marks were from the normal bypass slide travel. These marks could only happen upon disassembly or assembly from some debris or FOD that would have been felt as resistance removing or inserting the slide. Also, the lines are not straight in the longitudinal direction. Rather, the lines follow a curved line as if taking the slide out of the sleeve and twisting slightly. The corresponding slide surfaces in this area look clean and there is no evidence of chip shear. These marks are very light and not deep and would not affect the bypass valve function. Analyzing these marks per the SEM is not required as the ~150x magnification used with the borescope is more than adequate to characterize and understand the marks.

Page 8, paragraph 2:

"Moreover, there are manufacturing defects related to the drilling of the sleeve land. This influences the operation of the assembly and can cause the anomalies in the operation. On this issue the Corporation declared that this condition matched with the drawing requirements, although the investigation team had not been provided with those drawings."

Response: There was a feature of the right hand PCU control valve secondary slide during manufacture of the recessed hole where the flow ports are machined. The machining operation lightly touched the side of the edge of the land on the non-critical non-metering edge side. These features were determined to be within the tolerance requirements of the applicable drawing. Since this feature was within drawing tolerance requirements, testing per the ATP verified that these features have no effect on valve operation and is not a manufacturing defect. Test Data Sheets of the ATP flow tests were provided to all investigation parties including the FATA verifying proper operation.

Page 8, paragraph 3:

"It is worth noting that the revealed discrepancies from manufacturing specifications being obvious in opinion of the Russian experts were proposed by the Corporation to be considered as the unessential and invariant as for the assemblies total operation."

Response: There were no manufacturing discrepancies found. The revealed features were all within manufacturing specifications and in no way affected normal operation as evidenced by over 16 years and 31 years of in service operation.

Page 8, paragraph 4:

"It should be added as well that in the progress of the assemblies' condition analysis in USA the Corporation declared the following:

-there are no manufacturing documents for these units as they had been manufactured long time ago;

-there are no exact data on the assemblies accumulated hours as they are operated without life limit/service life;

-the revealed damages on the inner surfaces are considered common and can be observed in all assemblies with great quantity of accumulated hours. Still the Corporation did not present any disassembled unit from another aircraft with great amount of accumulated hours for comparison and did not show similar damages."

Response: The manufacturing documents do exist and are available but were not able to be matched to the specific VQ-BBNs PCUs as they are organized per PCU serial number. Since the part number and serial number data tags were missing from the PCUs, and no documentation was available recording which serial numbers were installed on the aircraft, the specific manufacturing documents are not able to be confirmed and matched to the PCUs.

Parker does not track accumulated hours on any components whether hard timed or on-condition and is up to the operator to track and report this data.

Parker presented control valve testing results showing simulated chip shear and contamination testing. None of these distinct and obvious conditions were observed on VQ-BBN PCUs.

Page 8, paragraph 6:

"Besides it is important to note that the total of discovered marks, burrs, increased friction load, the non- conformity of the minimum clearance to the drawing requirement, which is the evidence of the manufacture failure, is considered insignificant by the Corporation due to the fact that there is a specific team within the Corporation that, in case of manufacturing defects are revealed, makes the decision on the basis of their own reasoning whether to release to service the assembly with defective part or not. The passing of the flow tests is the main criterion. The data on the accident units as far as their conformity to the flow tests specification at the date of their manufacturing were not presented to the investigation team."

Response: These PCU control valves exhibited normal manufacturing, in-service, and assembly/disassembly marks which did not affect normal operation as verified by the ATP flow test performed, recorded on the Test Data Sheets, and distributed to all investigation parties including the FATA. The manufacturing data and paperwork was unable to be located due to the missing PCU data tags and no aircraft paperwork showing the installed serial numbers of the PCUs. When or if this could be determined and provided, Parker would be able to confirm the manufacturing paperwork and share this with the investigation parties.

Page 9, paragraph2 :

"*For instance on November 19th, 2013 at the approach to the Kittilä airport (Finland) the serious incident occurred to the Norwegian Air Shuttle ASA Boeing 737-800 aircraft because of the anomaly in the PCU functioning, the self-induced elevator deflection in nose up direction. After the pilots' intervention with the control input of 94 kg the crew managed to recover the control of the aircraft*

(pp. 163-164). This enables to presume that the Boeing 737-500 (53A) VQ-BBN fatal accident could have occurred on the same scenario, only the elevator displacement occurred to nose down."

Response: The Norwegian Air Shuttle event occurred on December 26, 2012, and the FDR data show characteristics of an elevator restriction in which elevator did not deflect with column deflection. By contrast, the column-elevator relationship shown on the VQ-BBN accident flight is linear, and is completely different from that observed on the Norwegian Air Shuttle event. In addition, the Norwegian Air Shuttle incident was controllable with appropriate input from the pilots of that flight, but the FDR data for the VQ-BBN accident flight do not reflect any similar input from the pilots. Therefore, the Norwegian Air Shuttle event data provide substantiation that the VQ-BBN accident flight did not experience a similar elevator control system anomaly.

Parker participated in the Norwegian Air investigation and examination of the PCUs and there was clear FDR evidence that de-icing fluid had frozen and affected the PCUs operation. The autopilot commanded the horizontal stabilizer to change angle which resulted in the aircraft pitching up. When the crew applied a force to the column, the ice was able to be overcome and eventually PCU and elevator control returned to normal. FDR data for the VQ-BBN accident clearly shows the PCU and elevator position matched column input unlike the Norwegian event. Also, there was not any evidence of contamination on the VQ- BBN PCU manifolds or input lever areas. The Norwegian Air incident and VQ-BBN accident are not related.

Page 9, paragraph 4:

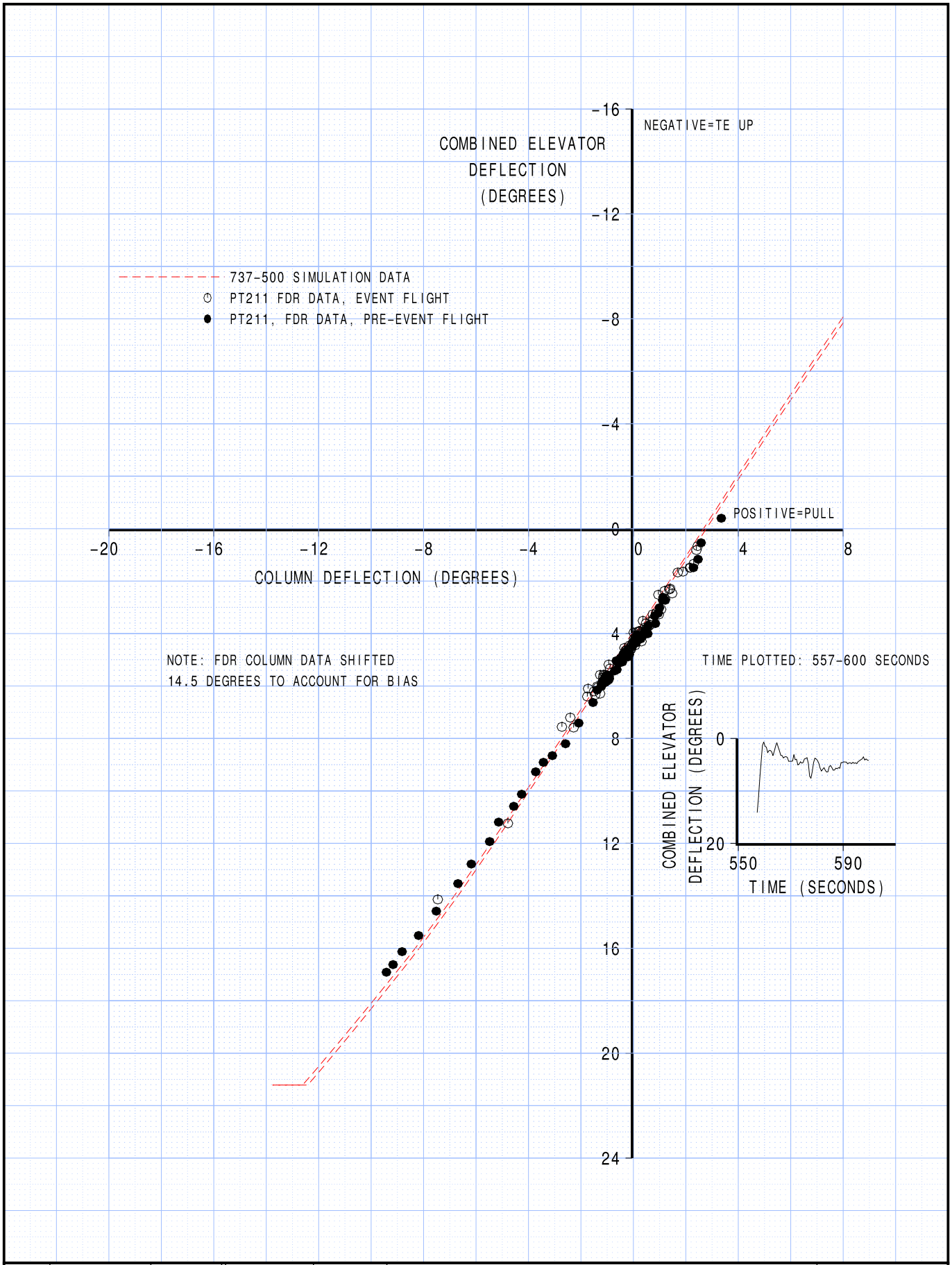
"Thus as for the examined assemblies of the control system of the Boeing 737-500 (53A) VQ-BBN aircraft that sustained the accident in the Kazan International airport on November 17th, 2013, there are discrepancies from specifications (the increased friction load) and geometry (the sleeve land is drilled, there are the burrs on the port edge) as well as marks on the contact surfaces. All the revealed defects should be analyzed with the use of specific investigation methods, compared to the manufacture documentation data, as well as simulated from the point of view of the possible consequences on aircraft control. No sooner than after that the definite and the evidential answer can be given to the question whether the Boeing 737-500 (53A) VQ-BBN control system assemblies' condition could have had the effect on the air accident in the Kazan International airport on November 17th, 2013."

Response: Since the valves had been disassembled and open to the air for 3 months, there was an increased friction observed during ATP testing. This increased friction at the control column was measured at 0.04 lb and 0.06 lb for the left and right PCU respectively. Assuming this was present prior to the accident would only increase the force required to move the column by 0.1 lb which is insignificant and would not be noticed by the pilots. The manufacturing "discrepancies" alleged by FATA are not discrepancies and are within drawing requirements and do not have an effect on performance as verified by acceptable flow testing performed and confirmed by the ATP. All marks observed on the control valve were the result of disassembly, manufacturing, and normal in service usage which do not affect the performance of the control valve as confirmed by the acceptable flow parameters measured by the ATP testing.

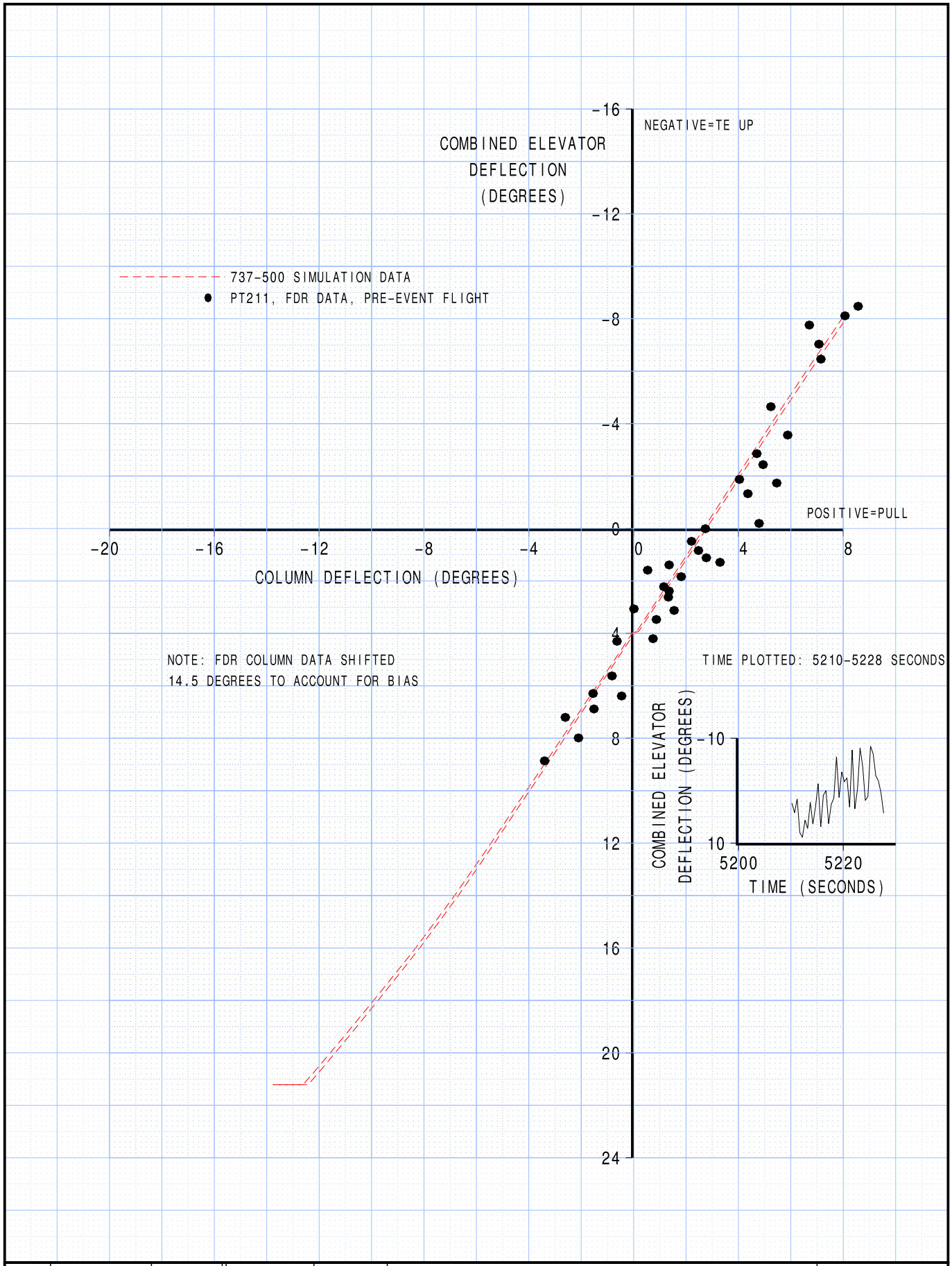
<u>Page 12, last paragraph</u>:

"*The mentioned facts can be the evidence of the non-conformity of the Boeing 737-500 aircraft type design with the certification requirements and of the Interstate Aviation Committee disinterest in the objective investigation being the organization that combines the functions of type certification and the air accident investigation of civil aircraft on the territory of Russian Federation in one legal entity.*"

<u>Response:</u> The US agrees with the Interstate Aviation Committee's draft Final Report on the accident involving airplane VQ-BBN. The aircraft underwent extensive analysis and testing, and was shown to conform to all requirements, before it was certified as airworthy. Nothing in the data from the VQ-BBN accident flight, or anything in the accident airplane's service history since its original delivery, calls into question the conclusions reached during certification. The accident airplane functioned as designed and responded to the crew inputs as designed. There was no evidence of any airplane anomalies during the accident flight.



CALC	AERODYNAMICS	9Dec15	REVISED	DATE	TTQ 737-500 GO-AROUND ACCIDENT 17NOV13--TIME-ALIGNED FDR DATA EVENT VS. PRE-EVENT FLIGHT,ELEV X-PLOT(TKO)	PT211/VQ-BBN
CHECK						FIGURE 1
APPD.						
APPD.					BOEING®	PAGE



CALC	AERODYNAMICS	9Dec15	REVISED	DATE	TTQ 737-500 GO-AROUND ACCIDENT 17NOV13--TIME-ALIGNED FDR DATA PRE-EVENT FLIGHT, ELEV X-PLOT (LANDING)	PT211/VQ-BBN
CHECK						FIGURE 2
APPD.						
APPD.					BOEING®	PAGE