NATIONAL TRANSPORTATION SAFETY BOARD
Investigative Hearing
Alaska Airlines Flight 1282
Boeing 737-9, N704AL
Left Mid Exit Door Plug Separation in Portland, OR
January 5, 2024

Docket No.	SA-543
EXHIBIT	
11A	

Manufacturing Records and Human Performance Factual Report

(56 Pages)

National Transportation Safety Board
Office of Aviation Safety
Washington, DC 20594

DCA24MA063

MANUFACTURING RECORDS AND HUMAN PERFOMANCE

Group Chairs' Factual Report

July 3, 2024

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A ACCIDENT

Location: Portland, OR
Date: January 5, 2024
Time: 1714 Pacific Standard Time
0114 Universal Time Coordinated
Airplane: Boeing 737-9, Alaska Airlines N704AL (SN: 67501, Line 8789)

B MANUFACTURING RECORDS AND HUMAN PERFOMANCE GROUP

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Group Member	Troy Levanen/Sam Hong Alaska Airlines Seattle, WA
Group Member	Captain Bjorn Anderson Air Line Pilots Association Seattle, WA

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C SUMMARY

On January 5, 2024, at about 1714 Pacific Standard Time, Alaska Airlines flight 1282, a Boeing 737-9, N704AL, returned to Portland International Airport (PDX) after the airplane suffered a rapid decompression when the left-hand mid exit door plug departed the airplane, resulting in substantial damage. On board were 2 flight crew, 4 cabin crew and 171 passengers all of whom deplaned at the gate. Several passengers received minor injuries. The flight was a Title 14 *CFR* part 121 scheduled domestic passenger flight from PDX to Ontario, California (ONT).

D DETAILS OF THE INVESTIGATION/FACTUAL INFORMATION

The mid exit door (MED) plug was first introduced into production on a 737-900ER that was delivered on January 14, 2008. The first 737-9 with a MED plug installed was delivered on April 23, 2018.

As detailed in the preliminary report, the accident MED plug was manufactured by Spirit AeroSystems Malaysia on March 24, 2023, and was received at Spirit AeroSystems Wichita on May 10, 2023. The MED plug was then installed and prerigged on the fuselage (Spirit AeroSystems Fuselage Line 8789) before it was shipped to Boeing on August 20, 2023. The fuselage arrived at Boeing's Renton, Washington, facility on August 31, 2023.

The MED plug was primarily constructed of aluminum and was installed in the fuselage by means of two upper guide fittings and two lower hinge fittings (See Figures 1 and 2). The two upper guide fittings were located on the upper sides of the plug and engage with two upper guide rollers that were fixed to the upper sides of the forward and aft frames common to the fuselage opening (See Figure 3). Two lower hinge guide fittings were fixed to the lower section of the MED plug and engaged with the two lower hinge fittings that were attached to the frame common to the bottom of the fuselage opening at the lower hinge bracket assemblies.

Once the MED plug was in place, it was secured from moving vertically by a total of four bolts. There was a bolt installed through each upper guide fitting and each lower hinge guide fitting. Once these bolts were installed, they were secured using castle nuts and cotter pins. Outboard motion of the MED plug was prevented by 12 stop fittings (6 along each forward and aft edge) installed on the fuselage frame structure common to the MED plug.

The MED plug was only intended to be opened for maintenance and inspection, which required removing the vertical movement arrestor bolts and upper guide track bolts. The strap assemblies below the second stop pad from the top restrict the plug from opening further than 15°, suitable for maintenance and inspection purposes (See Figure 3).

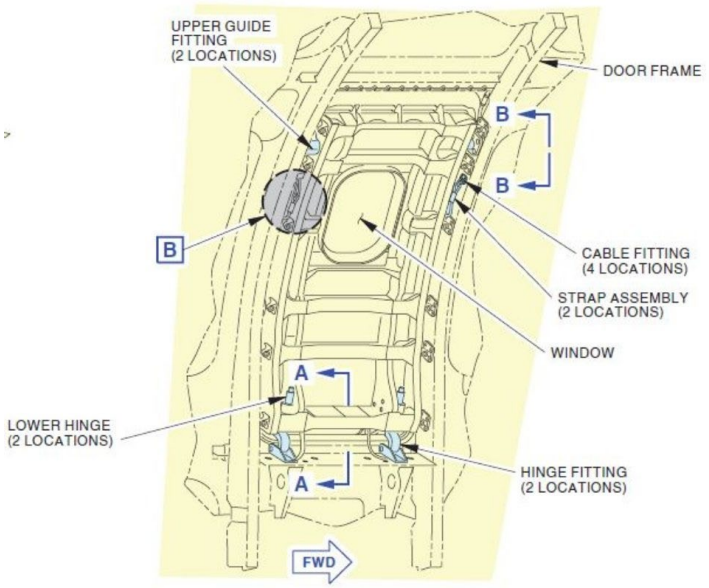

Figure 1. 737-9 Mid Exit Door plug. (Source: Boeing. Image Copyright © Boeing. Reproduced with permission.)

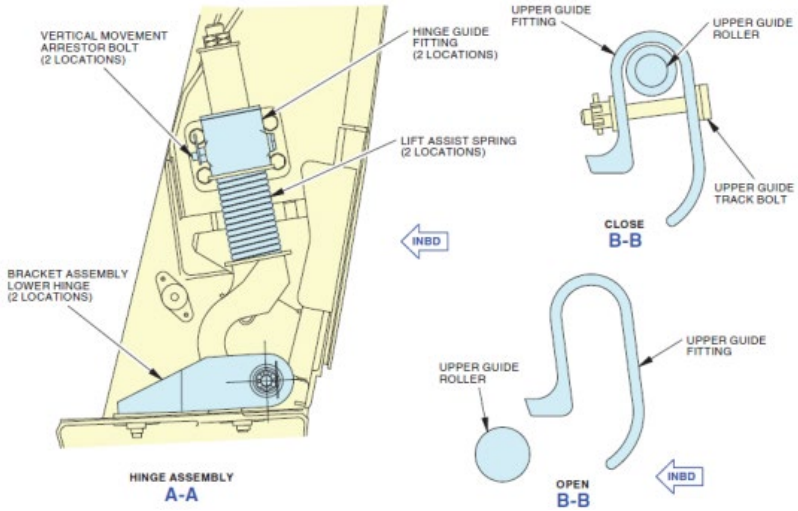

Figure 2. 737-9 Mid Exit Door plug – Arrestor and Track Bolts. Boxes added for emphasis. (Source: Boeing. Image Copyright © Boeing. Reproduced with permission.)

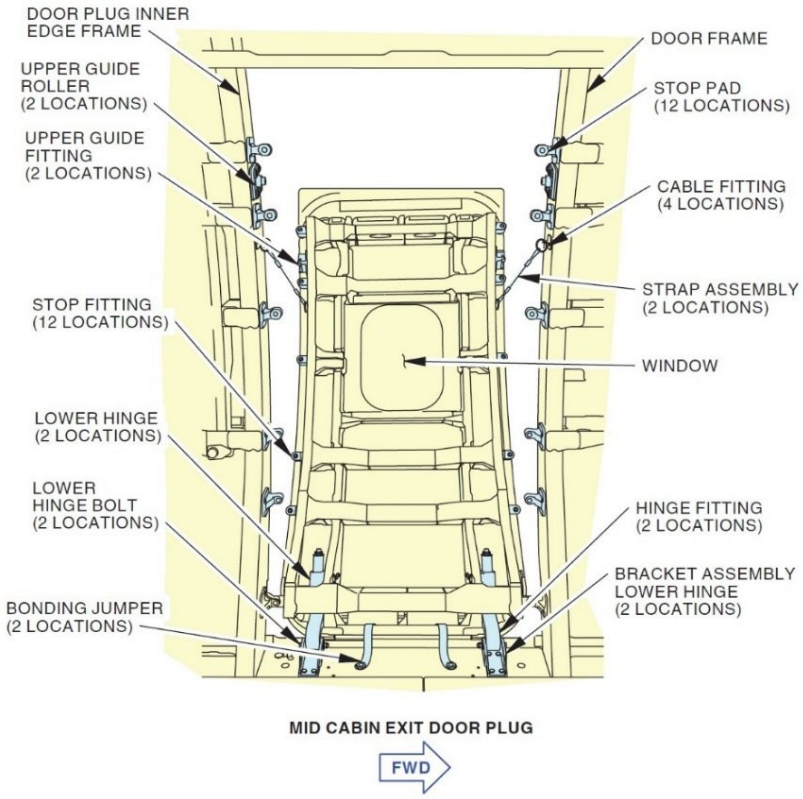

Figure 3. 737-9 Mid Exit Door plug – Components. (Source: Boeing. Image Copyright © Boeing. Reproduced with permission.)

The NTSB's investigative team conducted a post-accident examination of the Left-Hand (LH) MED plug and its installation hardware. Observed damage patterns and absence of contact damage or deformation around holes associated with the vertical movement arrestor bolts and upper guide track bolts in the upper guide fittings, hinge fittings, and recovered aft lower hinge guide fitting indicate that the four bolts that prevent upward movement of the MED plug were missing before the MED plug moved upward off the stop pads. For additional information see the Materials Laboratory Factual Report 24-007.

1.0 Manufacturing Records and Human Performance Group

The Manufacturing and Human Performance Group was formed to review typical Build Process and Manufacturing Records for the event airplane with a focus on the Mid Exit Door (MED) plug, Quality Management System (QMS), Safety Management System (SMS) and Federal Aviation Administration (FAA) Oversight.

1.1 Manufacturing Records and Human Performance Group Activities

a. On January 13–14, 2024, the Group met at Boeing's Renton facility in Seattle, WA, to review the Boeing Build Process and review records from the event airplane.

b. On January 15–17, 2024, the Group traveled to Spirit AeroSystems facility in Wichita, KS, to review the Spirit AeroSystems Build Process.

c. On January 23–24, 2024, the Group met at AAR Aircraft Services in Oklahoma City, OK to review the Supplemental Type Certificate (STC) of the WIFI and PCS Antenna Installation of the event airplane.

d. On January 25–27, the Human Performance Investigator traveled to the Boeing Renton Facility to review information pertaining to Boeing's supplier quality management system and their voluntary safety management system.

e. On March 4–7, 2024, the Group met at Boeing's Renton facility in Seattle, WA to interview Spirit AeroSystems and Boeing Manufacturing Personnel.

f. On April 9–12, 2024, the Group met at Boeing's Renton facility in Seattle, WA and the FAA Regional Office in Des Moines, WA, to interview additional Boeing Manufacturing Personnel and FAA Oversight and FAA Safety Management System Personnel. Additionally, the Group reviewed the manufacturing removal process with Boeing Quality subject matter experts.

g. On May 7–8, 2024, the Group met at the FAA Regional Office in Des Moines, WA, to interview additional FAA Oversight and Safety Management System Personnel.

h. On May 17, 2024, the Group held a virtual meeting to interview the FAA personnel who performs oversight of Boeing supplier control at Spirit AeroSystems.

i. On June 5, 2024, the Group held a virtual meeting to interview a recently retired (December 2023) FAA employee involved in initial development of the FAA Safety Management System and was a previous Principal Inspector on the Boeing Production Certificate.

2.0 Spirit AeroSystems

Spirit AeroSystems (i.e. Spirit) was the world's largest manufacturer of aerostructures for commercial airplanes, business/regional jets, and defense platforms. The company was a major supplier of the 737 and 787 fuselage to the Boeing Company. Spirit AeroSystems was headquartered in Wichita, Kansas, with Spirit facilities in the US, UK, France, Malaysia, and Morocco.

2.1 Spirit AeroSystems Build Documents – Wichita, KS

Spirit AeroSystems used several build documents (Engineering Requirements, Work Instruction Documents, Quality Notifications, etc.) in the production of the 737 fuselage in their factory. A short description of the requirements and documents are as follows:

2.1.2 Engineering Requirements

The following represent the engineering requirements used in the 737 fuselage manufacturing process at Spirit AeroSystems.

- Engineering Drawings – Contained the product definition data. This included Computer-Aided Three-Dimensional Interactive Application (CATIA) Models, Supplier Module Parts Lists, and Picture Sheet Data Lists.

- Boeing Product Standards – Documents called out in engineering drawings (i.e. Boeing Process Specifications, Boeing Material Standards, Boeing Specification Support Standard)

2.1.3 Work Instruction Documents

- Spirit Installation Plans (SI) – Contains the master data[1] for installation plans.
- Production Orders – Manufacturing Execution System containing only parts and operations applicable to the specific line unit configuration. These are where operation labor is started, characteristic information is recorded (i.e. torque tools, seal information, etc.), Quality Notifications are written, and operations are confirmed.
- Rework Orders – Created from a Material Review Board Quality Notification disposition to accomplish engineering required rework or repair of a noted defect.
- Out of Sequence Plans – Only used for authorized work that is added to the baseline (late Engineering release or configuration change).

[1] Data that contains the work instructions and components to build the fuselage specific to customer requirements.

2.1.4 Quality Notification Documents

- Pick-up – A nonconformance record that documents conditions that exist on material, parts, assemblies, and installations that are not satisfactory and can be reworked back to conform to Engineering.
- Quality Notification (QN) – A nonconformance that is used to record and document conditions that cannot be reworked within the process specifications and require Material Review Board disposition by Liaison Engineering. Requires a rework order to be created and released.
- Supplier Non-conformance Notification (SNN) – A nonconformance not completed at Spirit that travels to Boeing requiring rework.
- Ship Short – Hardware, parts, or material is not available to complete work prior to unit shipping.

2.1.5 Record Retention Policy

Spirit AeroSystems complied with contractual requirements to Boeing that identified the records currently under Spirit's care, custody, and control. These requirements defined the minimum length of time which identified Boeing records and information that must be retained, regardless of media characteristics (e.g., paper, microforms, electronic, digital, etc.) and/or location. Spirit retains records in a retrievable format and for a period of not less than the record-keeping contractual requirements and makes records available to regulatory authorities and Boeing authorized representatives.

Engineering documents were typically kept for the Life of the Type Certificate.[2] Manufacturing Process and Evaluation Records, Quality Assurance Production Records, and FAA Certificates of Airworthiness and Conformity were kept for the Calendar year + 10 years from the date of shipment under each applicable order, unless otherwise specified. Nonconformance Records were kept for the life of the product.

Boeing reserved the right to request delivery of a copy of the records at the expiration of the record retention period. In the event Boeing chooses to exercise this right, Spirit must provide those records to Boeing.

[2] A design approval issued by the FAA when the applicant demonstrates that a product complies with applicable regulations. As defined by 14 CFR 21.41, the type certificate includes the type design, the operating limitations, the type design data sheet, the applicable regulations, and other conditions or limitations prescribed by the Administrator. The type certificate is the foundation for other Federal Aviation Administration approvals, including production and airworthiness approvals. Reference Order 8110.4C.

2.2 Mid Exit Door Plug

Figure 4. Left photo: Exemplar MED Plug installed on airplane. Right photo: Recovered LH MED Plug. [NTSB Photos]

Spirit AeroSystems had design responsibility for the MED plug. This included the build standards and Engineering Drawings. The LH MED plug installed on the accident airplane was built per applicable engineering drawings.

The LH MED plug installed on the accident airplane had the following data plate and written marking information:

Data Plate:	Marking:
Aircraft Mod. 737	Aircraft Mod: 737
MFR Code: Y0279	MFR: Y0279
Part No. 146A6202-9101	Part Number: 146A6202-9101
Serial No. Y0279-000153	Serial Number: Y0279-0000153 (sic)
Cont. Insp. SAA 101 QU (Stamp)	Line Unit: 8799[3]
	Made in Malaysia

[3] According to Spirit AeroSystems, the manufacture instructions for build of the MED plug specifies that it be serialized and marked for the intended fuselage line unit number. Commonly in aerospace manufacture, the requirement to mark the down-stream line unit number on an up-stream assembly is seen when there are different available variations in design of an assembly. The MED plugs are different numbers for the Left Hand and Right-Hand assemblies. However, neither the LH nor the RH MED plug assemblies have design variations, so labeling with a fuselage line unit number in build of the MED plug is not instrumental. There is no requirement in manufacture of the fuselage that the equivalent MED plug be installed on the same fuselage line unit number. The traceability of the MED plug assembly is ensured by serialization of the MED plug assembly.

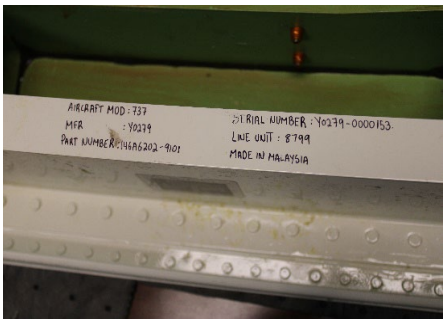

Figure 5. Left photo: LH MED plug Data Plate. Right photo: Markings on accident airplane [NTSB Photos]

According to Manufacturing Records, the LH MED plug installed on the accident airplane was manufactured by Spirit AeroSystems Malaysia on March 24, 2023, and received by Spirit AeroSystems Wichita on May 10, 2023.

The Spirit AeroSystems Malaysia Production Order showed discrepancies for the LH MED plug during manufacture. One discrepancy was for mechanics not recording torque wrench serial numbers in the production order and another discrepancy was for mechanics not providing the sealant/paint information in the production orders. Both discrepancies were later corrected per the Spirit AeroSystems process.

2.3 MED Plug Edge Frame Installation

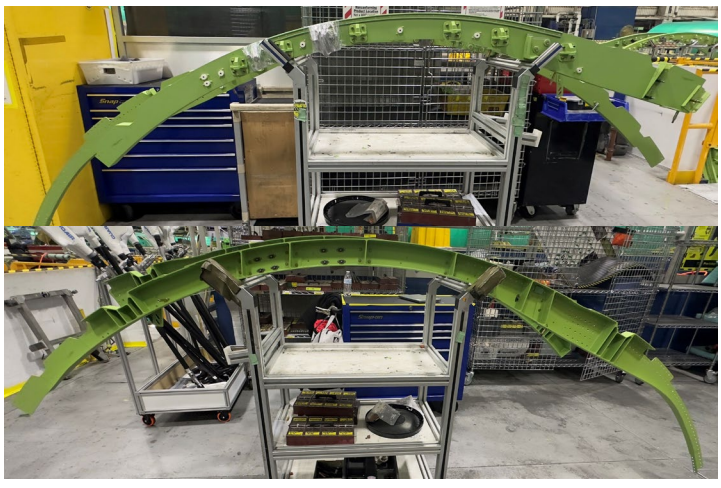

Figure 6. Left photo: MED Plug Edge Frame components. Right photo: Edge Frame Installation on Fuselage [Source: Spirit AeroSystems. Reproduced with permission]

Both the LH and Right-Hand (RH) MED plug edge frames components installed on the fuselages during production were manufactured by a Spirit AeroSystems supplier, Quik Tek. The edge frame components were delivered to Spirit AeroSystems, placed in inventory, and stored in the factory.

On fuselage 8789 the LH edge frame components were first installed on a MED edge frame locating jig and then installed on the fuselage, per Spirit AeroSystems Production Order 46534209. There were no QNs associated with the installation. The LH edge frame installation on Fuselage 8789 was started on June 16, 2023, and finished on June 19, 2023.

After the accident Spirit AeroSystems notified the edge frame assembly component manufacturer, Quik Tek, regarding the workmanship issues (NCR N1450292531 in Section 3.4.1) identified in fuselage 8789 in Renton. A review of the Quik Tek production process for the edge frames was started by Spirit AeroSystems as well as a complete inspection of the door edge frames installed at Spirit, in stock at Spirit, and in stock at Quik Tek. None of the edge frames exhibited conditions consistent with those reported by Boeing on the accident airplane. On March 5, 2024, Spirit AeroSystems generated a Supplier Activity Report (SAR 49736) to document the review process and additionally document resolution of a separate issue[4] identified during its review of the supplier production process.

2.4 Fuselage Production of 8789

The LH MED plug was installed and pre-rigged on fuselage 8789 on July 18, 2023, per Production Order 46554596. There was one Quality Notification (QN), (QN NW0002407062 - Route Fuselage Opening - LH Mid Exit Door) specific to the LH MED plug. The discrepancy was for the seal flushness being out of tolerance by 0.01 inches. No manufacturing rework was required as Spirit AeroSystems Engineering determined the condition was structurally and functionally acceptable, and did not adversely affect the fit, form, or function of the installation.

The close and verify pre-rig of the LH MED plug on fuselage 8789 was accomplished on July 28, 2023, per Production Oder 46606906. The four bolts that prevent upward movement of the MED plug were installed during the accomplishment of this production order. There were no additional QNs or pick-ups for the LH MED plug during the manufacturing process prior to fuselage 8789 leaving

[4] Spirit AeroSystems noted the presence of sealer on the rivets that is prone to collect foreign object debris at installation from burrs caused in the structure. The condition could be misidentified as a damaged rivet tail. Work instructions were modified to add specific instructions to clean off "excess" sealer per BAC 5000 on operation 27000.

Spirit AeroSystems. Additionally, Spirit AeroSystems records did not show any 'traveled work'[5] for Fuselage 8789 prior to shipment. Fuselage 8789 assembly was shipped to Boeing on August 20, 2023.

2.5 Observation of Installation and Pre-Rigging of MED Plug during Fuselage Production

On January 17, 2024, during the Investigative group's visit to Spirit AeroSystems, the group observed a MED plug Installation on fuselage 8970 and final closing and installation of the four bolts that prevent upward movement of the MED plug on a fuselage 8989.

Prior to a MED plug being closed on fuselage 8989, the installation mechanic was observed using a lubricant on the MED plug seal area to assist the closing of the door and to protect the seals from damage by the MED plug metal structure. Spirit AeroSystems identified the lubricant as Vaseline® and provided a Spirit AeroSystems engineering evaluation that stated that the use of Vaseline® would not negatively affect the aircraft. Engineering data were reviewed, and a drawing note was found that allowed the use of dish soap during MED plug installation. No documentation was found that allowed the use of Vaseline®, or another similar lubricant, during MED plug installation.

On February 1, 2024, Spirit AeroSystems generated a multi-unit nonconformance record[6] to document the process discrepancies. The corrective actions included the removal of Vaseline® from the seal area, cleaning the seal area and reinstallation using the appropriate liquid lubricant per applicable Boeing Specifications. Spirit AeroSystems then notified Boeing of the process discrepancy.

An examination of the accident airplane's LH and RH MED Plug seal area by the NTSB Materials Lab also revealed similar material (petrolatum/petroleum jelly) present on the seal area, Vaseline® is a brand name associated with petroleum jelly-based products. For additional information see the Materials Laboratory Factual Report 24-007.

[5] In the aviation industry, traveled work refers to jobs/tasks which are delayed and/or completed in a factory location other than what was originally planned. Traveled work takes longer to complete in terms of labor hours, and incomplete work can interfere with manufacturers' ability to complete other planned work causing cascading delays.

[6] NCR NW0003401480 (737-9 Max Left Hand MED Plug), NCR NW0003400827 (737-9 Max Right Hand MED Plug), NCR NW0003401572 (737-10 Max Left Hand MED Plug) and NCR NW0003401590 (Right Hand MED Plug).

2.6 Spirit AeroSystems Personnel at Boeing

For the 737 Program, Spirit AeroSystems employed several on-site personnel at the Boeing 737 production facility in Renton, WA, to address fuselage related issues identified by Boeing in the Renton Factory.

Spirit AeroSystems employed a Director of Customer Relations to oversee the Spirit AeroSystems personnel on-site. A total of four Managers, 20 mechanics and two Quality Assurance personnel worked for Spirit AeroSystems in September 2023. The Managers, Mechanics, and Quality Assurance personnel were independent subcontractors[7] hired locally by Spirit.

All personnel received mandatory training on the Spirit AeroSystems processes and procedures. Spirit AeroSystems trainers traveled to Renton to provide training on the following:

- Drilling and Countersinking Sheet Metal Material
- Hazardous Waste Training
- Export Awareness
- Introduction to Hazardous Communications
- Certification Training Requirements and SLS Overview
- Control of Nonconforming Material
- Foreign Object Prevention Program
- Insider Trading
- Counterfeit Parts Training
- Overhead Cab Crane Safety
- Boeing Assembly Sealing of Aircraft Structures
- Boeing Post Assembly Sealing of Aircraft Structures

Additionally, Sprit AeroSystems personnel were provided Boeing and Spirit AeroSystems site specific processes and procedures training in Renton prior to being allowed to work on the production line. The Boeing/Spirit AeroSystems training included the following:

- Boeing Quality System Audits Overview
- Boeing Foreign Object Debris Prevention

[7] Spirit AeroSystems draws upon the depth of aerospace talent and experience in the Seattle/Renton area by using qualified contractors who do not require relocation and can meet the demand for additional resources as required by production levels. Like Spirit AeroSystems employees, all contract personnel receive mandatory training on the Spirit AeroSystems processes and procedures as well as Boeing site-specific processes and procedures prior to being allowed to work on the production line.

- Boeing Hazardous Energy Training
- Boeing Certified Tools Requirement
- Boeing FOD Prevention
- Boeing Standard Methods for Inspections
- Spirit Quality Policy
- Spirit Renton Mechanic Overview and Sign of FAA Encounters
- Spirit Practical Test of Assemblies and Components

Boeing identified Spirit or Spirit supplier manufacturing defects on the 737 were communicated to Spirit managers in Renton, to request rework assistance. The Spirit managers coordinated a plan to rework the defects identified, including any request for access. Spirit mechanics performed the rework per Boeing processes and work instruction documents, when required. When the accident airplane was in the Boeing Renton 737 Production process, Boeing Quality personnel performed the final inspection and buyoff of all Spirit rework, except for in-process inspections. All work performed by Spirit AeroSystems in Boeing's 737 Renton Production facility was performed within Boeing's Quality Management System.

3.0 The Boeing Company

The Boeing Company developed, manufactured, and provided support for commercial airplanes, defense products and space systems, including the 737-model airplane. Final assembly of the 737 was accomplished in Renton, Washington within the Boeing Commercial Airplanes business unit.

3.1 Boeing Airplane Production Documents

3.1.1 Process Documents

The group reviewed the following process documents related to the build of airplane line 8789.

Initiate Rework Nonconformance Records - Described the actions for initiating and completing a rework type Nonconformance Record (NCR) in the Common Manufacturing Execution System.

Initiate or Revise a Disposition Required Nonconformance Record - Defined the method and organization responsibilities for initiating, revising and initial routing of Disposition Required NCR in the Common Manufacturing Execution System.

Perform Part or Assembly Removal - Provided the removal documentation requirements associated with removing, partially removing, loosening, or

disassembling a previously installed and accepted component, part, assembly, or standard.

Processing Work Instructions - Defined Manufacturing Operations use of work instructions, bar charts and related control systems to provide a standard process to accomplish work.

Boeing Production System Issue-Request using Shipside Action Tracker (SAT) - Defined the use of the Shipside Action Tracker (SAT) system tool process. It defined and governed the process steps required to facilitate, expedite, clarify the build process, and resolve production system constraints.

Note: The SAT system was not the authority to change or document changes to "Fit, Form, or Function" of the product, engineering specifications or drawings. SAT provided a tool for cross-functional communication during the build process.

Provide Oversight of Supplier Activities at Boeing Facilities - Defined the process for providing oversight of supplier activity accomplished at Boeing production facilities, including hardware handling, technical data and records.

Out of Sequence Re-Shops - Described Industrial Engineering's role and responsibilities when re-shopping Out-of-Sequence Installation Plans, NCOs, and Corrective Action Orders.

3.1.2 Engineering Requirements

The following represented the engineering requirements used in the 737 Manufacturing process.

- Engineering Drawings – contained the product definition data. This included Computer-Aided Three-Dimensional Interactive Application (CATIA) Models, Supplier Module Parts Lists, and Picture Sheet Data Lists.

- Boeing Product Standards – documents called out in engineering drawings (i.e. Boeing Process Specifications, Boeing Material Standards, Boeing Specification Support Standard)

3.1.3 Work Instruction Documents

Boeing's Common Manufacturing Execution System (CMES) was a web-based tool that provided 737 manufacturing personnel access to work instruction documents, engineering requirements, and other information required to support

the production process. When an airplane was in the production process all work instructions, including inspections, were signed off and recorded in CMES.

The following execution documents were used in the 737 Manufacturing process within CMES.

- Installation Plan (IP) – baseline work instructions the mechanic followed to build to engineering drawings and product standards.
- Out-of-Sequence Installation Plan (OSIP) – work instruction the mechanic followed to build to engineering drawings and product standard that were added to the baseline.
- Quality Installation Plan (IPQA) – instructions for quality inspectors to perform inspections in addition to what was inspected to complete all other work instructions.

The following documents provided the means of recording and document the resolution of nonconformances to type design data in the 737 Manufacturing process within CMES.

- Rework NCR – A nonconformance record (NCR) used to record conditions that exist on material, parts, assemblies, installations, data sheets, equipment, or test operations, that are not satisfactory, or do not conform with engineering drawings or specification requirements but may be corrected without an engineering disposition that changes type design data. A Rework NCR was also referred to as a Pick-Up or P/U.
- Disposition Required NCR - nonconformance record (NCR) that documents a condition that required an engineering disposition that may impose additional or new engineering requirements, which became part of the type design.
- Nonconformance Order (NCO) - Work instruction document that manufacturing and quality personnel followed to perform rework or repair required by an NCR.

3.1.4 Production Records Retention Policy

Boeing retained 737 Airplane Production Records (e.g. Installation Plans, Nonconformance Records, etc.) for the Life of the Product plus 10 years. While SAT records were not production records, they were also kept for the Life of the Product plus 10 years.

3.2 737 Door Personnel Duties and Responsibilities

Manufacturing personnel in 737 final assembly that performed work associated with airplane doors are part of two teams, the "Door Crew" and the "Door Masters". The "Door Crew" covered the manufacturing area for the Final Assembly of the 737 aircraft, for Flow Days 1, 2 and 3 (See Section 3.3). The "Door Masters" covered the Roll Out (Flow Day 10) and Ramp areas outside of the factory building for the Final Assembly of the 737 aircraft. Both teams aided with door related work throughout the 737 factory and preflight and typically work Monday thru Friday during the first shift. For the month of September 2023, both teams reported to a single Door Manager.

The Door Manager[8] was tasked to manage the "Door Crew" and "Door Master" employees. The manager prioritized, scheduled, and assigned work including making daily plans with team leads, discussing metrics and helped remove roadblocks for the team. The manager participated in daily Tier meetings with many levels of 737 manufacturing leadership to facilitate production efficiency, reviewed open jobs and addressed help needed requests for assistance throughout the 737 factory and Ramp areas The manager participated in Gemba walks[9] and tool kit audits. The manager oversaw improvement changes in safety and quality (identified and resolved issues), focused on cross training and ensured the team and work areas were in compliance.

The "Door Crew" and "Door Masters" team members were tasked with installing, rigging, and adjusting door parts and assemblies into aircraft structures. This included the automatic over-wing exit (AOE) doors, upper cabin doors and the air stair door (when applicable), section 41 access door, electronic equipment (EE) bay door, section 48 access, APU door, cargo doors, Mid Exit Doors (active and inactive) and MED plugs. They set up and performed some functional and operational tests, and trouble-shot all door systems. Door Team members also typically were assigned to work MED plug related issues should they arose.

3.3 Boeing 737 Manufacturing Process

There were typically ten factory positions referred to as Flow Days (FD) in the 737-9 Final Assembly process in Boeing's Renton factory, and specific work scope was performed at each flow day position. The flow day work scopes that were typically associated with the MED Plug areas included Load Fuselage (FD 1), Check

[8] Investigators were unable to interview or get statements from the Door Manager at the time line 8789 was being built in the factory due to being on Medical Leave.

[9] Gemba walks are conducted regularly for leaders to go where the work is done on the factory floor to understand the current state, interact and coach, build a cooperative atmosphere by listening and reflecting on actions needed, reinforce principles and practices, and provide support. The walks can address a specific area of concern by leadership or the team and can include bringing together support roles (such as engineering) on the floor in a specific work area.

Plug Rigging (FD 1-3), OK to Install Blankets (FD 1), High/Low Blow (FD 7), Mid Exit Door Plug Fit and Fair (FD 9), and Pre-Flight Low-Pressure Test (aircraft outside).

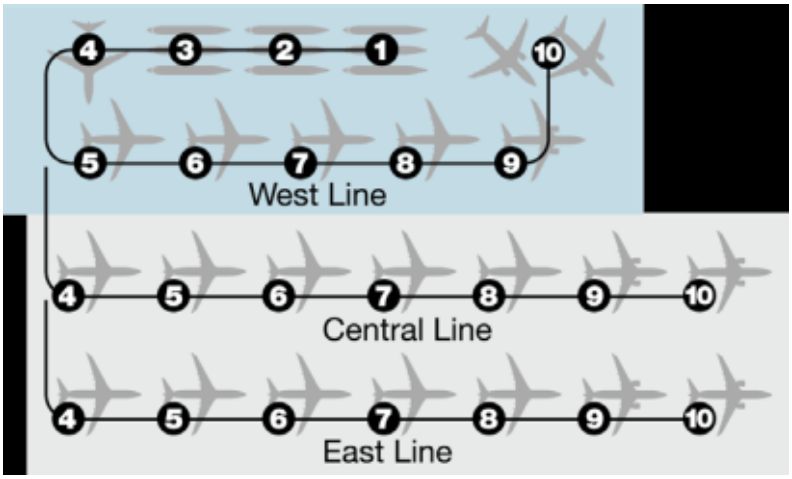

Figure 7. 737 Renton production line. Note: East, Central and West lines are collocated at Flow Days 1–3 positions. (Source: Boeing. Image Copyright © Boeing. Reproduced with permission.)

3.4 Line 8789 Manufacturing Process

Boeing received the fuselage for 737-9 airplane line number 8789 from Spirit AeroSystems on August 31, 2023, and the fuselage entered the 737 factory production line in Renton, WA, the same day. Once in the 737 final assembly building, the fuselage was referred to as line number 8789. During the manufacturing process, an NCR was generated if a nonconformance or discrepancy was found.

The Final Assembly documentation for line number 8789 associated with the MED plug areas are noted below, along with the final assembly Flow Day and preflight positions where the work scope took place.

Flow Days 1-3 – September 1-6, 2023

IP–Fuselage Load, Attach Static Ground

- The fuselage was loaded onto fixtures at the beginning of the production line, in which Static Ground Cables were attached to the fuselage and access stands and ladders were put in place. This IP's work scope also included inspections of the fuselage's general condition.
- There were no NCRs noted against the MED plugs.
- IP-Fuselage Load, Attach Static Ground was completed on September 1, 2023.

IP–Verify Rigging of Mid Exit Doors

- Checked that the MED plugs conformed to rigging drawing requirements, which included skin gaps, door flushness, stop pin alignment, guide roller gap, guide track serrated plate to body frame gap, visual inspection of exterior and interior, and serrated plate engagement. The MED plugs remained in the closed position, unless defects were found and required the MED plug to be opened for rework access.
- An NCR was initiated on August 31, 2023, to document and address six loose fasteners on the RH MED Plug. This NCR was completed on September 5, 2023.
- IP-Verify Rigging of Mid Exit Doors was completed on September 5, 2023.

IP–OK to Install Blankets – STA 727-887, STR 17L-17R Upper

- Prior to the installation of insulation blankets, an area of the fuselage that included the MED plugs was visually inspected for workmanship discrepancies (i.e. bent brackets/structures, riding conditions, open holes, fastener conditions, tool marks, corrosion inhibiting compound, seal voids, integrity of tamper proof seals).
- NCR N1450292531 and NCO 145-8789-RSHK-1296-002NC[10] were initiated on September 1, 2023, to document and address five discrepant rivets on the Edge Frame Forward of the LH MED plug.
    - NCR N1450293199 and NCO 145-8789-RGEN-RSHK-001NC[11] were initiated on September 7, 2023, to document unauthorized work performed by Spirit AeroSystems Renton contract personnel as they performed the work instructions in NCO 145-8789-RSHK-1296-002NC.
        - On September 6, 2023, Spirit AeroSystems Renton contract mechanic and quality personnel documented the rivets were removed and replaced.
        - On September 7, 2023, Boeing Quality found the rivets had not been replaced but had been painted over. Boeing Quality removed the supplier acceptance from NCO 145-8789-RSHK-1296-002NC.
        - On September 8, 2023, Spirit AeroSystems Renton contract mechanic and quality personnel applied supplier acceptances to NCO 145-8789-RSHK-1296-002NC noting the rivets bucktail damage was acceptable per Boeing specification. Later on September 8, 2023, Boeing Quality found the rivets were not

[10] See Attachment 1 - NCR N1450292531 and NCO 145-8789-RSHK-1296-00
[11] See Attachment 2 - NCR N1450293199 and NCO 145-8789-RGEN-RSHK-001NC

acceptable and need to be removed and replaced per Boeing specification.

  - The discrepant rivets were replaced and NCO 145-8789-RGEN-RSHK-001NC and NCO 145-8789-RGEN-RSHK-002NC were completed on September 19, 2023.

- An NCR was initiated on September 3, 2023, to document and address a Tooling Mark on the Edge Frame Forward of the LH MED plug surround structure.
  - A Disposition Required NCR was initiated on September 11, 2023, to provide an engineering disposition with work instructions to address the tool mark. The instructions included blend out instructions and a subsequent ultrasonic inspection.
  - The Disposition Required NCR was completed by Boeing personnel on September 15, 2023.
  - The original NCR was completed on September 16, 2023, and indicated the tool mark had been addressed by the Disposition Required NCR.
- IP-Ok to Install Blankets was completed on September 20, 2023.

Flow Day 7 – September 12, 2023

IP–Cabin Proof Pressure, Leakage and Low Blow Test

- This IP performed a System Functional Test of Body Drain Test, a Structural Proof Pressure Test, a Cabin Leakage Test, and an Internal Cabin Leakage Test
- There were no NCRs noted against the MED plugs.
- IP-Cabin Proof Pressure, Leakage and Low Blow Test was completed on September 12, 2023.

Flow Day 9 – September 14. 2023

IP–Exterior Door Operational Check

- This IP accomplished operational checks of all entry, galley exterior pressurized doors and hatches. The MED plugs were not opened when this IP was performed. The gaps around the plugs were measured and the plugs were checked for proper flushness to the fuselage.
- There were no NCRs noted against the MED plugs.
- IP-Exterior Door Operation Check was completed on September 21, 2023

Pre-Flight Low-Pressure Test (Renton Preflight B Ramp Stall B4)

IP–Cabin Leakage Test Pre-Flight

- The IP accomplished a fuselage pressurization test where the Auxiliary Power Unit was used to pressurize the aircraft. After 5 minutes, it was verified no door warning indications were present in the flight deck.
- There were no NCRs noted against the MED plugs.
- IP-Cabin Leakage Test Pre-Flight was completed on October 13, 2023.

Additional IPs and NCRs

IP–Aircraft Protection Requirements

- The IP prepared the aircraft for movement and storage outside of the factory.
    - One work step in the IP reviewed the aircraft for missing parts such as doors, windows, panels, fairings, antennas, and fasteners prior to rollout. Shop acceptance was on September 19, 2023, at 18:14. This acceptance was later removed, and the work step was reaccepted on September 20, 2023, at 15:31, with missing stabilizer panels and a temporary nose wheel well camlock noted.
    - One other work step in the IP ensures all doors and hatches were closed when the airplane was unattended. This work step was completed on September 19, 2023, at 21:03.
    - No NCRs were noted against this IP.
    - All IP-Aircraft Protection Requirements work steps were completed on October 9, 2023.

IP–Customer Paint Inspection Requirements

- Technicians reviewed aircraft paint condition prior to customer acceptance.
    - No NCRs were noted against the LH MED plug.
    - All IP-Customer Paint Inspection Requirements work steps were completed on October 24, 2023

IP-Customer Inspection Requirements

- Technicians reviewed the aircraft's overall condition prior to customer acceptance.

- An NCR documented cracked sealant on the LH MED plug on October 26, 2023. Technicians applied aerosmooth seal and touch up paint per Boeing specifications. The NCR was closed with customer acceptance on October 30, 2023.
- An NCR documented a dent on skin panel assembly located 9.5 inches under bottom of RH MED plug.
    - Initiated on October 25, 2023. Engineering disposition was to eddy current inspect the dent. Measurements by technicians suggested the skin blend was within aerodynamic smoothness limits per engineering drawings.
    - The NCR was closed on October 29, 2023, with Customer acceptance.
- All IP-Customer Inspection Requirements work steps were completed on October 30, 2023.

3.4.1 NCR N1450292531 and NCO 145-8789-RSHK-1296-002NC

As noted in Section 3.4, NCR N1450292531 and NCO 145-8789-RSHK-1296-002NC was initiated to document and address five discrepant rivets in the edge frame forward of the left MED plug. As these rivets were mis-installed by Quick Tek (a supplier to Spirit AeroSystems), Boeing contacted Spirit AeroSystems' representatives in Boeing's Renton facility. Spirit AeroSystems' representatives agreed to correct the discrepancies.

The following included both Boeing and Spirit AeroSystems responsibilities when Spirit AeroSystems representatives performed work in Boeing's Renton factory:

- Boeing was responsible for removing any parts required to access and complete the requested work. Spirit AeroSystems personnel were not authorized to remove completed installations.
- Boeing and/or Spirit AeroSystems were responsible for controlling and processing non-conforming parts.
- Spirit AeroSystems was required to coordinate a time for Spirit AeroSystems personnel to perform the required work.
- Boeing was typically responsible for supplying Spirit AeroSystems representatives any additional supplies or paperwork (i.e. additional removals or removing parts for access) required.

Once Spirit AeroSystems had access to the work area, and all the required parts were available, the rework was completed with no additional discrepancies.

To provide access for Spirit AeroSystems personnel to replace the five discrepant rivets, Boeing manufacturing personnel were responsible for the opening and closure of the completed MED plug installation. Opening of the MED plug required the removal of the four bolts that prevent upward movement of the MED plug. Per the Boeing process *Perform a Part or Assembly Removal*, removal of the bolts would have required a removal record to be initiated.

3.4.2 Missing Removal Documentation/Record

As specified by Boeing process *Perform Part or Assembly Removal*, removal records document pertinent information related to removing, partially removing, loosening, or disassembling a previously installed and accepted component, part, assembly, or standard requires removal documentation. Removal records, in part, ensured that removed items were reinstalled and reinspected by Quality Assurance Inspectors.

After an extensive search, Boeing and the investigative group determined when work associated with NCR N1450292531 was performed, no removal records were created to document the removal of the four bolts that prevent upward movement of the MED plug to facilitate the opening of the LH MED plug on Line 8789.

3.4.3 Approximate MED Plug Timeline

Due to the lack of removal documentation, a timeline was developed to determine the approximate times the Left MED plug was opened and closed. Different data types were used to construct the timeline. The data included the Shipside Action Tracker (SAT), Installation Plans, NCRs, NCOs, Shop and Quality Signoffs, Computer time stamps, Boeing employee communication records (i.e. email, text), employee airplane entry and exit time records (Barge Log), employee timecards, written statements and interviews, and photographs from both Spirit and Boeing employees. There were no available security video recordings of line 8789 during the build process.[12] The timeline for both September 18 and 19 can be seen in Figure 8.

[12] According to Boeing, 737 production security video recordings are maintained on a rolling 30-day basis. The fuselage was manufactured in September 2023 and delivered to Alaska Airlines in October 2023. The accident occurred beyond this 30 day time period in January 2024; as such, the 737 production security video recordings were not available.

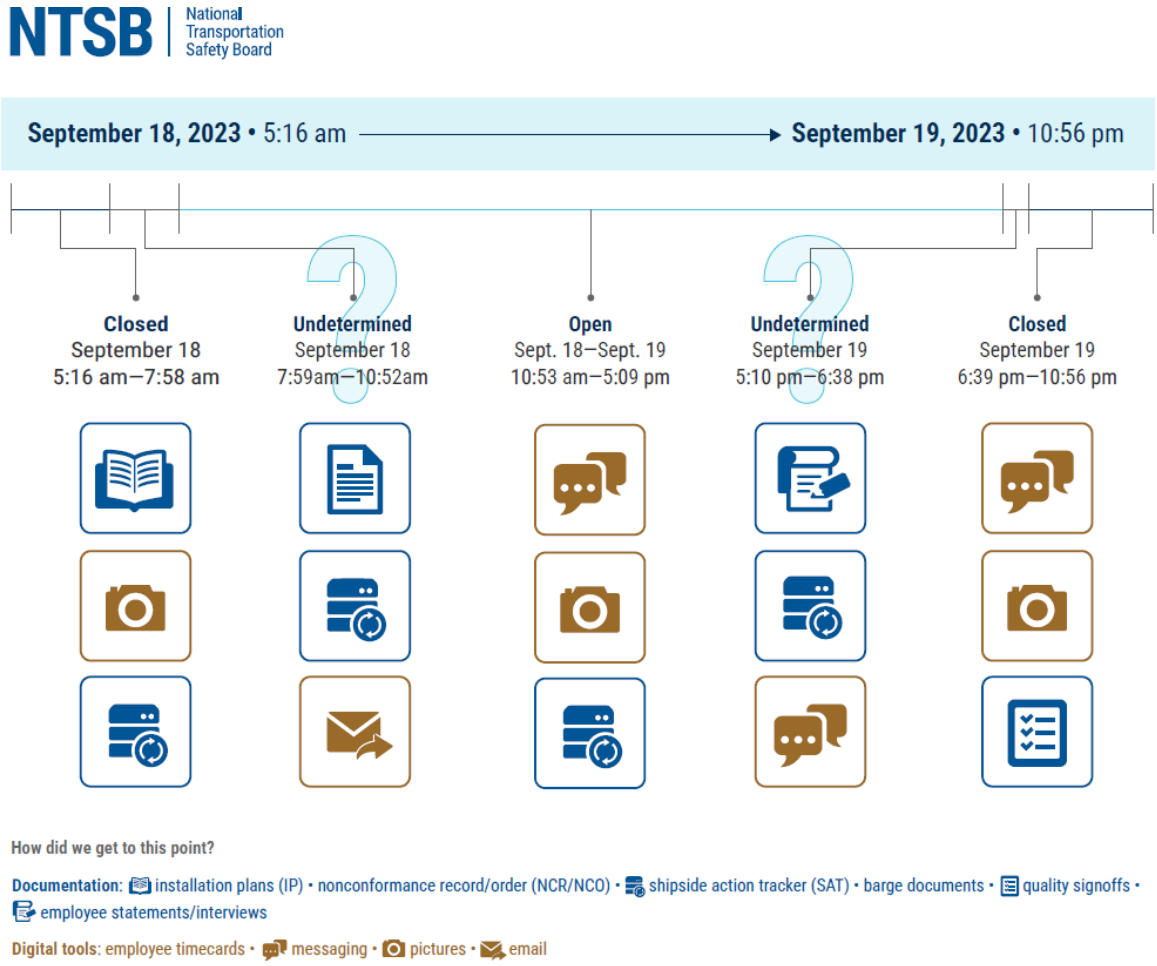

Figure 8. Approximate Timeline of opening and closing of LH MED Plug on Line 8789 [Source: NTSB]

3.4.4 Shipside Action Tracker (SAT) 4650723

The SAT was a tracking tool used to provide cross-functional communication between Manufacturing and Functional support organizations. The SAT tool retained a record of manufacturing requests for assistance and the documented actions for each request, on both current and follow-on units. It was a vehicle to elevate awareness that drove actions to permanently resolve build issues. According to Boeing, SAT records were not production records.

To track and support Spirit AeroSystems' rework of the five discrepant rivets noted in NCR N1450292531, SAT 4650723[13] was generated on September 1, 2023, at 11:16 am by Line Side Control Center (LSCC) personnel. A table in the SAT showed the chronological communication and update entries, which were documented primarily by LSCC personnel. Below are brief summaries of entries from the SAT

[13] See Attachment 3 - Shipside Action Tracker (SAT) 4650723

table. It should be noted the times shown below are the time an entry was made in the SAT and is not the time an action occurred:

- On September 1, 2023, at 11:54 am - the work package was handed off to Spirit AeroSystems via Boeing Supplier Management.
- On September 5, 2023, at 5:24 pm - the work on NCR N1450292531 was held for backlog work according to Spirit AeroSystems management.
- On September 7, 2023, at 6:26 am - "supplier acceptances removed with statement of: CONDITION STILL EXIST. RIVETS WERE JUST PAINTED OVER. copy of NCR delivered to spirit manager."
- On September 7, 2023, at 6:00 pm - extending estimated completion date for Spirit to work NCR N1450292531 and NCR N1450293199.
- On September 11 and 12, 2023, - Shop and Quality Acceptance Stamps were removed from both NCO 145-8789-RSHK-1296-002NC (NCR N1450292531) and NCO 145-8789-RGEN-RSHK-001NC (NCR N1450293199) with comment "Damaged rivets are not acceptable and need to be removed and replaced".
- On September 14, 2023, at 12:49 pm - elevated from Tier 1 to Tier 2 for enhanced Boeing management visibility of issue.
- On September 15, 2023, at 5:19 am - per Spirit management access and removal are needed.
- On September 17, 2023, at 8:41 am - "NCR N1450292531 no access at this time". At 3:54 pm elevated from Tier 2 to Tier 3 for additional Boeing management visibility of issue. "LSCC will help coordinate with first shift to gain access to the damaged rivets, which include opening/removing the mid exit door". At 6:15 pm, Senior Manager worked with Door Crew Manager to determine if door can just be opened, or it needs removal. "If removal needed, a removal needs to written first."
- On September 18, 2023, at 7:00 am - downgraded from Tier 3 to Tier 2. Boeing Door Crew Manager stated, "door is being opened by mechanic". At 11:00 am, Per Spirit Manager, "access is now available", and a Spirit mechanic will be assigned to work after current assignment. At 12:08 pm parts were ordered for the rivet replacement.
- On September 19, 2023, at 12:09 pm - all parts were received and delivered to Spirit. At 11:09 pm all NCRs have been addressed.

- On September 20, 2023, at 8:58 am concurrence to close the SAT was received on behalf of the SAT initiator.

3.5 Spirit AeroSystems and Boeing Personnel Written Statements

The investigative group requested statements from both Spirit AeroSystems and Boeing personnel who may have knowledge of the removal or closure of the Left MED plug. The following is a list of personnel that provided written statements:

Spirit AeroSystems Personnel:
- 3 Managers
- 3 Mechanics
- 1 Quality Assurance Inspector

Boeing Personnel:
- 24 Door Personnel
- 2 Quality Assurance Inspectors
- 1 Interiors Manager (FD 6-7)
- 1 Door Lining Manager
- 1 Blanket Install Manager (FD 1)
- 1 Level 1 Manager
- 1 Functional Test Team Lead
- 2 Senior Managers
- 1 Shipside Operation Specialist and Team Captain
- 1 Shipside Support Specialist (FD 6-7)
- 3 Interior Seat installers (FD 8-10)
- 1 Team Lead – Interiors (FD 9)

3.6 Spirit AeroSystems and Boeing Personnel Interviews

Based on the statements, specific personnel were selected for interviews. The following is a list of personnel that were interviewed:

Spirit AeroSystems Personnel:
- 1 Spirit AeroSystems Manager
- 1 Spirit AeroSystems Structures Mechanic
- 1 Spirit AeroSystems Quality Assurance Inspector

Boeing Personnel:
- 5 Door Personnel (2 Door leads)
- 1 Quality Assurance Inspector

- 1 Interiors Manager (FD 6-7)
- 1 Functional Test Team Lead
- 1 Shipside Operation Specialist and Team Captain
- 1 Blanket Install Manager (FD 1)
- 3 Interior Seat Installers (FD 8-10)

During the week of March 4, 2024, the Investigative Group interviewed Boeing and Spirit personnel. Three independent contractors who performed work under contract on behalf of Spirit AeroSystems at the Boeing Renton facility were interviewed. The Group interviewed a Manager, Structures Mechanic, and a Quality Assurance inspector who were contractors from Launch Aviation, Strom Aviation, and Aerotek, respectively. Boeing Personnel interviews consisted of a Door Team Lead, a Door Team member, a Quality Assurance Inspector, an Interiors Manager (FD 6-7), Blanket Install Manager (FD -1), a Functional Test Team Lead and a Shipside Operation Specialist and Team Captain.

During the week of April 8, 2024, the Investigative Group interviewed additional Boeing Personnel consisting of a Door Team Lead, two Door Team members and three Seat Installers (FD 8-10).

None of the Boeing or Spirit AeroSystems employees stated they had knowledge of the opening or closure of the Left MED Plug.

3.7 Previous MED Plug Documentation

Since the first production installation of an MED plug on 737-9 aircraft (April 23, 2018), there have been 62 instances[14] (occurring on 28 airplanes) where documentation was generated (NCRs and NCOs) and recorded in CMES at Boeing to account for opening or full removal of an MED plug during the airplane manufacturing process.

NCRs, NCOs, and removal records were created in accordance with Boeing process *Perform Part or Assembly Removal*, to document the opening/removal and/or closing/installation of the MED plugs. The majority (57 instances) were initiated to gain access to facilitate other work, while others (5 instances) were for removals/installations for use on other airplanes.

24 instances (occurring on 15 airplanes) were initiated while the airplane was in production within the Renton factory. The remaining (38) of these instances (occurring on 13 airplanes) were initiated in field locations after factory rollout (pre-flight, delivery center, or storage sites).

[14] See Attachment 4 – Previous MED plug Removals

3.8 Boeing Process Perform Part or Assembly Removal – Revision History

Boeing process *Perform Part or Assembly Removal* detailed the record requirements for removals and was applicable to not only to 737 production line but also the rest of the Boeing Commercial Airplanes product lines. Removal records were documentation that:

- Ensured the product was restored according to all released engineering requirements.
- Made certain there was a production record within a Common Manufacturing Execution System (CMES) for previously accepted parts, assemblies, or installations that have been subsequently disturbed.
- Safeguarded prior part, assembly, or installation acceptances from legal liability due to subsequent tampering of an accepted part, assembly, or installation.
- Confirmed configuration accountability through completed records of all activity occurring on aircraft parts, assemblies, and installations.

There were 11 notable revisions/enhancements to the Boeing process *Perform Part or Assembly Removal* that occurred from 2013 through 2023, which resulted from a variety of sources, including scheduled periodic reviews, Boeing internal reporting and audit findings, as well as FAA findings and Boeing commitments to the FAA.

Boeing had initiated Safety Risk Management (SRM) activities to identify potential future changes to this process as part of its Safety Management System (SMS).

3.9 Regulatory Compliance issues regarding Boeing Process *Perform Part or Assembly Removal*

From 2018 to 2023, there were 16 Regulatory Compliance issues directly regarding or partially including Boeing process *Perform Part or Assembly Removal*; 9 Voluntary Disclosures[15] (4 for 737) and 7 Compliance Actions[16] (4 for 737).

[15] The Voluntary Disclosure Reporting Program (VDRP): See https://www.faa.gov/documentLibrary/media/Order/FAA_Order_2150.3C_with_Changes_1-11.pdf#page=49

[16] Compliance Action is the FAA's non-enforcement method to correct unintentional deviations or noncompliance arising from flawed systems and procedures, simple mistakes, lack of understanding, or diminished skills. Compliance Action also includes the FAA's sharing of safety concerns or recommendations when no deviation occurs. A Compliance Action is not an adjudication and is not a finding of violation. A Compliance action is intended to fix safety problems using an open and

Voluntary Disclosures (submitted from Boeing to the FAA)

- VDR2023NM420023 – 737-8 MAX Incorrect Passenger Seat Attach Fittings Installation - Open
- VDR2023NM420020 – SDC 737-9 MAX Fan Cowl FOD - Open
- VDR2023NM470017 – BSC Delivery Center 787-8 Incorrect Software Loaded in Nose Landing Gear - Closed
- VDR2022NM410005 – EVT 767-2C 48 Section Multiple Loose BACC63BP Connectors - Closed
- VDR2020NM420165 – 737 Upper Attachment Lug Assembly Re-Torqued to Unknown Value - Closed
- VDR2020NM410127 – Multiple FOD items found 767-2C, LN 1126 & LN 1188 - Closed
- VDR2020NM410115 – Multiple FOD items found 767-2C, LN 1129 & LN 1184 - Closed
- VDR2020NM420034 – 737 NG and MAX Mid Exit Doors Escape Slide Incorrect Rigging - Closed
- VDR2018NM410003 – 777 Departed wing panel during B1 flight – Closed

transparent safety information exchange between FAA personnel and the PAH. Its only purpose is to restore compliance and to identify and correct the underlying causes that led to the deviation.

Compliance Actions (submitted from the FAA to Boeing)

- CMP2023NM470001 – 787 missing operations for RR engine borescope on supplier assist - Closed
- CMP2021NM420030 – SDC 737 MAX Missing Panel P91 Removal Documentation - Closed
- CMP2021NM420018 – 737 Incorrect software after removal - Closed
- CMP2020NM420008 – FAA Skin Changes Paperwork Review[17] - Closed
- CMP2019NM470019 –BSC 787 PI Audit Flight Line Storage Protection, Shim Removal, Not Ok to Fly – Closed
- CMP2019NM420015 – FAA PI audits 737 & 787 Functional test completed without removals - Open[18]
- CMP2019NM470005 – FAA PI audit 787 Unauthorized removals of fire extinguisher lines – Closed

The process to investigate and address compliance issues with the FAA was managed by Boeing's Regulatory and Quality System Oversight (RQSO) organization. Resolutions for the noted issues were coordinated with the FAA and involved a combination of the following corrective actions:

- Process/Document Updates
- Quality Alerts
- Training Updates
- Form Updates
- Workshops

3.10 Boeing Internal Audits and Employee Speak-Up Reports on Perform Part Assembly and Removals

From 2018–2024, Boeing conducted several internal audits across different production lines that found issues with unauthorized removals. The results were as follows:

737 Production Line

- November 2021 – Insufficient review of Work Instructions led to unauthorized part removal and ineffective part control.

[17] Includes 737 aircraft.
[18] Boeing submitted a Corrective Action Validation to the FAA on June 9, 2021, and is awaiting the FAA's response.

- October 2022 – Parts are not consistently identified after removal or prior to installation.

767 Production Line
- May 2021 – Internal Controls for part removals are ineffective.

777 Production Line
- October 2022 – Removal process and documentation is not being performed consistently.
- October 2023 – Perform Part or Assembly Removal documentation is not consistently performed.
- March 2024 – Repeat Finding- Internal controls for preventing unauthorized removal is ineffective.

787 Production Line
- December 2019 – Removal of Passenger door edge protection
- October 2023 – Removal Record not generated prior to part removal
- October 2023 – Emergent removal record completed with incorrect data
- February 2024 Internal controls for part removals are ineffective.

From January 2019-April 2024 Boeing had received 35 employee Speak-up reports (See Section 3.13) concerning Boeing process *Perform Part or Assembly Removal*. Twenty-five of these reports have been investigated and closed as of April 2024. In some of those cases, Safety Risk Management tools and processes were used to identify corrective actions. The remaining 10 Speak-up reports remained under investigation.

Corrective actions to date included process reviews, documentation updates, employee training, team stand downs, other employee discussions, quality alerts, and airplane record corrections.

Prior to 2020, an initial Removal training course provided removal training to 737 manufacturing and quality personnel, and others. In 2020, an updated Removal training course was developed for all employees that utilized both Boeing process *Perform Part or Assembly Removal* and Boeing's CMES, including 737 manufacturing and quality personnel.

Boeing used an on-going process to determine what courses will be assigned to individual employees based on their responsibilities. The initial and updated Removal training courses were deployed to 737 manufacturing and quality personnel in many past years, but not on an annual basis. The updated Removal training course was completed by Boeing 737 manufacturing and quality personnel in the years the training was assigned, including 2020 and 2022.

As part of its SMS activities, in June 2023 Boeing initiated a Safety Risk Management (SRM) activity titled Removals. The SRM activity was ongoing and three actions were completed that included a June 12, 2024 revision to the Boeing process *Perform Part Assembly or Removal*, release of additional training to emphasize when and why removal documentation was required, and a change to CMES to only allow those personnel who had completed the additional training to initiate a removal. Only functional leads were to initiate removals until the new training could be completed.

3.11 Boeing Quality Alerts

A communication method used by Boeing to re-emphasize process requirements to manufacturing and quality personnel was Quality Alerts. These alerts were typically sent to affected Boeing employees via company e-mail. An electronic confirmation that the alert had been read was required from each affected employee.

Below were the three categories of 737 Quality Alerts, regarding Boeing process *Perform Part or Assembly Removal* that were issued from 2020 through 2023:

- Documentation Requirements – Seven Quality Alerts were issues to bring attention to the documentation requirements for removing parts or assemblies.
- Supplier Part Requirements – Two Quality Alerts, one of which was revised and reissued, was issued to emphasize part removal and control requirements for supplier articles.
- Short Form versus Long Form Requirements – Three Quality Alerts were issued to address personnel not properly selecting the correct removal templates within CMES.

Quality Alert 2023-0056-AR[19] was issued on July 24, 2023, to remind all employees of the documentation requirements for removing parts or assemblies after performing acceptance in CMES. This quality alert was issued prior to the event airplane entering the Boeing 737 manufacturing process on September 1, 2023.

3.12 Boeing Commercial Airplanes (BCA) Quality Management System (QMS)

The Boeing Commercial Airplanes Quality Management System (QMS) was overseen by the Total Quality Team. The organization was divided into four functional groups; Core Quality, Airplane (AP) Program Quality, Supplier Quality, and Delivery Centers.

[19] See Attachment 5 – Boeing Quality Alert 2023-0056-AR

The Production Certificate (PC) 700 was issued by the FAA and was Boeing's authorization to manufacture the listed type-certificated products and articles. The Boeing Quality Management System was defined in their BCA Quality Manual (Rev I), dated June 26, 2023, complied with AS9100, and approved by the FAA.

According to the BCA Quality Manual, the QMS was "the organizational structure, processes, procedures, records, and resources needed to integrate, document, implement, and maintain the various components of an effective business system that meets or exceeds BCA requirements." It was intended to ensure each product that was presented for airworthiness certification met its approved design and was in a condition that was safe for operation. Boeing's QMS covers:

- Design data control
- Document control
- Supplier control
- Manufacturing process control
- Inspecting and testing
- Inspection, measuring, and test equipment control
- Inspection and test status
- Nonconforming product and article control
- Corrective and preventive actions
- Handling and storage
- Control of quality records
- Internal audits
- In-service feedback
- Quality escapes

In addition to the BCA Quality Manual, Boeing used an internal software platform to house its process documents and maintains a Code of Federal Regulation (CFR)/QMS matrix that maps BCA QMS compliance to applicable CFRs. The QMS was externally audited by the FAA in accordance with FAA Order 8120.23A and internally audited as stipulated by the BCA Quality Manual.

3.12.1 Document Control

Boeing's process documents were controlled using an internal software system. Within that system was information pertaining to the responsibilities, requirements, structure, and hierarchy of the process owners, and a guide that described the creation and revision process for the writings housed within it. Quality and manufacturing business records for the articles and/or products that Boeing was authorized to produce via the privileges of PC 700 must be maintained for a

minimum of a calendar year+10 years to comply with 14 CFR § 21.137(k) and other regulatory requirements.[20]

3.12.2 Supplier Control

The QMS manual contained requirements for Boeing to ensure each supplier-provided product, article or service conformed to the Boeing standard and states suppliers were selected based on previous performance and their ability to meet the requirements delineated by the quality system.[21] The Boeing Supplier Quality organization oversaw all suppliers.

3.12.3 Quality Escapes

When a product or article did not conform to its approved design and has been released from Boeing's quality system, it was called a quality escape. The Quality Escapes section of the quality manual described how to identify, control, document and disposition a product that did not conform to those specifications regardless if the nonconforming product or service could have been generated internally, received from an external provider or identified by the customer.[22]

3.13 The Boeing Company Safety Management Systems (SMS)

Boeing's Voluntary Safety Management System[23] (VSMS) implementation was approved by the FAA in December of 2020 and went operational in June of 2021. According to Boeing, their SMS provided structure, policies, and procedures for ensuring compliance (design), conformity (quality), and operational (safety) assurances.

Boeing's Safety Management System Policy is found below and lists several aspects to include the desire to foster a positive safety culture, promote a Just Culture,[24] respond to emergencies, eliminate, or mitigate potential safety, quality, and

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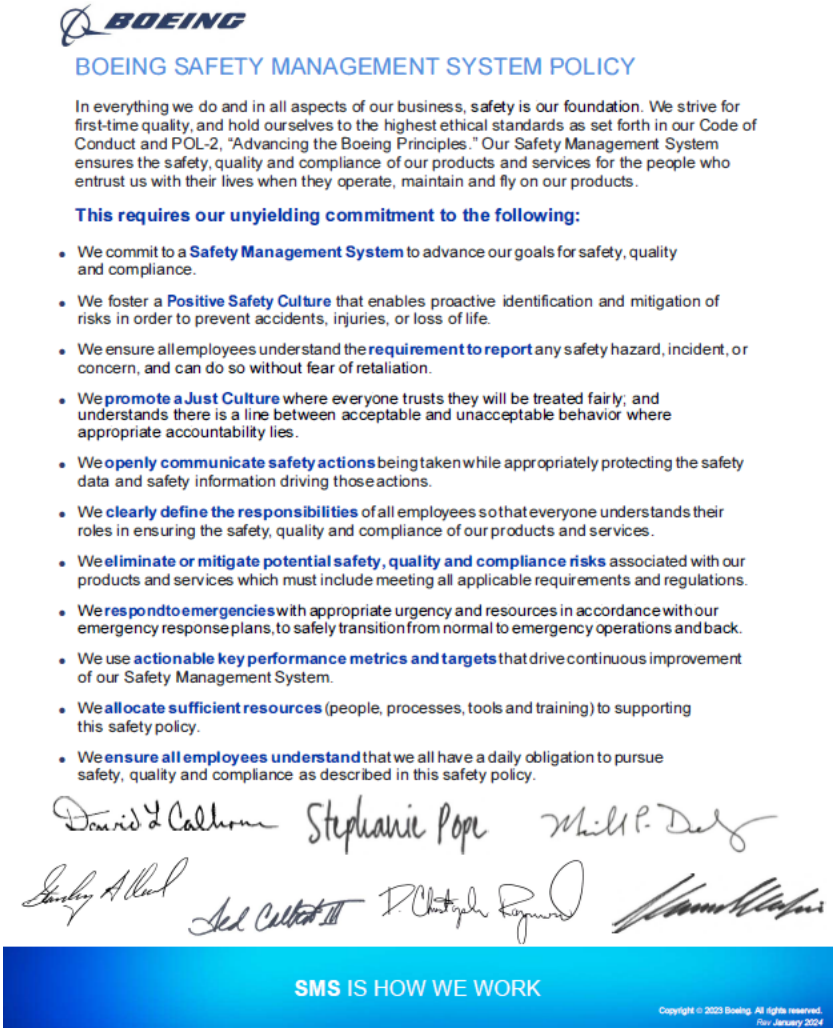
[20] See Attachment 6 - BCA QMS Document Control Excerpt
[21] See Attachment 7 - BCA QMS Supplier Control Excerpt
[22] See Attachment 8 - BCA QMS Quality Escapes Excerpt
[23] Prior to establishing a new rule on May 28, 2024, that mandated the requirement for an SMS program, the FAA established a voluntary SMS program for companies certificated under 14 CFR Part 21 Certification Procedures for Parts and Articles (and others). After assessing the applicant's VSMS to determine if it met the requirements established by the 14 CFR Part 5, the FAA would award a letter stating the voluntary SMS Program had been accepted. See: https://www.faa.gov/about/initiatives/sms/specifics_by_aviation_industry_type/design_and_manufacturing_organizations
[24] A Just Culture treats people fairly for honest mistakes and errors with a focus on learning how to prevent those errors from happening again. It instills an atmosphere of trust in which people are encouraged to provide essential safety-related information, but it is also clear about where the line between acceptable and unacceptable behavior is. See: https://skybrary.aero/articles/just-culture

compliance risks, define responsibilities, drive continuous improvement, and ensure employee understanding. The policy was signed by Boeing Executive Leadership.



BOEING

BOEING SAFETY MANAGEMENT SYSTEM POLICY

In everything we do and in all aspects of our business, safety is our foundation. We strive for first-time quality, and hold ourselves to the highest ethical standards as set forth in our Code of Conduct and POL-2, "Advancing the Boeing Principles." Our Safety Management System ensures the safety, quality and compliance of our products and services for the people who entrust us with their lives when they operate, maintain and fly on our products.

This requires our unyielding commitment to the following:

- We commit to a **Safety Management System** to advance our goals for safety, quality and compliance.
- We foster a **Positive Safety Culture** that enables proactive identification and mitigation of risks in order to prevent accidents, injuries, or loss of life.
- We ensure all employees understand the **requirement to report** any safety hazard, incident, or concern, and can do so without fear of retaliation.
- We **promote a Just Culture** where everyone trusts they will be treated fairly; and understands there is a line between acceptable and unacceptable behavior where appropriate accountability lies.
- We **openly communicate safety actions** being taken while appropriately protecting the safety data and safety information driving those actions.
- We **clearly define the responsibilities** of all employees so that everyone understands their roles in ensuring the safety, quality and compliance of our products and services.
- We **eliminate or mitigate potential safety, quality and compliance risks** associated with our products and services which must include meeting all applicable requirements and regulations.
- We **respond to emergencies** with appropriate urgency and resources in accordance with our emergency response plans, to safely transition from normal to emergency operations and back.
- We use **actionable key performance metrics and targets** that drive continuous improvement of our Safety Management System.
- We **allocate sufficient resources** (people, processes, tools and training) to supporting this safety policy.
- We **ensure all employees understand** that we all have a daily obligation to pursue safety, quality and compliance as described in this safety policy.

SMS IS HOW WE WORK

Rev January 2024

Figure 10. Boeing Safety Management System Policy

Boeing reported the SMS system was in place at the enterprise, business, major functions, test and technology levels, and had been working to a 2025 timeframe for there to be full implementation at the production floor level. The Senior Director for Boeing's safety management system acknowledged awareness of SMS had not yet proliferated beyond the senior manager level.

When asked, most of the Boeing technicians that were interviewed did not recognize what a safety management system was by name, however almost all were able to detail aspects of *safety promotion* and *positive safety culture* as it related to anonymous feedback and reporting systems. The small sample size of technicians relevant to the accident reported they were comfortable going to their managers to

voice concerns and in using the Boeing reporting system called *Speak Up*. According to Boeing, *Speak Up* was the employee reporting process that allows for a Reporting Culture and enables Boeing employees to report the risks and hazards they see. Other indicators of a positive safety culture such as the ability to conduct real time safety risk assessments and to report errors or experiences without fear of reprisal were not fully assessed by the time this report was written.

3.13.1 Safety Risk Assessment

Boeing reported a safety risk assessment would be conducted when any of the four triggers of SRM (new system, change to existing system, new operational procedure, ineffective risk control) were identified. The triggers might be identified in a variety of ways, including but not limited to: planning directives, changes to procedure or process documents, employee reports, leadership identification, hazards identified from customers, etc. When a potential hazard was identified, Boeing utilized the Safety Risk Management process to identify causes, consequence, and risk controls. The appropriate tool for each assessment would be based on the complexity of the hazard. Boeing would then identify the risk mitigation actions and what monitoring would be necessary to achieve the target risk.

3.13.2 Safety Assurance

Boeing implemented target monitoring plans to ensure risk control actions improved the risk controls and mitigated the risk. Boeing reported they also conduct continuous monitoring of key performance indicators (KPIs) to determine if unfavorable trends were being detected. If a trend was detected, a risk assessment was conducted to identify if new hazards had been introduced or if additional corrective action was necessary. If new hazards were introduced, the safety risk management process steps were followed to mitigate and continue monitoring.

4.0 Federal Aviation Administration (FAA) Oversight

Title 49 of the United States Code (49 U.S.C.) subtitle VII provided the statutory authority for the Aircraft Certification Service (AIR) certificate management (CM) program and allowed the FAA to perform oversight of production approval holders (PAH) at any time and take appropriate actions in the interest of safety. FAA Order 8120.23A[25] defined the components of the AIR CM program for production approval holders (PAHs).

[25] FAA Order 8120.23A was effective at the time line 8789 was manufactured. FAA Order 8120.23A Change 1 was effective on October 27, 2023.

Title 14 of the Code of Federal Regulations (14 CFR) part 21, specifically, 14 CFR 21.137 required a PAH to describe in writing a quality system that ensured each product and article conforms to its approved design and is in a condition for safe operation. Holders of Production Certificates (PC) authorizations must meet the responsibilities of a holder as described in 14 CFR 21.146.

4.1 The Boeing Production/Manufacturing Certificate Managing Office

The Boeing Certificate Management Office was located at 2200 South 216th Street, Des Moines, WA, 98198. Boeing's production certificate was managed by the System Operation & Oversight Branch (AIR-580), in the Integrated Certificate Management Division (AIR-500). The Branch consisted of multiple Sections.

The Airplane Oversight Section had three subsections (AIR-582A, AIR-582B, and AIR-582C):

- AIR-582A was responsible for certificate management of the Boeing Everett and Renton, WA, production and delivery centers.
- AIR-582B was responsible for certificate management of the Boeing Charleston, SC production and delivery centers. The Principal Inspector (PI) for Boeing was the Manager of the Airplane Oversight Section (AIR-582B) and was in Charleston, SC.
- AIR-582C was responsible for certificate management of Boeing Engineering, Organization Designation Authorization (ODA), and production.

The Supplier Systems Section (AIR-583) was responsible for certificate management of Boeing's internal and external supply base including Spirit AeroSystems in Wichita, KS.

The investigative group interviewed seven active and one retired ASI, the ASI's manager, the principal inspector for the certificate, and the program manager responsible for helping to establish Boeing's VSMS program. When asked about their respective interactions with the company, the regulators stated Boeing was always clear and transparent, and committed to quality assurance and delivering a safe product.

At the time of the writing of this report, AIR-580 was seeking to hire additional Aviation Safety Inspectors (ASIs) and Aviation Safety Engineers (ASEs). In September 2023, there were a total of 11 ASEs and 23 ASIs with certificate management responsibility for Boeing.

4.2 FAA Certificate Management Program

The CM program consisted of the policies, procedures, and associated information technologies by which the FAA fulfills its statutory responsibilities to ensure a PAH remained in compliance with the regulations governing the manufacturing of its products or articles. It was a system approach to monitoring a PAH's compliance with regulations, ensuring appropriate corrective actions were taken. The applicable FAA manufacturing managing office was responsible for all activities associated with the CM of PAHs.

The PAH's manufacturing system was based on the quality system elements defined in 14 CFR 21.137. There were 15 system elements that addressed a specific activity or function affecting the maintenance of the FAA-approved design or quality data. The following was a brief summarization of the system elements:

1. Design Control – Section 21.137(a) required procedures for controlling design data, and subsequent changes, to ensure only current, correct, and approved data were used.

2. Document Control – Section 21.137(b) required procedures for controlling quality system documents and data, and subsequent changes, to ensure only current, correct, and approved documents and data are used.

3. Supplier Control – Section 21.137(c) required procedures for ensuring each supplier-provided product, article, or service conformed to the PAH's requirements. This section also required a PAH to establish a supplier reporting process for products, articles, or services that have been released from or provided by a supplier and subsequently found not to conform to the PAH's requirements.

4. Manufacturing Process Control – Section 21.137(d) required procedures for controlling manufacturing processes to ensure each product and article conforms to its approved design.

5. Inspection and Testing – Section 21.137(e) required procedures for inspections and tests used to ensure each product and article conformed to its approved design. These procedures were required by the rule to include the following, as applicable, a flight test of each aircraft produced unless that aircraft will be exported as an unassembled aircraft, and a functional test of each aircraft engine and each propeller produced.

6. Inspection, Measuring and Test Equipment Control – Section 21.137(f) required procedures to ensure calibration and control of all inspection, measuring, and test equipment used in determining conformity of each

product and article to its approved design. Each calibration standard was required by the rule to be traceable to a standard acceptable to the FAA.

7. Inspection and Test Status – Section 21.137(g) required procedures for documenting the inspection and test status of products and articles supplied or manufactured to the approved design.

8. Nonconforming Product and Article Control – Section 21.137(h) required procedures to ensure only products or articles that conformed to their approved design were installed on a type-certificated product. These procedures were required by the rule to provide for the identification, documentation, evaluation, segregation, and disposition of nonconforming products and articles. Only authorized individuals may make disposition determinations. Section 21.137(h) also required procedures to ensure discarded articles were rendered unusable.

9. Corrective and Preventative Action – Section 21.137(i) required procedures for implementing corrective and preventive actions to eliminate the causes of an actual or potential nonconformity to the approved design or noncompliance with the approved quality system.

10. Handling and Storage – Section 21.137(j) required procedures to prevent damage and deterioration of each product and article during handling, storage, preservation, and packaging.

11. Control of Quality Records – Section 21.137(k) required the PAH's quality system to have procedures for identifying, storing, protecting, retrieving, and retaining quality records. The same section also required a PAH to retain these records for at least 5 years for the products and articles manufactured under the approval, and at least 10 years for critical components identified pursuant to § 45.15(c).

12. Internal Audits – Section 21.137(l) required procedures for planning, conducting, and documenting internal audits to ensure compliance with the approved quality system. The procedures were required by the rule to include reporting results of internal audits to the manager responsible for implementing corrective and preventive actions.

13. In-Service Feedback – Section 21.137(m) required procedures for receiving and processing feedback on in-service failures, malfunctions, and defects. These procedures were required by the rule to include a process to assist design approval holders to address any in-service problem(s) involving design changes and determine if any changes to the Instructions for Continued Airworthiness (ICA) were necessary.

14. Quality Escapes – Section 21.137(n) required procedures for identifying, analyzing, and initiating appropriate corrective action for products or articles that have been released from the quality system and did not conform to the applicable design data or quality system requirements.

15. Issuing Authorized Release Documents – Section 21.137(o) required a PAH to have procedures providing for the selection, appointment, training, management, and removal of individuals authorized by the PAH to issue authorized release documents.

On a yearly basis, a certificate management plan was developed to assist the PI in planning and tracking the performance of ongoing certificate management responsibilities. A Risk-Based Resource Targeting (RBRT) assessment tool was used to assign risk to a PAH according to the likelihood that it would produce nonconforming products, articles, or parts, and consequential results associated with introducing those products, articles, or parts into the system. RBRT assessments and associated procedures provided a consistent and justifiable basis for effective deployment of FAA resources when performing CM. FAA Management then developed a certificate management plan for each PI using the Aircraft Certification Audit Information System (ACAIS).

The program consisted of the following process:

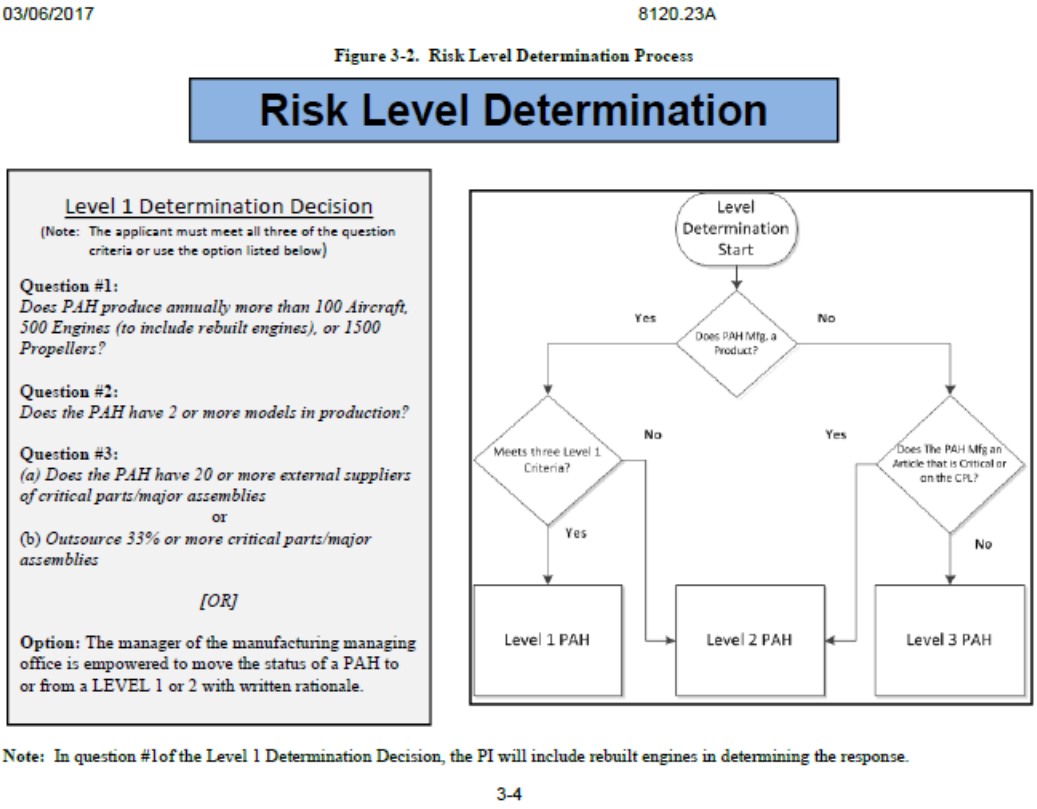
1. Planning audit activities
2. Conducting audits
3. Documenting audit activities
4. Performing post-audit activities

Additional CM Responsibilities accomplished on an as-required basis by the manufacturing managing office responsible for the PAH include:

1. Audit/inspect changes to a PAH's quality system that may affect the inspection, conformity, or airworthiness of the product or article.
2. Investigate service difficulties that involve quality system problems.
3. Investigate regulatory violations.
4. Ensure appropriate corrective actions have been proposed and taken for all noncompliances identified at a PAH.
5. Determine the need for unscheduled Principal Inspector (PI) audits, Quality System Audits (QSA), supplier control audits, product audits, and other investigation activity.

6. Provide guidance and assistance to the PAH as necessary.

In according with to FAA Order 8120.23A,[26] the Boeing Renton, Everett, and Charleston production sites have been determined to be Level 1 High Risk[27] (Level 1). Figures 11–12 below from FAA Order 8120.23A specified National Airspace System (NAS) Level 1 risk determination criteria. FAA manufacturing managing offices annually determined a PAH's organizational risk level as High, Medium, or Low using the RBRT tool:



03/06/2017 8120.23A

Figure 3-2. Risk Level Determination Process

Risk Level Determination

Level 1 Determination Decision

(Note: The applicant must meet all three of the question criteria or use the option listed below)

Question #1:
Does PAH produce annually more than 100 Aircraft, 500 Engines (to include rebuilt engines), or 1500 Propellers?

Question #2:
Does the PAH have 2 or more models in production?

Question #3:
(a) Does the PAH have 20 or more external suppliers of critical parts/major assemblies
or
(b) *Outsource 33% or more critical parts/major assemblies*

[OR]

Option: The manager of the manufacturing managing office is empowered to move the status of a PAH to or from a LEVEL 1 or 2 with written rationale.

Note: In question #1of the Level 1 Determination Decision, the PI will include rebuilt engines in determining the response.

3-4

Figure 11. FAA Risks List Level Determination Process

[26] https://www.faa.gov/documentLibrary/media/Order/Order_8120.23A_change_1.pdf#page=19
[27] PAH manufacture products, as defined by §21.1, at high production rates, with greater complexity, and significantly outsource production to its suppliers.

3-7. Organizational Risk Assessment. Subsequent to the results of the risk level determination, the second pillar of the PAH's overall risk assessment uses the RBRT assessment tool to determine the organizational risk. The tool includes several factors that result in the identification of quality systems and complexities according to their potential to produce nonconforming products or articles and the consequential results associated with introducing those products or articles into the system. As a result of the RBRT assessment, a PAH is assigned one of the following organizational risk levels:

a. **High.** A PAH with the greatest potential to produce nonconforming products or articles.

b. **Medium.** A PAH with a moderate potential to produce nonconforming products or articles.

c. **Low.** A PAH with low potential to produce nonconforming products or articles.

Note: The RBRT assessment questions and the guidance for completing the assessment are located in ACAIS.

Figure 12. Organization Risk Assessment Description

The NAS and organizational risk level determinations was used to define the minimum certificate management audits to be performed at a PAH site. Figure 13 below from FAA Order 8120.23A provides guidance on audit frequency.

Part 2. Audit Requirements and CM Plan

3-12. Minimum Audit Requirements. The output of the PAH's risk assessment, specifically the risk level determination and the organizational RBRT designation, is used to define the manufacturing managing office's CM audit responsibilities. Table 3-1 provides the minimum of audits and corresponding frequencies associated with the ongoing CM of PAHs.

Table 3-1. Ongoing CM Audit Responsibilities (Minimum Requirements)

Level 3 Low	Level 3 Medium	Level 2 Low	Level 2 Medium	Level 2 High	Level 1 Low	Level 1 Medium	Level 1 High
1+ Audit within every 60 months	1+ Audit within every 48 months	1+ Audits within every 36 months 1 QSA NTE 48 months	3+ Audits within every 24 months 1 QSA NTE 36 months	4+ Audits within every 12 months 1 QSA NTE 24 months	6+ Audits within every 12 months 1 QSA NTE 36 months	12+ Audits within every 12 months 1 QSA NTE 24 months	18+ Audits within every 12 months 1 QSA NTE 24 months

Note 1: All audits in the table above are only "minimum" audit requirements. The plus symbol (+) indicates that management of the manufacturing managing office may determine additional audits are required based on risk.

Note 2: Product Audits must be conducted during all audits.

Figure 13. Audit Frequency Minimum Requirements

The Boeing Production Certificate 700 (PC700) list 29 production sites that the FAA assessed for NAS and organizational risk. Each site had a risk assessment and corresponding minimum audit requirements.

A Quality System Audit (QSA) was a comprehensive system audit and was an element of the FAA's mission of continued operational safety. The QSA:

- Ascertained whether the PAHs and associate facilities met the applicable requirements of 14 CFR and comply with procedures established to meet the requirements.
- Populated a database for analyzing audit results and reporting trends.
- Provided continuous improvement for the FAA by continually auditing customer feedback reports and considering proposed improvements by FAA internal and external customers.
- Evaluated the continued integrity of the design data at PAHs and associate facilities after initial approval by FAA. The QSA did not reevaluate the

approval of previously approved data such as quality manuals or design data.

A Principal Inspector (PI) Audit employed a product-based system approach to evaluate whether a PAH was complying with its approved quality procedures. During the PI audit, the FAA evaluated the quality system elements.

Additionally, a Supplier Control Audit (SCA) was employed to determine compliance of an established supplier system or inspected products, articles, or parts with the PAH's requirements, technical data, or specifications. An SCA was conducted to evaluate the PAH's established system to control the articles, materials, supplies, and services provided by outside sources.

As part of the surveillance of a PAH, the FAA conducted various Product Audits to determine the airworthiness of the components during the manufacturing process. The product audit ensured conformity to the type design using the following criteria:

- Operational/Functional
- Dimensional
- Visual
- Identification
- Documentation
- Special Processes
- Material

4.3 Renton Facility – FAA Audits from October 2022 – September 2023

Between October 2022 to September 2023, a total of 22 PI, 1 QSA, and 53 product audits were completed at the Renton facility.

There were 68 alleged noncompliance's documented with FAA Form 8100-6 for these audits. The Boeing quality system elements observed as non-compliant were as follows:

- Document control (10 alleged noncompliances),
- Inspection, measuring, and test equipment control (4 alleged noncompliance)
- Inspection and testing (1 alleged noncompliance)
- Manufacturing process control (33 alleged noncompliances)
- Handling and storage (10 alleged noncompliances)
- Corrective and preventative actions (1 alleged noncompliance)
- Quality escapes (4 alleged noncompliances)
- Supplier control (1 alleged noncompliance)

- Design Data Control (1 alleged noncompliance)
- Control of Quality Records (1 alleged noncompliance)
- Nonconforming product and article control (1 alleged noncompliance)
- Issuing authorized release documents (1 alleged noncompliance)

None of the 68 alleged noncompliances referenced the Boeing process *Perform Part or Assembly Removal*.

Boeing developed corrective action plans (CAP) to address the noncompliance's identified during the audits to ensure the corrective actions are effective and sustaining. All corrective action plans were subject to FAA approval and required Boeing to assign a Project Leader and Executive to implement the corrective action. As corrective action tasks or activities were completed, Boeing provided the FAA Corrective Action Verification (CAV) letters with objective evidence to support tracking of CAP progress. The FAA continually monitored Boeing's progress through regular meetings, correspondence, and surveillance.

4.4 Spirit AeroSystems – FAA Audits from October 2022 – September 2023

Additionally, the FAA conducted 16 Supplier Control Audits[28] (consisting of 12 audits at the facility in Wichita, 2 audits at the facility in Tulsa, 1 audit at the facility in Europe, and 1 audit at the facility in Malaysia). During this same time period, 32 Product Audits were conducted at Spirit AeroSystems. The audits consisted of quality elements in manufacturing process control and supplier control.

A total of 27 alleged noncompliance issues were documented relating to 14 CFR 21.146(b), which requires that the holder of a production certificate must maintain the quality system in compliance with the data and procedures approved for the production certificate. Various quality procedures were observed as not being followed.

Similar to Section 4.3, Boeing has developed corrective action plans to address the noncompliances identified during the audits to ensure the corrective actions were effective and sustaining. The FAA continually monitored Boeing's progress through regular meetings and correspondence.

[28] Supplier Control Audits are an evaluation or audit of the PAH's ability to flow down its quality system to control the supplier and the products and articles produced or supplied by them, it is NOT an audit of the supplier itself.

4.5 FAA Compliance and Enforcement Program

FAA Order 2150.3C (Change 11) outlined the FAA Compliance and Enforcement Program. The program provided a person or in this case a PAH with a notice that the PAH was under investigation for an apparent statutory or regulatory violation. The program had two key aspects. One aspect involved the promotion of safety and compliance by encouraging regulated entities to adopt practices to ensure compliance and, when violations occur, to disclose the violations to the FAA and the circumstances surrounding the violations. Based on information provided through such disclosures, the agency's compliance and enforcement program fosters the implementation of permanent corrective measures to improve overall safety. The second aspect involved the responsibility of agency enforcement personnel to ensure that statutory or regulatory noncompliance was addressed promptly through the application of the FAA Compliance Program as appropriate, including the use of compliance action, administrative action, or legal enforcement action.

The FAA had programs to incentivize regulated entities to disclose their violations, other safety discrepancies, and general safety information to the FAA, and to promptly take corrective action to prevent future violations. These programs were the Voluntary Disclosure Reporting Program (VDRP), Aviation Safety Action Program (ASAP), Flight Operational Quality Assurance (FOQA) Program, and Aviation Safety Reporting Program (ASRP).

As part of the FAA's surveillance, audits conducted were documented in ACAIS. Should noncompliance issues be documented by the audits, the FAA exercised prosecutorial discretion when using compliance, administrative, and legal enforcement actions to ensure that all regulated entities conformed their conduct to statutory and regulatory requirements. Noncompliances by regulated entities that were willing and able to comply and willing to cooperate in corrective actions may be addressed with compliance actions, except when legal enforcement action was required, or administrative or legal enforcement action was preferred. Noncompliances by regulated entities unwilling or unable to comply or not cooperative in corrective actions must be addressed with enforcement action. Note that in every case, regardless of how a noncompliance was addressed, the regulated entity must return to compliance, now and for the future, or enforcement action may be taken.

Should the FAA determine that Legal or administrative Enforcement Actions are necessary, an Enforcement Investigative Report (EIR) Letter of Investigation (LOI) was provided to the PAH. The PAH was given an opportunity to respond to the contents of the letter.

The FAA provided two EIR/LOIs for the 737 as it related to Boeing process *Perform Part or Assembly Removal*; EIR2019NM420001- Functional Test Removals and EIR2013NM410009 - Unauthorized removals. Both cases were closed.

4.6 FAA Findings on Boeing process Perform Part Assembly or Removal

The ACAIS tool tracked the elements in FAA Order 8120.23A. The Order did not have a specific element to audit for Boeing process *Perform Part Assembly or Removal*. A review of the elements conducted by PI audits and QSA audits did not reveal specific noncompliances to Boeing process *Perform Part Assembly or Removal* from October 2022-September 2023 for the 737 production line.

Issues with the Boeing process *Perform Part Assembly or Removal* were identified during previous surveillance of the Boeing Production Certificate. The investigative group determined this through a review of FAA and Boeing provided data for the period of 2018 to 2023, interviews of aviation safety inspectors, and an interview of a retired FAA Certificate Office Manager.

4.7 FAA Compliance and Enforcement Case Record Retention

According to FAA Orders 1350.14B Records Management and 2150.3C FAA Compliance and Enforcement Program, Violations Investigation Records which were records relating to the investigation of violations of rules, regulations, and orders were destroyed 5 Year(s) after closure, but longer retention was authorized if needed.

Similarly, EIR Records were destroyed two years after closure in the Enforcement Information System (EIS). A Legal Enforcement Action case was destroyed five years after closure in EIS.

4.8 FAA Production/Manufacturing Certificate Management Personnel Interviews

On April 11–12, 2024, the investigative group traveled to the FAA Boeing Certificate Management Office in Des Moines, WA, to interview four members of the FAA oversight team for Boeing. This included an Aviation Safety Inspector; the Principal Inspector; a Program Manager; and the Manager from AIR-580 System Operation & Oversight Branch.

On May 7-8, 2024, the Investigative group traveled to the FAA Boeing Certificate Management Office in Des Moines, WA, to interview two FAA Aviation Safety Inspectors; one Senior Aviation Safety Inspector; one Aviation Safety Engineer; and the Manager for AIR-582A for the Boeing Company Production Certificate.

On May 17, 2024, the investigative group conducted a virtual interview with one of the Aviation Safety Inspectors who performed oversight of Boeing supplier control at Spirit AeroSystems.

On June 5, 2024, the investigative group held a virtual meeting to interview a recently (December 2023) retired FAA employee involved in initial development of the FAA Safety Management System and was a previous Principal Inspector on the Boeing Production Certificate.

4.9 FAA Oversight of Boeing SMS

The FAA 's new rule requiring an SMS (14 CFR Part 5) for Part 21 took effect on 28 May 2024 and mandated full implementation within 36 months. When asked, the FAA aviation safety inspectors/engineer and the principal inspector assigned to Boeing, and the product manager assigned to aid in the development of Boeing's SMS reported Boeing had performed well in developing and implementing its VSMS and was poised and ready to implement their regulatory SMS program. The regulators professed no concerns about the company's ability to successfully implement the change in the timeline required.

5.0 Alaska Airlines

Alaska Airlines is a major American airline headquartered in SeaTac, Washington, within the Seattle metropolitan area. Alaska, together with its regional partners Horizon Air and SkyWest Airlines, operated a route network primarily focused on connecting cities along the west coast of the United States.

5.1 Alaska Airlines Operating Certificates

The Federal Aviation Administration (FAA) Cascadia Certificate Management Office issued an Air Carrier Certificate (Certificate Number ASAA802A, dated September 23, 1946; reissue: January 10, 2023) to Alaska Airlines,19300 International Boulevard, Seattle, Washington, 98188.

5.2 Alaska Airlines N704AL

N704AL (Serial Number: 67501, Line 8789) was delivered to Alaska Airlines on October 31, 2023. From the day of delivery to November 11, Alaska Airlines accomplished Pre-Revenue Conformity Checks and Pre-Service work on the airplane. Alaska Airlines records showed none of the work accessed the MED plugs. The aircraft was put into revenue service on November 11, 2023.

From November 11 to November 27, Alaska Airlines records showed that there was one door writeup on November 21 for a Forward Cargo Door Handling Lanyard Missing (Log Page 60716876). Maintenance personnel installed a new lanyard in accordance with Aircraft Maintenance Manual (AMM) 52-31-14 and closed the discrepancy on the same day.

On November 27, 2023, the aircraft was flown to AAR Aircraft Service – Oklahoma to have the 2KU WIFI and PCS antenna retrofit installed. Details related to the work associated with retrofit can be seen in Section 6.2. The aircraft was returned to Alaska Airlines on December 7, 2023.

From December 7, 2023, to the time of the accident, Alaska Airlines records showed that there was one door writeup on December 31 for a forward entry door hard to open (Log Page 60697306 continued to 60697309). Maintenance personnel lubricated the door per AMM 12-25-11-640-801 and closed the discrepancy on January 1, 2024.

Alaska Airlines records showed from the time the aircraft was delivered to the time of the accident, no maintenance tasks were recorded for opening the accident aircrafts MED plugs.

At the time of the accident the aircraft had accumulated 510 hours and 154 cycles.

6.0 AAR Aircraft Services

AAR was a global aerospace and defense aftermarket solutions company with operations in over 20 countries. Headquartered in the Chicago area, AAR supported commercial and government customers through four operating segments: Parts Supply, Repair & Engineering, Integrated Solutions, and Expeditionary Services.

The Airframe Maintenance, Repair, and Overhaul (MRO) performed major services and airframe repair, modifications, inspections, upgrades, refurbishments, and painting services on a range of aircraft platforms, including Airbus, Boeing, Bombardier, and Embraer.

6.1 AAR Aircraft Services – Oklahoma Operating Certificates

The Federal Aviation Administration (FAA) Flight Standards District Office issued an approved Repair Station Certificate (Certificate Number JR2F936K, dated January 28, 1976) to AAR Aircraft Services d/b/a AAR Aircraft Services - Oklahoma whose business address is 6611 South Meridian, Oklahoma City, Oklahoma 73159 with the following ratings: Limited Airframe (February 4, 1999), Limited Engine (July 27, 1988), Limited Instrument (August 6, 2013), Limited Radio (March 26, 2008),

Limited Accessories (February 4, 1999), Limited Non-Destructive Inspection, Testing and Processing (February 25, 2002) and Limited Specialized Services (February 25, 2002).

The European Union Aviation Safety Agency (EASA) issued an approved EASA Part-145 Repair Station Certificate (Certificate Number EASA.145.4008, date of issue of November 8, 2022, with a renewal date January 31, 2025, to AAR Aircraft Services, Inc. d/b/a AAR Aircraft Services - Oklahoma whose business address is 6611 South Meridian, Oklahoma City, Oklahoma, 73159 with limitations outlined in FAA Operating Certificate JR2F936K.

6.2 AAR Aircraft Services –WiFi and PCS antenna retrofit

Alaska Airlines contracted AAR Aircraft Services – Oklahoma to accomplish the 2KU WIFI and Personal Communication System (PCS) antenna Installation retrofit (STC ST03403NY and ST03405NY) for aircraft N704AL. The aircraft was delivered to AAR Aircraft Services - Oklahoma on November 27, 2023, at 1600 local time.

A review of the installation retrofit documents revealed no major discrepancies with the installation. All work performed by technicians were inspected and stamped off by quality assurance personnel.

The group witnessed a WiFi and PCS antenna installation retrofit in progress on Alaska Airlines N709AL. All cabin ceiling access panels and necessary side panels were removed making it visible for viewing. According to AAR Aircraft Services – Oklahoma, they had accomplished approximately 60 WIFI and PCS Installation retrofits on Alaska Airlines B737-9 aircraft and there had never been a reason to open or remove MED Plugs for the retrofit.

The aircraft was delivered back to Alaska Airlines on December 7, 2023, at 0900 local time.

7.0 Safety Actions

7.1 Spirit AeroSystems Safety Actions

In the third quarter 2023, Spirit AeroSystems instituted a multi-phased comprehensive 737 Quality Improvement Plan after allowing fuselages with undetected nonconformances to be delivered to Boeing. This Improvement Plan targeted production, quality, and risk management.

Following the Alaska Airlines accident, Spirit AeroSystems implemented further initiatives into the Improvement Plan. The improvements included:

- Added inspection points on MED plugs,
- Replicated inspections documented by MOM-MOM-24-0010-01B(R4)
- Changed manufacturing planning build validation for the MED plugs (to ensure the upper guide track bolts and vertical movement arrestor bolts have been installed correctly and cotter pinned per procedures)
- Jointly Performed Safety Management Risk Assessment with Boeing which identified and prioritized critical installation plans to incorporate mitigating actions.
- Targeted employee communications (e.g. Quality Standdown/Town Hall with Boeing/Customer Messaging).
- Received and Analyzed Regulatory and Boeing audit data, Airline Customer feedback to improve quality management system.
- Implemented final product acceptance jointly with Boeing to improve quality and reduce 'traveled work.'

Moreover, Spirit AeroSystems had voluntarily undertaken the implementation of the fundamentals of an SMS program throughout the company, as well as a focused assessment of the skills, performance and training of production/audit/inspection of personnel.

7.2 The Boeing Company

Shortly after the accident, the FAA issued Emergency AD 2024-02-51 on January 6, 2024, based on the preliminary findings from the investigation. The AD prohibited further flight of all 737- 9 airplanes until the LH and RH MED plugs had been inspected and any discrepancies were corrected using a method approved by the FAA. Boeing worked with the FAA to develop multi-operator message MOM-MOM-24-0010-01B(R4) that provided approved inspection instructions for in service 737-9 MED plugs. Similar inspections were put in place for airplanes prior to delivery.

Boeing conducted a comprehensive review of the 737 airplane production system, the Boeing Supply chain, and Quality System. Boeing initiated the following safety actions:

- Boeing quality stand downs at every major facility in Boeing Commercial Airplanes, with more than 70,000 employees participating to share their perspectives on improving safety, quality, and compliance.
- Revised the build plans, training, maintenance planning, aircraft manual documentation, removal requirements and inspection criteria for the MED plug.
- Initiated additional controls to prevent defects in the MED plug and similar structures and assemblies.

- Added conformance inspections to nine critical build points.
- Processed fleet and production inspection findings through Boeing's SMS and Quality Management System (QMS)
- Published alerts on removals and rework, signed by all factory employees.
- Instituted additional controls at Spirit to prevent defects in the MED plug and similar structures and assemblies.
- Added new inspections at Spirit, as well as pre-shipment approval requirements on fuselages prior to shipment to Boeing.
- Added competency assessments for all supplier mechanics doing structural work at Boeing sites.
- Issued supplier bulletins to strengthen focus on conformance and reduce the risks of defects being shipped.
- Implemented a "move ready" process where 737 airplanes may not move to the next factory position until identified build milestones are completed, unless a Safety Risk Assessment (SRA) is conducted, and a mitigation plan is in place.

Further, the Federal Aviation Administration conducted its own investigation/audits of the Boeing Company and Spirit AeroSystems after the accident. The findings resulted in additional Boeing Safety Actions that can be seen in more detail in Attachment 9.

7.3 The Federal Aviation Administration

After the accident on January 5, 2024, the FAA took the following actions:

- Launched with NTSB Go Team
- Released Emergency Airworthiness Directive (EAD) 2024-02-51 which Immediately grounded 171 Boeing 737-9 MAX aircraft operated by U.S. airlines or in U.S. territory.
- Increased onsite safety inspector presence at Boeing's facility in Renton, Washington, and Spirit AeroSystems' facility in Wichita, Kansas.
- Halted production expansion of the Boeing 737 MAX.
- The FAA Administrator actively encouraged all hotline and whistleblower complaints, and the FAA investigated every single one.
- Concluded an audit of Boeing's 737 production line that went above and beyond FAA's standard inspection process. The FAA identified non-compliance issues in Boeing's manufacturing process control, parts handling and storage, and product control. The post-accident audit was completed and was part of an ongoing investigation.

- FAA was in the process of hiring 15+ Aviation Safety Inspectors to provide additional oversight at Boeing manufacturing locations and suppliers.

The FAA communicated with Boeing officials in the months following the accident to ensure the administration's expectations were met and to provide oversight of the changes to the production system. The administration required Boeing to provide a detailed update on completed actions as well as mid- and long-term actions. These actions include but were not limited to:

- Strengthening its Safety Management System, including employee safety reporting
- Simplifying processes and procedures and clarifying work instructions
- Enhanced supplier oversight
- Enhanced employee training and communication
- Increased internal audits of production system.
- Improve Installation Plans

Additionally, Boeing had to identify the results of completed actions and how it will monitor those and future actions to validate progress and sustain the changes.

To ensure long-term success, the FAA actively monitored Boeing's progress in a variety of ways, including:

- A team of FAA subject matter experts continually reviewed Boeing's progress and the effectiveness of the changes in addressing the audit findings and expert panel recommendations.
- Senior FAA leaders met with Boeing on a weekly basis to review performance metrics, progress, and any challenges they're faced in implementing the changes.
- They planned to conduct monthly reviews to gauge Boeing's progress.

The FAA continued its enhanced oversight of Boeing and its suppliers. This included:

- Increased safety inspector presence in the Boeing and Spirit AeroSystems facilities.
- Targeted auditing and surveillance of manufacturing and quality activities to conduct oversight of improvement activities.
- Additional auditing at critical points of the production process and involvement in quality and manufacturing daily/weekly activities.
- Monitoring quality system metrics to identify any areas of concern to include targeting auditing activities.

7.4 Alaska Airlines

7.4.1 Immediate Actions

Following Flight 1282, Alaska Airlines immediately grounded its entire Boeing 737-9 Max fleet a day before the FAA issued a similar directive to all US operators of the 737-9 MAX fleet. Alaska Airlines stated the airline took the initiative to ground the fleet in an abundance of caution, as it was unknown whether a similar manufacturing defect existed in the rest of the Alaska Airline's 737-9 Max fleet.

As part of the FAA's required steps to return the 737-9 MAX to service, Alaska Airlines conducted thorough inspections of all MED plugs on its 737-9 MAX fleet aircraft before each aircraft was returned to service in late January 2024. Further, Alaska Airlines also inspected all MED plugs on older model Boeing 737-900ER aircraft.

7.4.2 Alaska Airlines Oversight of Boeing

After the accident occurred, Alaska Airlines engaged directly with Boeing's CEO and leadership team to understand their plans to adequately address quality assurance in the MAX fleet. Alaska Airlines implemented a thorough review of Boeing's production quality and control systems, including a review of Boeing's oversight of their vendors and suppliers connected to the 737-9 MAX program.

The Alaska Airlines Audit team engaged with Boeing to review their manufacturing improvement plans, provide feedback, and monitor execution of those improvements. This included sharing best practices between safety and quality leaders. Alaska Airlines stated the airline continued to work with Boeing to collect factory non-conformance data so quality issues were addressed sooner and action plans were implemented with Boeing on a regular basis.

The Alaska Maintenance and Engineering (M&E) team enhanced the airlines on-site inspection program for in-production Alaska aircraft. Alaska Airlines brought two former M&E leaders back from retirement who were on the production floor in Renton, Washington inspecting critical aspects of Alaska Airlines aircraft and working to revamp the supplier inspection program.

Finally, Alaska Airlines enhanced their intake inspections of newly delivered aircraft to Alaska Airlines, including inspections of each MED plug on every aircraft delivered from Boeing before the aircraft enters service.

According to Alaska Airlines, these efforts, along with those of the FAA, were ongoing (at the time of the writing of this report) and were designed to ensure the

aircraft Alaska Airlines purchases from Boeing were safe and met all design specifications.

E LIST OF ATTACHMENTS

Attachment 1 – NCR N1450292531 and NCO 145-8789-RSHK-1296-002NC
Attachment 2 – NCR N1450293199 and NCO 145-8789-RGEN-RSHK-001NC
Attachment 3 – Shipside Action Tracker (SAT) 4650723
Attachment 4 – Previous MED plug Removals
Attachment 5 – Boeing Quality Alert 2023-0056-AR
Attachment 6 – BCA QMS Document Control Excerpt
Attachment 7 – BCA QMS Supplier Control Excerpt
Attachment 8 – BCA QMS Quality Escapes Excerpt
Attachment 9 – Boeing Safety Actions
Attachment 10 – Boeing Interview Transcripts
Attachment 11 – Spirit AeroSystems Interview Transcripts
Attachment 12 – FAA Interview Transcripts

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