AIR LINE PILOTS ASSOCIATION, INTERNATIONAL

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August 23, 2002

Mr. Richard Rodriguez
Investigator-In-Charge
Major Investigations Division
National Transportation Safety Board
AS-10, Room 5305
490 L'Enfant Plaza East, S.W.
Washington, DC 20594-2000

Dear Mr. Rodriguez:

In accordance with the Board's rules, the Air Line Pilots Association (ALPA) submits the following comments concerning the aircraft accident involving Alaska Airlines Flight 261, which occurred on January 31, 2000 off the coast of Port Hueneme, California.

On January 31, 2000, at approximately 1621 Pacific Standard Time, N963AS, a McDonnell Douglas MD-83, operating as Alaska Airlines Flight 261, crashed into the Pacific Ocean about 3 miles from Anacapa Island, California. All 83 passengers and 5 crewmembers were fatally injured. The flight, from Puerto Vallarta, Mexico, to Seattle, Washington, with an intermediate stop in San Francisco, California, was operating under Title 14 Code of Federal Regulations Part 121.

Accident Discussion

Given the apparent condition of the Acme nut at the beginning of the accident flight, this accident was inevitable and unavoidable. The attached submission contains ALPA's analysis of the facts surrounding the accident based upon information obtained through the NTSB's investigation. Also included are ALPA's suggested Safety Recommendations for the NTSB to consider.

The factual record indicates that had the accident not occurred on this particular flight, it would have occurred in the very near future. The condition of the jackscrew components was the result of years of mismanagement and poor oversight on the part of Alaska Airlines and the Federal Aviation Administration.

The following is a discussion of several key factors that were involved in this accident. These factors relate to issues involving flawed design and certification decisions by the FAA on the failed aircraft components, inadequate maintenance policies and practices as implemented and approved by Alaska Airlines and the FAA respectively. Other factors include the inappropriate or non-existent oversight by both Alaska Airlines and the Federal Aviation Administration.

Chronology of Failure Scenario

As the aircraft was climbing out from Puerta Vallarta, the autopilot was engaged by the flight crew at approximately 7,000'. Normal alternate trim was applied by the autopilot to the horizontal stabilizer as the aircraft continued its ascent. Unbeknownst to the crew, the condition of the Acme nut, a specific component integral to the horizontal stabilizer trim system, was worn to the point of failure due to years of a lack of lubrication.

During the climb, the threads on the horizontal stabilizer Acme nut, already worn to 10% of their original thickness, began to fail. At an altitude of approximately 23,500', the threads in the Acme nut failed completely and caused the Acme nut to jam, resulting in the horizontal stabilizer ceasing movement at a near-neutral position (~0.37° aircraft nose down). The horizontal stabilizer remained in this position for a majority of the flight. As the aircraft continued its climb on the autopilot, the alternate trim system was no longer able to function due to the jammed condition, and at ~29,000', the autopilot disconnected due to its inability to maintain a trim condition on the aircraft. The flightcrew leveled the aircraft temporarily at 29,000' for other traffic, and then continued their climb to their final cruising altitude of 31,000'.

Thirty minutes prior to the accident, the cockpit voice recorder begins with the flightcrew discussing their situation with Alaska Airlines. From the ensuing discussions between the flightcrew and company personnel, it was evident that all of the individuals involved initially believed that the malfunction they were experiencing were electrical in nature.

Approximately 11½ minutes prior to the accident, the aircraft experienced a severe pitchover, due to the unjamming of the horizontal stabilizer trim system. For the aircraft to behave in this way, the Acme nut would have to be beyond the full aircraft nose down trim position. This aircraft behavior surprised the flight crew and required approximately 1½ minutes to regain control of the aircraft. Although the flightcrew did regain partial control of the aircraft, the aircraft was still difficult to handle and required a large amount of backpressure on the control column to counter the pitch-down attitude.

Approximately 3½ minutes prior to the accident, the flightcrew made a comment that indicated that they now felt that the anomaly they were experiencing may be mechanical versus electrical.

Approximately 1½ minutes prior to the accident, a "thump" is heard on the CVR, and the crew begins to experience more difficulty controlling the aircraft over a matter of seconds. The aircraft violently pitched over, the flight crew experienced a negative 3 g's and the aircraft rolled inverted. At this point, the remaining components of the horizontal stabilizer assembly failed and the horizontal stabilizer went to a position that rendered the aircraft uncontrollable. The flightcrew was unable to recover from this inverted attitude.

Certification of DC-9 / MD-80

The initial models of the Douglas Aircraft Company, DC-9 were type certificated under the Civil Aeronautics Regulations, CAR 4b, dated December 31, 1953, including Amendments up to 4b-16 and certain special conditions. Application by McDonnell Douglas to build the MD-80 series required significant modifications to the design of the aircraft; therefore those significant aircraft modifications were required to meet the requirements of FAR Part 25. Since no significant changes were made to the trim system components and the system did not show an unsatisfactory service history, the certification basis for the trim system components on the MD-80 series aircraft remains CAR 4b.

This accident demonstrates that the FAA's consideration of the horizontal stabilizer trim system as a "structural element", despite the fact that the assembly consists of moving parts of the stabilizer trim system, is flawed. This type of classification would rely on inspection and maintenance alone to maintain the airworthiness of the components and preclude a catastrophic failure of a primary flight control system. This inappropriate classification allowed this critical, non-redundant flight control system to be approved without consideration of wear to the components. The FAA's interpretation of how this particular system should be characterized (structure versus system) led to a certification of an assembly that allowed a failure mode (i.e. total wear of the Acme nut threads) to present itself that rendered the aircraft uncontrollable. It is appropriate for a certification philosophy to assume that a proper maintenance and inspection program will maintain the type design. However, when the maintenance program fails or is inadequate, this protection is lost.

The design of the horizontal stabilizer jackscrew assembly presumably met established certification criteria in place at the time. However, these "structural" components were required to conform to Subpart C, Structure of CAR 4b. CAR 4b.201, Strength and Deformation, subpart (b) states that the *"structure shall be capable of supporting limit loads without suffering detrimental permanent deformations"*. CAR 4b.201(c) states, *"the structure shall be capable of supporting ultimate loads without failure"*. The factual record shows that these particular components do not appear to meet the requirements of CAR 4b.201(b) or (c).

As another example of a failure to comply with the applicable regulations, CAR 4b.270(b), Fail Safe Strength, goes on to state that *"...catastrophic failure or excessive structural deformation, which could adversely affect the flight characteristics of the airplane, are not probable after fatigue failure or obvious partial failure of a single principal structural element."* This particular system on the DC-9 / MD-80 series aircraft also does not appear to meet the requirements of CAR 4b.270(b).

Alaska Airlines Maintenance Program and Oversight

The NTSB's public hearing identified that the FAA's Maintenance Review Board (MRB) document is simply an acceptance of the Maintenance Steering Group (MSG) standards. The FAA does not get involved in the development process, but allows the industry group to totally direct and control these standards for maintenance programs. It is self-evident that the groups represented benefit from designing these programs to be as economical as possible. There was a shift in philosophy, with the development of MSG-3, to base scheduled inspections or scheduled maintenance on component failure rates. Any component failures that were "detectable by the flight crew" do not, under this new MSG-3 philosophy, require scheduled maintenance or inspections until such failures are detected. The NTSB Maintenance Records Factual Report also discusses this MSG-3 philosophy and describes the logic as a "from the top down" or "consequence of failure approach." The report also documents that MSG-3 addresses and emphasizes economic issues: *"Several of the potential impact areas that are examined are initial design, maintenance / ownership cost, and premature removal rates."* It is obvious that the FAA's MRB was not doing the reviewing which the name of the document implies, that the FAA was not a safety net in this process, and that the FAA's oversight is systemically deficient.

Between November 1966 and September 1991, Douglas issued several All Operators Letters related to lubrication intervals. Each AOL was in reference to a specific in-service incident related to inappropriate lubrication of the horizontal stabilizer jackscrew assembly. In each AOL, Douglas recommended that the lubrication interval be every 600 hours or sooner with the Douglas approved grease. At the time of the accident, the lubrication interval at Alaska Airlines for the horizontal stabilizer assembly was approximately 2550 hours. At no time was the McDonnell Douglas recommended lubrication interval extended by McDonnell Douglas. Therefore, Alaska Airlines extended their lubrication intervals based upon insufficient rationale for doing so and the FAA's oversight allowed these escalations to occur.

Continuing Airworthiness

The NTSB's Maintenance Records Group and the FAA's Special Inspection Team found deficiencies in the Maintenance & Engineering Department's organization, administration, and staffing. Many of these positions were not filled at Alaska Airlines at the time of the accident. This gravely impacted the safety of the company and was directly related to the inadequate oversight by the FAA for allowing such positions to remain unfilled.

There was not a full-time Director of Maintenance or Director of Safety at Alaska Airlines as required by FAR Part 119.65. The Director of Maintenance position had been vacant for almost two years at the time of the accident, and at the time of the accident the acting Director of Safety also had the responsibilities of two other positions, Director of Quality Control and Director of Training. Formal interviews conducted by the NTSB's Maintenance Records Group with several of Alaska Airline's management personnel and with several members of the FAA's Certificate Management Team (CMT) revealed that there was not a formal safety reporting system in effect prior to, or at the time of, the accident. Interviews indicated that there was no formal division of responsibilities between the part-time Director of Safety and the Director of Flight Safety.

Inadequate command, control, and responsibility within the Alaska Airlines maintenance organization were also discovered during the investigation. There were no written procedures for Production Control during heavy checks at the Oakland maintenance facility (violation of FAR 121.135). This lack of written procedures for heavy checks is an important factor in this accident and directly relates to management's reversal of the decision to replace the stabilizer jackscrew assembly during the C5 check of aircraft N963AS (accident aircraft) in September 1997 at the Oakland Maintenance Facility. The NTSB's Maintenance Records Group was unable to establish who had the authority to authorize this change to the planned replacement of the jackscrew assembly on aircraft N963AS.

Lubrication intervals at Alaska Airlines for the stabilizer jackscrew were escalated from an interval of 500 hours in 1987 to an interval of 8 months (approximately 2,550 hours) in 1996.

This was done in spite of the fact that the McDonnell Douglas recommended lubrication interval was consistently identified in several AOLs as 600 hours. The dramatic difference in the extended lubrication intervals used by Alaska and those recommended by the manufacturer had a significant effect on the overall wear of the jackscrew components.

As the lubrication intervals for the stabilizer jackscrew assembly were being escalated at Alaska Airlines, the inspection and endplay check intervals were not shortened in order to monitor the affects of the decreased frequency of lubrication. The opposite was actually being implemented. As the interval between lubrications increased from an interval of 500 hours in 1987 to an interval of 8 months (approximately 2550 hours) in 1996, the interval between inspections and endplay checks increased from 5000 hours in 1985 to 30 months (approximately 9950 hours) in 1996. Note the change from an hourly requirement to a calendar requirement. No special monitoring program or special inspections were established for the Reliability Analysis Program to monitor the affects of decreased lubrication on the MD-80 stabilizer jackscrew assembly.

The last required lubrication of the horizontal stabilizer jackscrew assembly on N963AS was documented on September 24, 1999, at SFO. At the time of this lubrication the task card for this procedure specified Aeroshell 33 as the grease to be used. The Alaska Airlines GMM, however, specified Mobilgrease 28. The Maintenance Records Group was not able to establish which type of grease was actually used for the lubrication. Mechanics interviewed indicated that the assembly was lubricated, and the task cards called for Aeroshell 33. Although the task card for this lubrication in 1999 indicated that Aeroshell 33 was used, the Materials Group found no visible Aeroshell 33 either on the Acme screw or the Acme nut. Nor did the Materials Group find any evidence of Aeroshell 33 in the Acme nut gimbal ring (which is also a component of the jackscrew assembly that would have required lubrication at that time). This indicates that either Mobilgrease 28 was used (contrary to the task card), or the component was not greased as the task card indicated.

The change to Aeroshell 33 from Mobilgrease 28 by Alaska Airlines was significant with respect to the lack of oversight on the part of the FAA and the failure to follow procedures on the part of Alaska Airlines. However, we must add here that the grease change, in and of itself, did not have any significant impact on the lubricating abilities or the wear characteristics of the components. In fact, the NTSB's Grease Group determined that Aeroshell 33 actually provided better friction characteristics than Mobilgrease 28 and mixtures of the two greases had little effect on the lubricating properties.

An effective Reliability Analysis Program (RAP) for the MD-80 might have prevented the catastrophic failure of the horizontal stabilizer jackscrew assembly. However, the RAP used by Alaska Airlines was ineffective. The FAA authorized its use for the MD-80, as part of Alaska's maintenance program under the guidelines of FAA Advisory Circular AC 120-17, "Maintenance Control by Reliability Methods." The objectives of the program are to improve airworthiness, reliability and cost effectiveness of the inspection, maintenance and overhaul programs for a particular aircraft. In view of the complexity and flexibility of such a program, it requires special attention by the FAA before approval is granted because every element of the program must be studied.

Investigation by the NTSB Maintenance Records Group disclosed that the Unscheduled Removal Alert report for 1999 (including a three-month rate per 1,000 unit hours, for components related to the stabilizer trim system) contained the removal of only two horizontal stabilizer jackscrews and support assemblies while there had actually been three assemblies removed and replaced. The third unit was removed in November 1999; however, a new unit was not installed until January 2000. Thus, the airplane check and component report were not completed until January 2000. Even though two removals occurred in November 1999, at no time before the accident did the component unscheduled removal rate trigger the alerting system, requiring an investigation. In spite of these three removals, Alaska Airlines did not submit to the FAA SDRs about these assemblies as required by federal regulation.

Alaska Airlines did not have an effective Continuous Analysis and Surveillance System (CASS) at the time of the accident. This is a violation of FAR 121.373. The regulation requires that "*each certificate holder shall establish and maintain a system for the continuing analysis and surveillance of the performance and effectiveness of its inspection program and the program covering other maintenance, preventive maintenance, and alterations and for the correction of any deficiency in those programs, regardless of whether those programs are carried out by the certificate holder or by another person.*" Prior to the accident, the FAA never took any action against Alaska Airlines as a result of this failure to comply with the provisions of 121.373. Administration of the CASS system is a function of the Quality Assurance (QA) Department at Alaska Airlines. Interviews conducted with members of the FAA's CMT and with the former PMI for the airline indicated that the QA was not performing its required functions.

Performance of the endplay check of the horizontal stabilizer requires the use of a "restraining device" and a "dial indicator." Until the accident, Alaska Airlines had only one restraining fixture tool in its inventory, and this tool was located in OAK. Prior to the accident, there was no procedure in place to sign-out a measurement tool at the maintenance facilities. The tool was manufactured in-house by Alaska Airlines and did not meet either McDonnell Douglas or Boeing specifications.

On August 2, 2000 (6 months after the accident), Alaska Airlines reported a concern to the FAA that the restraining fixture tool used by Alaska Airlines and manufactured in-house may not be "an equivalent substitute" for the Boeing/McDonnell Douglas fixture as called for in the MD-80 Maintenance Manual. Among several potential areas of concern was the problem that these tools could bottom out during the check, thus yielding an erroneous measurement. Alaska Airlines then quarantined all the tools that were not manufactured by Boeing. The NTSB Systems Group performed a series of both laboratory and on-wing tests comparing the accuracy of endplay checks using authentic Boeing tools and Alaska clone tools. They discovered that the force output from the Alaska clone tools was so low that their use could lead to artificially low endplay readings, especially on MD-83s with their heavier tail structures (963 was an MD-83).

Corporate Culture

A poignant reflection of the corporate culture is revealed by the flightcrews conversation within the cockpit during the last thirty minutes of the flight. The crew commented to each other about the pressure placed on them by the company to continue to SFO, the planned destination, and about the failure of the dispatcher to get an instructor pilot on the radio to assist them. It appears that even the "A" flight attendant was aware of the culture when she made the statement (recorded by the CVR): *"So they're trying to put the pressure on you –".* This provides some insight into the management culture that prevailed at Alaska Airlines.

It is apparent from a review of the factual data collected by the NTSB Accident Investigation Team, the FAA's Special Inspection of the airline, and the audit conducted by the Enders group, that the motivation for maximum income with minimum operational cost resulted in a high tolerance for risk with regard to safety. In a post-accident interview with the Director of Flight Safety at the time of the accident, he stated: *"The role of both maintenance control and dispatch was to push aircraft. Pilots determined if the aircraft was flyable. This was the philosophy and always has been."*

FAA Oversight

The Reliability Program establishes the important criteria for determining routine maintenance, overhauls, and inspections and must be initially linked to the manufacturer's recommended maintenance program and the MSG-2 document. Alaska did not incorporate the required maintenance and inspection data necessary from which to make these important and informed decisions. The FAA CMO failed to correct this problem over the many years that it was responsible for their regulatory oversight.

The implementation of ATOS could have been instrumental in uncovering deficiencies at Alaska Airlines if the Principal Inspectors involved had been honest and forthright about their concerns over Alaska's maintenance and inspection functions. The FAA implemented ATOS in the fall of 1998 in a major attempt to re-structure and significantly enhance its surveillance process of the top ten air carriers, of which Alaska Airlines was one.

The FAA's April 2000 (3 months after the accident) Special Inspection of Alaska Airlines conducted by the System Process Audit Program staff reported the significance of its findings. The report disclosed that 22 of its associated findings "had a HIGH criticality baseline." Of the breakdowns identified in Alaska's systems, 15 (27%) were uncovered in the Maintenance Program alone. The report also showed that if a hazard analysis were to have been conducted, it would have identified such areas as the abuse of the maintenance deferral system, ineffective quality control and assurance departments, vacant key management positions and aircraft released to service without proper documentation with the following consequences: use of non-airworthy aircraft in service, poor on-time performance, aircraft incidents and accidents.

The evidence clearly shows that in the years Alaska had been operating, fundamental and critical deficiencies in its systems, processes and procedures were allowed to exist. Many of these deficiencies should have been discovered by the CMO during its initial certification and approval of these activities. ATOS notwithstanding, any subsequent deviation from what was approved should have been detected through surveillance and corrected. The fact that these deficiencies have existed for so long explains why the carrier had developed a culture of non-compliance with regulatory standards and best practices, which the CMO allowed.

The PMI involved had spent eight years with the carrier over the period when Alaska Airlines had acquired the MD-80 until the accident. The PMI should have been intimately familiar with the Alaska's maintenance, inspection and engineering functions and its culture. Appropriate guidance was available to Principal Inspectors about growth and aircraft utilization rates from which to monitor the airline. Yet, in the case of Alaska, its systems were not able to adequately support the carrier's aggressive flight schedule. As summed up in the System Process Audit report, *"...there seems to be a basic lack of understanding regarding the complexity of operating an airline of this size."* The question is why were deficiencies not previously detected and corrected?

Title 49, Section 44702(b) of the US Code places primary responsibility to provide the public with the highest possible degree of safety on the air carrier. It is the responsibility of the FAA to promulgate and enforce adequate standards and regulations. As the subsequent special investigations conducted by the FAA showed, the CMO had the authority, responsibility and justification for suspending Alaska's operating certificate until such time as Alaska had corrected the systemic deficiencies in its operating systems and achieved compliance with regulatory standards. Had this been done long ago, this type of accident might not have occurred. In the Special Audit Team's report under the Surety Model, it proposed that, *"A plan needs to be developed to integrate effective controls and standardize all systems and manuals."* One of its proposed potential corrections was, *"Limit growth until all threats have been eliminated."* Clearly, had the CMO taken this action long ago, it could have achieved control over Alaska's operation and established systemic improvement. It chose not to do this, but instead only reacted to Alaska's demands.

ALPA concludes that the factors involved in the accident should be attributed to the following:

- Deterioration of the Acme nut threads was caused by a lack of lubrication to the Acme screw / nut assembly.

- The total failure of the Acme nut threads resulted in a total mechanical failure of the horizontal stabilizer system and the surrounding aircraft structure. These combined failures allowed the horizontal stabilizer to move to a position beyond full nose down trim that rendered the aircraft uncontrollable.

- The failure of the Alaska Airlines Maintenance and Engineering Department to properly conduct endplay measurements, to properly lubricate this jackscrew assembly and to establish reasonable inspection intervals based upon supportable data was directly causal to this accident.

- The FAA approved a type design for the stabilizer trim system that did not meet several of the applicable portions of both the original Civil Aeronautics Regulations (CAR) and the current FAR Part 25 requirements.

- This type design, along with the failure mode experienced on these components, does not provide adequate redundancy to preclude total mechanical failure of the stabilizer system.

- Organizational shortcomings that existed within the maintenance, engineering and flight operations departments at Alaska Airlines.

- The certification, inspection, and surveillance failures on the part of the Federal Aviation Administration (FAA) Certificate Management Office for Alaska Airlines allowed years of questionable corporate practices at the airline.

- The industry's Maintenance Steering Group Task Force failed to base maintenance recommendations (MSG-2 and MSG-3) for the horizontal stabilizer on established engineering data, thread wear rates, service history, manufacturer's service bulletins, and the FAA's Service Difficulty Reports (SDRs).

- The flawed certification philosophy of the trim system led to an inadequate Abnormal Procedures Checklist that failed to address all of the potential failure modes and risks of an inoperative or failed jackscrew.

Based upon the factual record and ALPA's analysis of those facts, ALPA offers the following Safety Recommendations:

1. The FAA must deploy its System Process Audit team to monitor the effectiveness of the ATOS program and other means of oversight to identify shortcomings, develop strategies for improved operator oversight and to improve the training and standardization of its inspector workforce.

2. The manufacturer must identify a more thorough and representative horizontal stabilizer endplay check procedure to accurately determine jackscrew component thread wear.

3. In conjunction with an improved endplay check procedure, the FAA and the operator must ensure that mechanics are properly trained in conducting such checks to preclude erroneous measurements.

4. The FAA must require the operators to record, retain and track all horizontal stabilizer endplay check measurements.

5. The FAA and the manufacturer must identify improved horizontal stabilizer jackscrew lubrication procedures to ensure that the Acme nut and screw threads receive a thorough amount of lubrication. Improved lubrication procedures must take into account accessibility, number of grease fittings, lubricant properties and lubrication intervals.

6. In conjunction with improved lubrication procedures, the FAA and the operator must ensure that mechanics are properly trained in conducting such lubrications to preclude inadequate lubrication of critical components.

7. The FAA and the operator must develop additional flightcrew training and guidance materials to address mechanical failures of critical aircraft systems and components.

8. The manufacturer must develop a mechanical system to preclude critical flight components (e.g. horizontal stabilizer, rudder, etc.) from reaching a position of which the flight crew would be unable to overcome the failure through other means.

9. The concept of Derivative Certifications should be revisited to ensure that when current regulations provide an increased level of safety to aircraft systems or components, that those new regulations are applied and enforced.

10. The FAA's concept of "structural element" should be revisited to ensure that the regulations in place related specifically to structural elements provide the highest level of safety.

11. Continuing Airworthiness programs must be monitored and compared with current certification requirements to identify possible areas of regulatory compliance deficiencies.

12. Operator management structures must be reviewed to ensure that the positions required by Federal Regulation are filled in compliance with the requirements mandated by the FAA.

13. The FAA must ensure that it assigns qualified airworthiness inspectors capable of evaluating, certificating and surveilling air carrier maintenance reliability analysis programs and continuous analysis and surveillance systems through actions, such as, improving present human resource staffing policies, inspector training curriculum, and certificate office management decisions regarding inspector assignments and supervision.

14. The FAA should take an aggressive stance and deploy the use of its expert CSET and System Process Audit teams to examine the status of critical air carrier systems where there is justification to ensure regulatory compliance, improve industry standardization, resolve deficiencies and clarify any regulatory misunderstandings about these systems on the part of certificate holders.

15. The FAA must review and improve its policies with respect to the Flight Standards Service tenure of its inspectors assigned to air carrier certificate management teams as well as its office supervisory staff to prevent improper relationships with their certificate holders and misconduct on the part of inspectors and managers.

16. To assist the industry in identifying maintenance trends, the FAA must strictly enforce the requirement for operators to submit Service Difficulty and Mechanical Interruption Reports.

ALPA appreciates the opportunity to have participated as a party to the investigation and hopes that the attached analysis, conclusions and safety recommendations will be of assistance as the NTSB concludes its investigation.

Sincerely,

Christopher W Wolf

Captain Christopher W. Wolf, Sr.
Air Line Pilots Association
ALPA Coordinator

Attachment

cc: Chairperson Marion Blakey
Member Carol Carmody
Member John Goglia
Member John Hammerschmidt
Member George Black
Mr. John Clarke
Mr. Tom Haueter
ALPA Accident Investigation Board

SUBMISSION OF THE

AIR LINE PILOTS ASSOCIATION

TO THE

NATIONAL TRANSPORTATION SAFETY BOARD

REGARDING THE ACCIDENT INVOLVING

ALASKA AIRLINES FLIGHT 261

NEAR PORT HUENEME, CALIFORNIA

ON JANUARY 31, 2000

TABLE OF CONTENTS

I. FAILURE SCENARIO AND FLIGHTCREW ACTIONS

This section is intended to give an overview of the history of the accident flight from the time of its departure from Puerto Vallarta until the accident occurred off the coast of southern California. Based upon the factual record, we will explain the jackscrew failure scenario and the most probable flightcrew actions based upon the factual record and the expertise of the ALPA pilots who participated in the accident investigation. Systemic failures that lead up to the final mechanical failures will be addressed in subsequent sections of this report.

Conclusions:

- **The mechanical failure scenario involves several key events over a period of approximately 2½ years.**
    - **The systemic failure that allowed unreasonable jackscrew assembly inspection intervals to be implemented without regard to the impact on thread wear progression within the Alaska Airlines fleet.**
    - **Failure by Alaska Airlines to maintain an adequate inspection program and properly lubricate the stabilizer jackscrew assembly.**
    - **Inadequate checklists and training related to pitch trim system anomalies that were based upon electrical malfunctions and did not consider the possibility of total mechanical failure.**
- **The Acme nut threads deteriorated over an extended period of time due to a lack of lubrication of the Acme screw / nut assembly.**
- **Because of a lack of understanding on the part of the flightcrew and Alaska Airlines related to a mechanical failure of the jackscrew, Alaska Airlines maintenance and dispatch personnel were unable to provide any significant support to the flightcrew during the flightcrews attempts to isolate the cause of the malfunction.**
- **The ultimate failure of the Acme nut threads during the climb from Puerto Vallarta was due to thread wear beyond a point where the threads could maintain the loads being imparted on them.**
- **The final mechanical failure of key pitch trim system components late in the flight rendered the aircraft uncontrollable.**
- **The flightcrews use of the autopilot and their handling of the trim failure was according to the company prescribed training and FAA approved checklist procedures.**
- **The flight crew's decision to continue their flight was in accordance with approved company and FAA procedures.**

A. FAILURE SCENARIO

1. Precursor to Initial Mechanical Failure

The mechanical failure[1] of the jackscrew assembly was the result of many systemic failures that began years prior to January 2000. The maintenance records group factual report goes into great detail about the events of September 1997, in which this particular aircraft was undergoing a C-Check at the Airlines Oakland maintenance facility. During this C-Check, the mechanic conducting the endplay check[2] of the jackscrew assembly determined that the endplay measurement was 0.040”, which was the Original Equipment Manufacturer (Douglas) recommended maximum limit before the unit would have to be replaced. Three days after the initial series of measurements, supervisors decided that the unit should be lubricated and re-measured. It was during this re-measurement of the assembly that the final recorded endplay reading of 0.033” was obtained. The factual record indicates that there were no spare jackscrew assemblies available within the Alaska Airlines (ASA) inventory during this time period. This jackscrew assembly remained on the aircraft and was put back into service. During this C-check, the jackscrew assembly was presumably lubricated with Mobilgrease 28[3], which was being used by Alaska Airlines maintenance at that time.

Records indicate that the jackscrew assembly was subsequently lubricated on June 26, 1998; January 13, 1999 (C6 Check); and on September 24, 1999. There was no requirement during the three lubrication cycles mentioned above to conduct an endplay check on the jackscrew assembly. Lubrications and inspections do not necessarily occur at the same interval. The task cards for these last three lubrications specified Aeroshell 33[4] grease as the lubricant to be used in spite of the fact that this grease was not technically approved by the FAA. However, post-accident analysis of the jackscrew assembly and the associated components revealed several important facts:

- Little evidence of Aeroshell 33 was found on any of the components of the jackscrew assembly.
- There was no evidence of Aeroshell 33 within the grease orifices of the Acme nut gimbal ring[5], another component of the jackscrew assembly.
- There was no evidence of Aeroshell 33 within the Acme nut zerk (grease) fitting,[6] which supplies grease to the grease reservoir (counterbore) internal to the Acme nut.
- Post-accident analysis showed that the grease counterbore, found internal to the Acme nut, was clogged with hard, residual dirt and grease, making it impossible for grease to be applied to the internal Acme nut threads through the Acme nut grease fitting[7].

[1] The systemic failures involved in this accident will be discussed in sections III through VI of this report.
[2] The endplay check procedure deficiencies will be discussed in section II.D.2 of this report.
[3] Mobilgrease 28 is red in color.
[4] Aeroshell 33 grease is light, dull green in color. On December 18, 1997, task card 24312000 changed the lubrication grease from Mobilgrease 28 to Aeroshell 33 grease (BMS 3-33).
[5] Reference Materials Group Factual Report 00-145, figure 53.
[6] Reference Materials Group Factual Report 00-145, figure 49.
[7] Reference Materials Group Factual Report 00-145, figure 50.

2. Initial Mechanical Failure

On January 31, 2000, the aircraft departed Puerto Vallarta at approximately 1537 local time (1337 PST). Flight data recorder information indicates that during the climb, normal primary and alternate pitch trim system activity was recorded until approximately 13 minutes after departure. At this time and at an altitude of approximately 23,500’, the stabilizer trim position became fixed at 0.37º aircraft nose down (AND). The stabilizer trim position remained in this position for a majority of the flight.

The probable scenario for the failure of the Acme nut threads is that during normal trimming of the aircraft during the climb, the internal Acme nut threads reached their ability to sustain the loads being imparted on them and began to fail. A failed thread or threads became lodged between the internal wall of the Acme nut and the Acme screw threads and jammed the assembly in the 0.37º AND position. This scenario is based upon evidence from the factual record:

1. Acme nut thread remnants were found clustered at very specific locations on the recovered Acme screw.
2. Only 73% of the total Acme nut thread windings were found on the Acme screw. 27% of the total Acme nut thread windings were unaccounted for.
3. Each thread remnant recovered was approximately 10% of its total, unworn thickness.
4. All Acme nut thread remnants were positioned on the Acme screw in a measured range that corresponds with the Acme nut at the takeoff trim position of the aircraft[8].
5. Some Acme nut thread remnants were found on the Acme nut screw in a measured range that corresponds with the Acme nut at the 0.37º aircraft nose down trim position[9].
6. There were **<u>no</u>** Acme nut thread remnants found on the Acme screw in a measured range that corresponds with the Acme nut being in the full aircraft nose down position[10].
7. Some Acme nut thread remnants showed signs of crushing and metal scoring along the width of the remnant.

The aircraft momentarily leveled at 29,000’ for traffic, then climbed and leveled 31,000’. The flight continued northbound toward the United States and accelerated to an in-trim airspeed for an aircraft with a stabilizer trim setting of 0.37º AND.

3. Initial Pitchover

The flight proceeded at 31,000’ until time 1609:17 PST, when the aircraft began a rapid descent following an apparent freeing of the jammed stabilizer condition. The jammed Acme nut apparently became freed and the DFDR recorded the autopilot disconnecting and the horizontal stabilizer moved to 2.4º AND within two seconds[11]. The aircraft violently pitched

[8] Reference the Materials Group Factual Report Number 00-145, figure 33.
[9] Reference the Materials Group Factual Report Number 00-145, figure 33.
[10] Reference the Materials Group Factual Report Number 00-145, figure 33.
[11] Full aircraft nose down trim would be 2.4º. The Acme nut would be against the lower mechanical stop in this position.

in the nosedown direction. Not only is this 0.3º beyond the normal nosedown limit, but also the rate of change was significant. The stabilizer was previously at the 0.37º AND position. Therefore, the rate of movement would have been 1º per second, which is three times faster than the normal primary trim rate.

The data showed that the stabilizer remained in this position up until the last minute of the DFDR recording. It must be pointed out that the horizontal stabilizer position transducer can only record up to a value of approximately 2.4º AND. Therefore, a fixed reading in this range of values may not indicate an actual stabilizer position. In fact, the actual position could be much greater than that being recorded on the DFDR. Both the Aircraft Performance and Systems Group work conducted during the investigation validate this. The data indicates that to achieve the actual aircraft performance exhibited during this initial pitchover, the stabilizer position would have had to have been greater than 2.5º AND.

4. Final Pitchover

At time 1619:21.1 PST, five seconds after the crew indicates they are heading for LA, there was the faint sound of a thump. The CVR exchange gives an indication that the handling qualities of the aircraft have changed significantly at this time and that the aircraft is much more difficult to control. It is entirely possible that at this time, the aircraft structure and torque tube support nut that were holding the horizontal stabilizer in fixed position have begun to yield to the forces being exerted on it by the airloads. At time 1619:32.8 PST, there is the sound of two clicks similar to the sound of the slat/flap handle movement. This presumably is the flightcrew's attempt to regain some control of the aircraft by extending the flaps and slats, a configuration that was somewhat controllable earlier in the flight. About 4 seconds later, there is the sound of an extremely loud noise and the sound similar to loose articles moving around the cockpit. At this point, the remaining tail structure in the area of the horizontal stabilizer failed and the airplane nosed over to a near inverted position and descended steeply.

Seconds later the captain stated, *"push and roll…push and roll…okay we are inverted…and now we gotta get it…"* The captain's flight control inputs and instructions were correct in order to recover from the dive and upset. For the next minute, the flight crew struggled unsuccessfully to control the airplane. The airplane impacted the water at 1620:57.1 PST.

B. FLIGHTCREW ACTIONS

On January 30, 2000, the accident flight crew arrived in Puerto Vallarta, Mexico on the second leg of their scheduled trip and began a 24-hour layover. The results of the investigation disclosed no factors that would have precluded them from performing their flight crewmember duties on the day of the accident.

On January 31, the accident airplane, N963AS, arrived in Puerto Vallarta at 1439 local time (1639 PST) following a flight from Anchorage, AK with intermediate stops in Seattle and San Francisco. A mechanic in Anchorage conducted the last documented walk-around inspection of the airplane. A subsequent maintenance "walk-around" inspection should have been performed in Seattle and San Francisco, but the logbook page was not located during the NTSB investigation. Based upon Operations Group interviews, the previous flightcrews indicated that they had accomplished an exterior pre-flight inspection of the aircraft in both Seattle and San Francisco. The incoming flight crew met with the accident flight crew and told them about one deferred maintenance item, which was a cabin overhead bin that did not close.

At 1337 PST, Alaska Airlines Flight 261 departed Puerto Vallarta on an IFR flight plan for San Francisco with 83 passengers and 5 crewmembers. The flight crew requested and was assigned a cruising altitude of flight level 310 (FL310). The first officer flew the airplane during its departure.

Post accident analysis of the Digital Flight Data Recorder (DFDR) showed that the autopilot was engaged during the climb out at about 7,000 feet m.s.l. at an airspeed of approximately 250 knots. At that point, the horizontal stabilizer was positioned at about the 2.0º airplane nose-up ANU position (NOTE: The aircraft took off with approximately 7º ANU stabilizer trim). The pitch trim position decreased to a normal aircraft nose down position of 0º as the airplane accelerated to its normal climb speed at 15,000 feet m.s.l.

At 1353 PST, the DFDR showed that as the aircraft began a gradual level off to FL290, the autopilot disconnected. It could not be determined whether the autopilot disconnected automatically as a result of a trim system malfunction or was disconnected intentionally by the flight crew.

The disconnecting of the autopilot did not, in and of itself, constitute an emergency. Only if the disconnect of the autopilot resulted in a significant mis-trimmed condition and flight control problem severe enough to make the controllability of the aircraft questionable, would a flight crew consider declaring an emergency and attempt to land as soon as possible.

The flight crew's response to the autopilot disconnect and the trim malfunction would have been to attempt to determine if there was a problem with the trim system by using the company procedures in the QRH[12]. The pertinent steps of the QRH would have required:

1) Resetting the circuit breakers if tripped for the Primary longitudinal trim, the autopilot, and the Alternate longitudinal trim systems;
2) Normal activation of the Primary and Alternate trim systems to verify that either one or both are working;
3) If both are not working, for the flight crew to consider that the stabilizer is jammed and that the autopilot should not be used.
4) Determine the best landing flap position for the airplane in its present trim condition. (In this case, the crew determined that a flaps 15 landing would have been required plus a large speed additive (V_{ref} for the approach would have been approximately 180 knots)). It would be desirable to burn down fuel to help reduce this unusually high approach speed.

[12] Reference Operations Group Factual Report, Attachment 2-J-2 and 2-J-3 for the appropriate QRH procedures. Alaska Airlines FAA Approved QRH, Stabilizer Inoperative Checklist, Page 54.

Moreover, the Alaska Airlines QRH checklist does not state, require, or address the need for an immediate landing for *"Stabilizer Inoperative"* or *"Runaway Stabilizer"*; the only two stabilizer anomaly conditions it addresses. The checklist relates only to electrical malfunctions. The preamble of the FAA approved QRH states that *"...The procedures established in this handbook represent the best known available facts about these subjects". "...Flight crews should follow these procedures as long as they fit the abnormal/emergency situation. However, at any time that they are inadequate or do not apply, the captain's best judgment shall prevail..."*

For the following reasons, it is highly probable that the flightcrew felt that the difficulty they were experiencing with the pitch trim system was electrical in nature:

- The investigation was unable to identify any known mechanical horizontal stabilizer jackscrew failures on the DC-9/MD-80 series aircraft.
- There is no QRH procedure for a mechanical failure of the pitch trim system.
- Mechanical failures of the pitch trim system were not addressed in any OEM documentation, aircraft manuals or training programs.
- Mechanical failures of various pitch trim system components were not addressed during the design and certification process.

The aircraft does, however, have a history of electrically induced inoperative and runaway stabilizer trim incidents.

Therefore, the flight crew was alerted to a stabilizer trim system malfunction, which resulted in the loss of the autopilot. The evidence shows that they dealt with the autopilot disconnect and trim failure according to the company prescribed training and FAA approved checklist procedures. These procedures, the crew's high experience level and company training procedures and guidance led the crew to initially conclude that the difficulty was an electrical malfunction within the pitch trim system.

The aircraft was then hand-flown to 31,000' to avoid other air traffic and accelerated to 0.814 mach to get the aircraft into a trimmed condition. The DFDR showed the horizontal stabilizer angle remained at the 0.37º AND position until around 1609 PST when the captain reported, *"I'm gonna click it off…"* in the course of talking with the mechanic in LAX.

1. Decision to Divert

The Alaska Airlines, FAA approved QRH abnormal procedure for an inoperative or runaway stabilizer does not require a return to the departure airport or an immediate landing.

During the first hour of the flight, the aircraft would have been in an overweight landing condition for any of the airports in Mexico. In addition, the Quick Reference Handbook (QRH) as it relates to a jammed stabilizer dictates an abnormal landing configuration for the aircraft (flaps 15 versus 40). This abnormal landing configuration would result in a much higher reference speed for approach and landing. Reducing the aircraft weight by burning off fuel would ultimately decrease this higher than normal approach and landing reference speed. Based upon what the flight crew knew about their situation at that time, a premature landing would have presented more of a risk of damaging the aircraft and injuring passengers and crew than the risk posed by the inoperative stabilizer trim problem.

It appears that the flightcrew attempted to contact Alaska Airlines Dispatch through the Dual Tone Multiple-Frequency (DTMF) remote communication sites in Mexico to discuss their options. The investigation disclosed, however, that the flight crew would have experienced difficulty contacting the company because several of the DTMF remote sites were not working. They were unable to get through to SEA to report their aircraft problem until the flight was approaching the United States. Consequently, by the time the crew had discussed the problem with SEA Maintenance Control and Dispatch, the flight was in range of landing in the Los Angeles area. It is reasonable to conclude that the flight crew continued on their route of flight in anticipation that they would soon be able to contact SEA Maintenance, Dispatch or Maintenance Control.

The flight crew's decision to continue their flight was in accordance with approved company and FAA procedures. Their decision was based upon: 1) the nature of the stabilizer problem as understood by the flight crew; 2) the heavy weight of the airplane and the associated airport requirements; and 3) the communication difficulties along their early route of flight.

2. Communications With and Support From Company Personnel

At about 1546 PST, according to the DFDR, the autopilot was re-engaged. This could have been an attempt by the flightcrew to either minimize their anticipated workload increase (e.g. weather, discussions with the company, passenger and flight attendant briefings, aircraft performance calculations, etc) on their approach into the Southern California area or an attempt to allow the secondary trim system (controlled by the autopilot) to trim the aircraft. Although in this particular instance the QRH recommends against autopilot usage, the preamble to the QRH directs that "*flightcrews should follow these procedures as long as they see fit…at any time that they are not adequate or do not apply, the captains best judgment should prevail*". It was around this time when, according to the CVR, the flight crew contacted Seattle Maintenance Control and asked for assistance in resolving the pitch trim system anomaly. The CVR recording starts at about 1549 PST and picks up the flight crew in mid-conversation with Seattle Maintenance Control asking for assistance with a problem they were experiencing with the pitch trim system. It should be noted here that at this time the aircraft had been flying in a trimmed condition at FL310 for approximately one hour and twenty-four minutes.

The CVR recording begins with the Maintenance Controller stating:
"um beyond that I have verified no history on your aircraft in the past thirty days." The captain responded, *"yea we didn't see anything in the logbook."*

The CVR recording makes clear that the flight crew tried to identify a switch or circuit breaker to which the Maintenance Controller had evidently referred to in an effort to identify the problem. The dispatcher then discussed with the flightcrew their decision to divert to LAX and at 1550:44 PST stated: *"understand you're requesting uh diversion to LA for this uh discrepancy is there a specific reason you prefer LA over San Francisco?"* The Captain replied, *“well a lotta times its windy and rainy and wet in San Francisco and uh, it seemed to me that a dry runway…where the wind is usually right down the runway seemed a little more reasonable.”*

This communication exchange begins an apparent turning point in their efforts to resolve the anomaly and focuses on their diversion decision. As a result, there is further discussion about the amount of fuel the aircraft will have on board if it lands in Los Angeles versus San Francisco, and the potential problem about holding delays in San Francisco.

At 1552:02 PST, Alaska’s dispatcher in Seattle contacted the flight and gave it the current weather and the following exchange took place
Dispatcher: *“if uh you want to land at LA of course for safety reasons we will do that uh wu we’ll uh tell you though that if we land in LA uh we’ll be looking at probably an hour to an hour and a half we have a major flow program going right now uh that’s for ATC back in San Francisco.”*
Captain: *“well uh yu you eh huh…boy you put me in a spot here um…I really didn’t want to hear about the flow being the reason you’re calling us cause I’m concerned about over flying suitable airports.”*
Dispatcher: *“well we wanna do what’s safe so if that’s what you feel is uh safe we just wanna make sure you have all of the uh…all the info.”*

This communication exchange obviously concerned the captain because he wanted to land the airplane at the most suitable airport.

At 1553:46 PST, the captain asked the dispatcher if he could get some support from any company instructors to see if they could assist the flightcrew with the pitch trim system anomaly they were experiencing. However, in the interim, the frequency became congested with another company aircraft talking to Alaska Airlines Operations requesting wheelchairs at the gate, and the captain’s request for an instructor was never fulfilled. This made it nearly impossible for the accident flightcrew to communicate with Alaska Airlines regarding their situation. The subtle pressure exerted by the Maintenance Controller and the Seattle Dispatcher over the diversion destination resulted in the captain expressing his frustration about the company’s handling of the situation. This episode is underscored by the following exchange between the captain and the flight attendant:

Captain: *“…just…drives me nuts not that I wanna go on about it…you know I it just blows me away they think we’re gonna land, they’re gonna fix it, now they’re worried about the flow I’m sorry this airplane’s isn’t gonna go anywhere for a while…so you know.”*
Flight attendant: *“so they’re trying to put the pressure on you…”*
Captain: *“well no yea.”*
Flight attendant: *"…we'll get it to where it needs to be [meaning the airplane]"*
Captain: *"and actually it doesn't matter that much to us."*
Flight attendant: *"still not gonna go out on time to the next__ ."*
Captain: *"yea…yea…I thought they'd cover the people [passengers] better from LA…"*
Flight attendant: *"LA."*
Captain: *"…then San Francisco."*

At 1556:26 PST, the captain contacted the dispatcher and stated: *"I have with the information I have available to me and we're waitin on the CG (center of gravity) update I'm looking at a uh approach speed of a hundred and eighty knots uh do you have a wind at LAX? [The wind was given at 260 at 9] …versus a direct crosswind which is effectively no change in groundspeed…I gotta tell you when I look at it from a safety point I think that something that lowers my groundspeed makes sense."* The dispatcher responded, *"okay two sixty one that'll uh that'll mean LAX then for you um I was gonna get you if I could to call LAX with that uh info and they can probably whip out the CG for you real quick."* The captain then stated, *"I suspect that uh that's what we'll have to do."*

It appears that the captain had to accept the fact that he would not get the CG figure from the dispatcher. The captain stated that they would go to a lower altitude to configure the airplane for landing and to check out its handling characteristics before proceeding with the landing approach.

At 1558:34 PST, the captain contacted Alaska's LAX Operations and the first thing the agent wanted to know was the flight's ETA. The captain estimated a landing in about 35 minutes then mentioned the need to burn more fuel and added:
Captain: *"but I wonder if you can compute our current CG based on the information we had at takeoff for me."*
Agent: *"okay you're transmission is coming in broken but uh go ahead."*
Captain: *"you know what I'll wait a minute we'll be a little bit closer…"*
Agent: *"okay also…just be advised uh because you're an international arrival we have to get landing rights…"*

At 1559:19 PST, the captain acknowledged this fact and suggested that LAX Operations get started on getting the approval. Radar data obtained during the investigation indicates that at this point the flight was approximately 94 miles from LAX. He turned flight control of the aircraft over to the first officer and listened to the LAX ATIS. The first officer evidently sensed a break in communications with LAX Operations and began to ask the captain about his conversation with the Seattle Dispatcher. Once again, the captain expressed his frustration with what appears to be a lack of support, communications and efficiency from dispatch and within the company.

At 1601:01 PST, the following exchange began between the captain and the first officer:
First officer: *"so he wanted us to go to San Fran initially?*
Captain: *"to keep the schedule alive I mean it was just…it was I mean he had all the reasons to do it…I stated concern about flying over flying a suitable airport…"*
First officer: *"Yeah."*
Captain, *"…but I was listening, then when he gives me the wind, its its…the wind was a ninety degree cross at ten knots two eight and we'd be landing on…"*
First officer: *"and they are using one nine?"*
Captain: *"you know I don't know…I wrote it down there…the winds were…one eighty at six…I don't know."*
First officer: *"I don't know."*

Captain: *"I don't care…you know what? I expect him to figure all that [expletive]."*
First officer: *"right."*
Captain: *"…he's got it on the screen…"*
First officer: "*that's why I was thinking that an instructor would really uh…cut through the crap there…they…not available?"*
Captain: *"well they just don't talk to each other."*
First officer: *"oh."*
Captain: *"I mean I [unintelligible word]"*
First officer: *"…they've always told us they were available you know…"*
Captain: *"yeah yeah."*
First officer: "*any time you have a problem…if they get one [instructor] down there."*

Seattle dispatch did not obtain an instructor nor did dispatch communicate with the flight crew any further. The investigation disclosed that there were three other dispatchers on duty at the time, but it is unclear whether they made any attempts to provide additional support to the flight crew.

At 1602:34 PST, the captain contacted LAX Operations again and asked if the agent could provide them with the winds at San Francisco. LAX reported the winds at SFO at one seventy at six knots (170/06). This apparently convinced the captain that a landing in LAX would be preferable. In an attempt to determine the most accurate landing speed, the captain asked the first officer to read the takeoff weight and balance data (which the first officer had recorded from the Operations agent at PVR prior to takeoff) to the LAX Operations agent to assist her in calculating the current center of gravity.

The first officer read the data to the agent who had trouble understanding the landing weight. Based upon the weight and balance information that the flight crew provided to the agent, this indicates that the flightcrew was properly conducting the "stabilizer inoperative" checklist procedure. The first officer had estimated that they would be landing at a weight of 112,700 lbs. The flight crew estimated their final landing speed to be approximately 148 knots (plus an additive) based upon the Landing with a Jammed Stabilizer QRH procedure. The Operations agent asked an LAX-based pilot who happened to be in the Operations office to assist her in calculating the new center of gravity (which was required by the QRH procedure for landing with a jammed stabilizer). She told the pilot assisting her that she did not know how to do it. The two worked on the calculations, but by the time they finally got the new CG calculated, the accident had already occurred. As a side note, the CG that they had calculated was incorrect. The factual record clearly indicates that Alaska Airlines Dispatch did not effectively deal with the situation and decision-making to support the flight crew.

3. Communications After Initial Pitchover

The following dialogue is intended to show, based upon the information being exchanged, that both the flightcrew and the mechanic believed that they were dealing with an electrical anomaly. At 1607:53 PST, a line mechanic at LAX Maintenance contacted the flight and asked the crew if they were the aircraft with the "*horizontal situation*." The captain replied, affirmative and the line mechanic wanted to know if they had tried the "*suitcase handles*" and the "*pickle*" switches. The captain stated that they had tried about everything and wanted to know if there were any hidden circuit breakers. The mechanic said he would double check the circuit breaker guide. He added:

Mechanic: *"…I just wanted to know if you tried the pickle switches and the suitcase handles to see if it was movin in with any of the uh other switches other than the uh suitcase handles alone or nothing."*

Captain: *"yeah we tried just about every iteration."*

Mechanic: *"and alternate's inop too huh?*

Captain: *"yup its just it appears to be jammed the uh the whole thing, it spikes out when we use the primary we get AC load that tells me the motor's tryin to run but the brake won't "move it when we use the alternate nothing happens."*

Mechanic: *"okay and you you you say you get a spike when on the meter up there in the cockpit when you uh try to move it with the uh um with the primary right?"*

The captain responded: *"affirmative we get a spike when we do the primary trim but there's no appreciable uh change in the uh electrical uh when we do the alternate."*

Mechanic: *"okay thank you sir see you here."*

At time 1609:17 PST, the jammed Acme nut apparently became freed, the autopilot disconnected and the horizontal stabilizer moved to at least 2.4º AND within two seconds. The aircraft violently pitched in the nosedown direction.

The flightcrew's surprise and reaction to this sudden and violent aircraft response is demonstrated by the conversation recorded by the CVR. At 1609:18 PST, the captain stated [ALPA believes the first officer is flying the airplane at this point.]: *"holy # [expletive]"* which is followed by the audible tone of the horizontal stabilizer trim-in-motion tone. Captain: *"you got it?…#me."*

First officer: *"what are you doin?"*

Captain: *"I it clicked off…"* Immediately there is the sound of the altitude chime. Captain: *"…it __ got worse…okay."* The sound of airframe vibration begins. Captain: *"you're stalled."* The vibration gets louder. Captain: *"no no you gotta release it ya gotta release it."* ALPA believes the captain was referring to the backpressure the first officer was exerting on the control column in an attempt to recover from the dive.

At 1609:34 PST, there is the sound of a click again and the vibration ends. Captain: *"lets [unintelligible word] speedbrake…gimme a high pressure pumps."* First officer: *"okay."* Captain: "*help me back help me back."* First officer: *"okay."* It is apparent that both crewmembers were on the flight controls at this point.

Immediately, the captain contacted LAX Center reporting that they were in a dive, that *"I've lost control, vertical pitch."*[13] This transmission is followed by the sound of the overspeed warning clacker (CAWS) at 1610:02 PST, which lasted for thirty-three seconds. The captain told LAX that they were out of 26,000 feet and repeated their predicament. At 1610:15 PST there is the sound of a click followed by the captain stating, *"just help me…once we get the speed slowed maybe…we'll be okay."* Then the captain told LAX that they were at 23,700

[13] Reporting the seriousness of the loss of control of the aircraft would be similar to declaring an emergency.

feet and that they finally had the aircraft under control. One second after the overspeed warning horn stops the first officer immediately transmits to LAX Center, *"no we don't okay."*

At time 1612:25.3, the captain contacted LAX Line Maintenance once again stating:
Captain: *"we did both the pickle switch and the suitcase handles and it ran away full nose trim down.*
Mechanic [a different mechanic]: *"oh it ran away trim down[?]"*
Captain: *"and now we're in a __ pinch so we're holding uh we're worse than we were."*
Mechanic: *"okay uh…geez."*
Second Mechanic [original mechanic in the background]: *"you want me to talk to em?"*
Mechanic [original mechanic], *"yea two sixty one maintenance uh uh you getting full nose trim down but are you getting any you don't get no nose trim up is that correct?*
Captain: *"that's affirm we went to full nose down and I'm afraid to try it again to see if we can get it to go in the other direction.*
Mechanic: *"okay well your discretion uh if you want to try it, that's okay with me if not that's fine um we'll see you at the gate."*

The statement that, *"…it ran away full nose trim down"* is consistent with the captain believing that they were experiencing a run-a-way trim system malfunction.

At 1613:20 PST, the flight crew discussed what had happened and what else they should do. They also expressed skepticism about reactivating the stabilizer trim. The captain expressed his belief that being over water was the right thing to do, but stated that they needed to continue to slow down. In the interim, the captain advised the passengers of their situation, that he didn't anticipate any big problems *"once they got a couple of sub systems on the line,"* but that they would be landing in Los Angeles in about thirty minutes. This statement is consistent with past assumptions by the crew that the central problem was related to the primary and alternate electrical trim systems.

At 1616:32 PST, the lead flight attendant arrived on the flight deck, at which time the captain told her that he needed to have everyone seated with seatbelts fastened and the cabin secured because he was about to try to put the airplane in a landing configuration to check out its handling characteristics. The flight attendant then told the crew, *"okay we had like a big bang back there…"* to which the captain replied, *"yea I heard it…the stab trim I think it…I think the stab trim thing is broke…"* Once again, the focus is on the trim system and not any structural failures in the tail of the aircraft.

At 1617:51 PST, the flight crew reconfigured the aircraft by deploying the flaps and slats to determine the controllability of the aircraft in a landing configuration. The crew had clearance to descend to 17,000 feet. They determined that with the slats extended and the flaps lowered to 11º, the airplane was *"pretty stable right here"* flying at 250 knots. But the captain added that they had to slow the aircraft to 180 knots to comply with the QRH procedure. The crew was well aware that, in their present aircraft condition and attitude, it would be extremely difficult to slow the aircraft to a suitable approach speed unless they regained a more effective stabilizer position. Knowing how the aircraft would handle at flaps

11, and based upon a previous discussion by the flightcrew on unloading[14] the horizontal stabilizer in an attempt to free the stabilizer from the perceived jammed condition, the crew elected to retract the flaps and slats to the clean configuration. They further discussed the possibility of unloading the horizontal stabilizer, but decided against conducting such a maneuver.

One must also consider the position of the control column as well as the control column forces. If the column was back near its aft travel limits while at 250 knots, it would have been an indication to the captain that they would not have had enough elevator control authority to keep the nose up and flare for a landing. It is consistent with the crews training, experience, and standard industry practice to find out if the aircraft would be controllable at a slower approach speed.

At 1619:01 PST, the captain realized that he could not get the trim to move, and stated "*it's on the stop now…*", presumably noting on the trim system indicator that the stabilizer is in the full nose-down position and is not responding to trim input by the crew. At 1619:07 PST, the first officer states: *"the trim might be and then it might be uh, if something's popped back there…it might be mechanical damage too."* The captain evidently agreed. This is the first indication on the part of the flightcrew that the problem might be something other than an electrical anomaly.

At 1619:14 PST, after some more discussion the first officer stated, "*I think if it's controllable we oughta just try to land it…*" The captain stated, *"you think so?…okay lets head for LA."* This was a good example of excellent Crew Resource Management (CRM) on the part of the flightcrew.

[14] Although not specifically prescribed for freeing jammed flight controls, positive g maneuvers are standard industry practice for the freeing of jammed / stuck landing gear.

II. TYPE DESIGN AND CERTIFICATION OF THE MCDONNELL DOUGLAS DC-9 / MD-80 AIRCRAFT

This section will describe the certification criteria which the DC-9 / MD-80 series aircraft were certificated. We will also highlight some of the erroneous assumptions made by the FAA in certificating the aircraft components involved in this accident.

Conclusions:

- **The original DC-9 aircraft was certificated to Civil Aeronautics Rule (CAR) 4b criteria.**
- **The accident aircraft, an MD-83, was a derivative certification of the original DC-9 aircraft.**
- **The longitudinal trim system components retained their CAR 4b certification.**
- **The current design of the horizontal stabilizer trim system on the DC-9 / MD-80 series aircraft fails to meet several of the applicable requirements of CAR 4b and FAR Part 25.**
- **DC-9 and derivative DC-9 aircraft utilize a single Acme screw and nut assembly[15].**
- **The horizontal stabilizer jackscrew components were considered a "structural element" by the certificating authority (FAA).**
- **Because the assembly was considered a structural element, "wear" was not considered a failure mode during certification of the assembly as the FAA determined that "wear" would be detected and corrected under an approved maintenance program.**
- **Wear to the Acme nut was not monitored by Alaska Airlines approved maintenance program.**
- **Boeing / Douglas believe they achieve redundancy in the DC-9 longitudinal trim system by incorporating a torque tube within the Acme screw. The Acme nut on the DC-9 assembly also incorporates a dual thread design, which is presumed to add redundancy to the system.**
- **This alleged redundancy did not provide protection against this particular failure mode.**

A. INITIAL CERTIFICATION

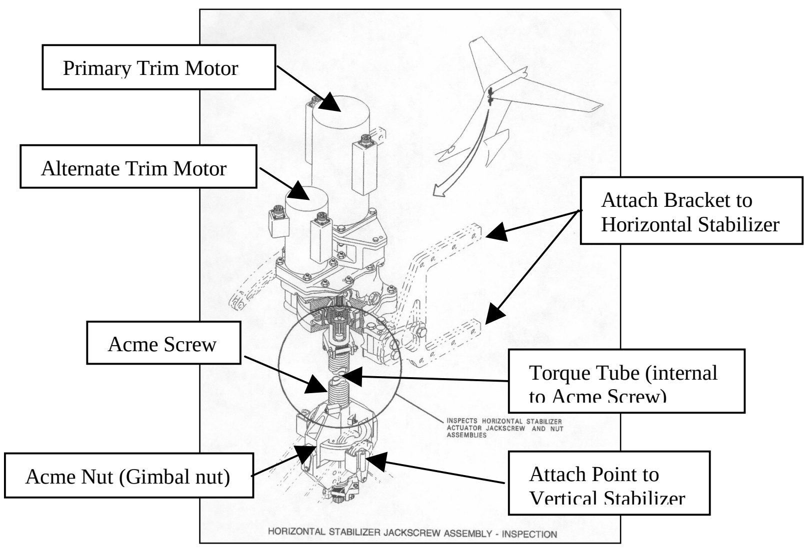
The initial models of the Douglas Aircraft Company, DC-9 were type certificated under the Civil Aeronautics Regulations, CAR 4b, dated December 31, 1953, including Amendments up to 4b-16 and certain special conditions[16]. Application by McDonnell Douglas to build the MD-80 series required significant modifications to the design of the aircraft (i.e. higher tail loads requiring larger diameter torque tube/Acme screw as in the MD-90), therefore those significant aircraft modifications were required to meet the requirements of FAR Part 25.

[15] DC-8 aircraft utilize a dual jackscrew system. The MD-90 aircraft utilizes a single jackscrew system with torque tube, but on a larger scale than the DC-9/MD-80 aircraft.
[16] Reference Addendum to Systems Group Chairman's Factual Report of the Investigation dated February 28, 2002.

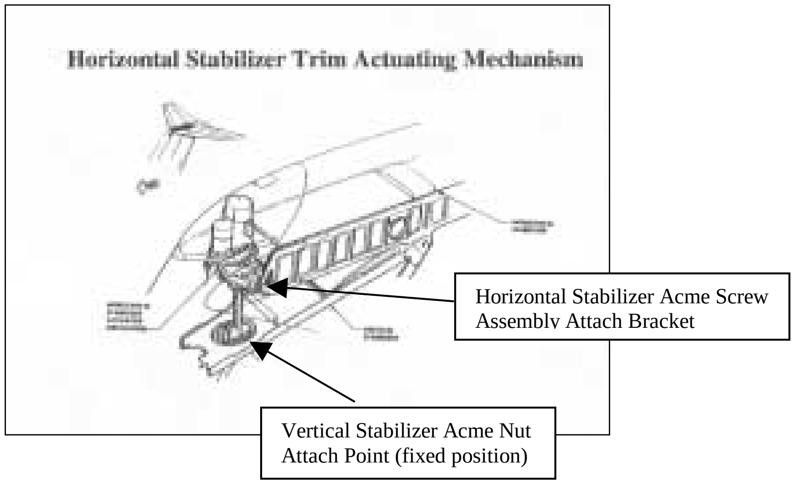
The accident aircraft, N963AS, line number 1995, was delivered new to Alaska Airlines in May 1992. On January 30, 1998, McDonnell Douglas Corporation transferred ownership of the type certificate to the Boeing Company. Since no significant changes were made to the trim system components and the system did not show an unsatisfactory service history, the certification basis for the trim system components on the MD-80 series aircraft remains CAR 4b.

B. HORIZONTAL STABILIZER JACKSCREW SYSTEM DESCRIPTION

The longitudinal trim actuating mechanism is located within the vertical stabilizer forward of the horizontal stabilizer front spar. The actuating mechanism consists of an Acme screw and nut, drive torque tube (quill shaft) located inside the Acme screw, a main gearbox, a sandwich gearbox, a primary longitudinal trim actuator motor, alternate longitudinal trim actuator motor and the necessary supports. The Acme nut (gimbal nut) is attached to the empennage structure by an Acme nut gimbal ring and retaining pins. The Acme screw is threaded in the Acme nut and attached to the upper support through the gearbox assembly, which is installed at the horizontal stabilizer front spar center section.



When either the primary or alternate trim motors are actuated, the gear system is driven and the Acme screw is in turn driven through a spline interface between the torque tube and the interior of the Acme screw. The Acme screw therefore rotates within the Acme nut. With the Acme nut being fixed to the vertical stabilizer internal structure and the screw being attached to the horizontal stabilizer structure, the stabilizer is in turn moved up or down based upon the direction commanded by either the flightcrew or the autopilot.



The MD-80 and DC-9 derivative aircraft utilize a single Acme screw / nut assembly to provide longitudinal trim control. This design incorporates an internal titanium torque tube as the Acme screw drive mechanism and redundant load path. The DC-8 aircraft, however, utilizes a dual Acme screw / nut assembly such as described above. Redundancy is provided through the dual assemblies. No torque tubes are used in the DC-8 design.

C. CERTIFICATION PHILOSOPHY

This accident demonstrates that the logic of the FAA to consider a horizontal stabilizer trim system as a “structural element” is flawed. The FAA considered the jackscrew assembly as a structural component, despite the fact that the assembly consists of moving parts of the stabilizer trim system. This inappropriate classification allowed this critical, non-redundant flight control system to be approved without consideration of wear to the components. The FAA’s interpretation of how this particular system should be characterized (structure versus system) led to a certification of an assembly that allowed a failure mode (i.e. total wear of the Acme nut threads) to present itself that rendered the aircraft uncontrollable. Previous designs of the system (i.e. DC-8 aircraft) did not include a torque tube as the redundant load path, but incorporated dual ACME screws as the means of redundancy.

Mr. Mike O’Neill, of the FAA Aircraft Certification Office, stated during his testimony at the public hearing, that the longitudinal trim system on the MD-80 series aircraft is a combination of structural and system elements. The interface with the gearbox assembly through the cockpit controls would constitute the system components, while the gearbox and Acme screw / nut combination would constitute the structural elements. The FAA considers these “structural” due to the fact that they maintain the primary load path between the vertical and horizontal stabilizers.

The design of the horizontal stabilizer jackscrew assembly presumably met established certification criteria in place at the time. However, these “structural” components were required to conform to Subpart C, Structure of CAR 4b. CAR 4b.201, <u>Strength and Deformation</u>, subpart (b) states that the *“structure shall be capable of supporting limit loads without suffering detrimental permanent deformations”*. CAR 4b.201(c) states “*the structure* *shall be capable of supporting ultimate loads without failure"*. The factual record shows that these particular components do not appear to meet the requirements of CAR 4b.201(b) or (c).

As another example of a failure to comply with the applicable regulations, CAR 4b.270(b), Fail Safe Strength, goes on to state that "*…catastrophic failure or excessive structural deformation, which could adversely affect the flight characteristics of the airplane, are not probable after fatigue failure or obvious partial failure of a single principle structural element.*" This particular system on the DC-9 / MD-80 series aircraft does not appear to meet the requirements of CAR 4b.270(b).

The FAA's interpretation of these particular components as "structural" precluded "wear" from being considered as a failure mode in the type design. Thus, the manufacturer and the FAA considered "wear" of this critical component normal and acceptable and assumed that the components would be maintained airworthy through a properly approved maintenance and inspection program. It is appropriate for a certification philosophy to assume that a proper maintenance and inspection program will maintain the type design. However, when the maintenance program fails or is inadequate, this protection is lost.

Where CAR 4b.270(b) relates to "Fail Safe Strength", FAR Part 25 airworthiness standards are based upon the "Failsafe Design Concept"[17]. It is unlikely that the trim system of this derivative of the DC-9 would meet this Failsafe Design Concept. The factual record clearly indicates that the failure of a single element (Acme nut threads) of this system and the inadequate redundancies built into the system would preclude this system from meeting several of the applicable Part 25 requirements. The certification requirements should be reviewed to determine whether they provide for an appropriate level of safety in component design. There is a need for continuing airworthiness to be monitored and compared with current certification requirements to identify possible areas of regulatory deficiencies.

D. HORIZONTAL STABILIZER IDENTIFIED DESIGN INADEQUACIES

1. Lubrication

The horizontal stabilizer jackscrew was designed in such a way that wear to the Acme nut was expected. Wear of these components is not considered a critical certification item. It was envisioned by the FAA during certification that an approved maintenance program would provide the system and the mechanism to adequately lubricate the components, thus minimizing the wear. The ability to adequately lubricate the assembly is paramount.

Based upon the findings of the investigative groups, design shortcomings exist in the ability to adequately lubricate the assembly, and a more efficient and repeatable means of lubricating the assembly must now be identified.

The Acme nut contains a single zerk fitting to provide lubrication to the internal threads of the Acme nut. However, it is now evident that a single zerk fitting might not be the optimal design to ensure thorough lubrication within the Acme nut. In fact, testing conducted by the

[17] Reference AC25.1309-1A, System Design and Analysis, Section 5, The Failsafe Design Concept

NTSB's Systems Group during this investigation concluded that lubrication of the Acme nut and screw through the Acme nut zerk fitting provided less than optimal lubrication. Lubrication of the assembly through the Acme nut zerk fitting afforded lubrication to approximately 25% of the Acme nut threads[18]. Lubrication of the zerk fitting and a "butter lube" of the Acme screw threads provided the most thorough lubrication of the assembly, but were not optimum. The lower 75% of the Acme nut threads did not receive an adequate amount of grease. Therefore, an improved methodology for ensuring total Acme nut and Acme screw thread lubrication must be identified.

Evidence shows that this particular jackscrew assembly Acme nut, at the time of its recovery from the ocean after the accident, was not able to accept grease due to a clogged zerk fitting[19]. Therefore, lubrication of the internal Acme nut and Acme screw threads would have been impossible in the as-recovered condition. The factual record indicates that this clogged Acme nut counterbore is the result of improper or missed lubrications over an extended period of time which caused the stagnant grease to become old, dry and hard.

Examination of other jackscrew assemblies during the course of the investigation showed similar trends toward clogged Acme nut zerk fittings. It was found on several occasions that grease that has not been purged or cycled out of the zerk fitting counterbore tended to harden and become compacted into the corners of the counterbore[20]. This hard material, if left for an extended length of time would eventually grow to fill the corners of the counterbore. Even with proper lubrications over time, grease would still have the tendency to stagnate in the corners of the counterbore and become dry and hard.

The design of the Acme nut zerk fitting must be corrected and an alternate method of ensuring adequate lubrication should be identified.

2. Endplay Check Procedure

The Systems Group factual reports[21] are full of data found during the analysis of the endplay check procedures in use at the various operators of the MD-80 aircraft. Early in the investigation, it became evident that the integrity of the Acme nut threads prior to the accident flight was in question. Several key facts caused an extensive review of the procedures in place: 1) The endplay check reading discrepancies found during the September 1997 measurement; 2) The questionable functionality of the Alaska Airlines endplay check tool; and 3) The inconsistent endplay check readings being experienced by all operators subsequent to the accident.

[18] Reference the Addendum to the Systems Group Factual Report dated February 28, 2002.
[19] Reference the Materials Group Factual Report 00-145, figure 51.
[20] Reference the Materials Group Factual Report 00-146, figure 25.
[21] Reference the Addendum to the Systems Group Factual Report dated February 28, 2002 and Addendum #3 to the Systems Group Factual Report dated August 21, 2002.

Since the endplay check procedure is vital in determining the amount of wear present in the jackscrew assembly, the factual record clearly indicates the need for a more precise and repeatable endplay check procedure, proper tooling to conduct the measurements and adequate training to ensure the measurements are meaningful and representative of the actual wear present.

III. MAINTENANCE PROGRAM GUIDANCE AND OVERSIGHT

This section is intended to describe the maintenance program within Alaska Airlines at the time of the accident, the oversight both within the company and outside the company (FAA) and the interrelationship of those oversight programs. This section will show how inadequacies in the internal and external oversight processes resulted in substandard maintenance, flawed guidance, poor documentation and improper decision making within the Alaska Airlines maintenance program and the FAA oversight thereof.

Conclusions:

- **The FAA's Maintenance Review Board was not adequately performing its intended function.**
- **Because the FAA's Maintenance Review Board was not performing their intended function, serious deficiencies in the maintenance program at Alaska Airlines were left uncorrected (i.e. lubrication and inspection interval escalations).**
- **Due to a lack of in-service mechanical difficulties on the horizontal stabilizer trim system, training programs, maintenance programs and flightcrew guidance was primarily based upon electrical difficulties.**

A. MAINTENANCE REVIEW BOARD (MRB)

The FAA Maintenance Review Board (MRB) report of the MD-80 series aircraft developed routine initial recommended inspection and maintenance guidelines to assist the operator in developing a Continuous Airworthiness and Maintenance Program (CAMP) for the aircraft. In the 1993 revision of the MSG-2 MRB (revision "Q"), the recommended scheduled inspection and maintenance phases were given as "R" (daily), "A" (450 flight hours), and "C" (3,500 flight hours or 15 months whichever comes first). It also included the inspection of Structural and Non-Structural Significant Items in the program for inspection at 15,000 and 30,000 flight-hour intervals.

However, ALPA noted during our review of the factual material that the MSG-3 MRB includes recommended lubrication intervals, but the MSG-2 MRB did not. We feel that the FAA believed at the time that such a requirement was best determined by the manufacturer and the operator because of the variety of aircraft cycles involved with various operators, which would dictate the lubrication schedules. Therefore, it was Alaska Airline's responsibility to coordinate with the manufacturer and develop and carefully monitor an appropriate lubrication program. Existing operators were permitted to choose from various recommendations of the MSG-2 or MSG-3 MRB's to modify their programs.

B. MANUFACTURER'S RECOMMENDED MAINTENANCE PROGRAM

Federal regulation FAR Part 25.1529, "Instructions for Continued Airworthiness," applies to the MD-80 series aircraft. Part 25.1529 required the manufacturer to provide a maintenance manual with instructions on servicing, degrees of inspections and frequencies, lubrication and wear tolerances and many other details, including a specific section on airworthiness limitations. In addition, Alaska Airlines was also able to obtain guidance from the industry as a whole in developing its program.

The process for development of specific standards for maintenance programs for commercial air carriers is outlined in the NTSB Maintenance Records Factual Report and was described in the testimony of Mr. Lee Koegel, a member of the FAAs Aircraft Evaluation Group, at the NTSB's public hearing. The Maintenance Steering Group (MSG) process, which derives the standards for these maintenance programs, is a combined effort of industry representatives (aircraft manufacturers, component manufacturers, suppliers and airlines). The MD-80 now has two MRB Reports. One is the MD-80 MRB Report derived through the MSG-3 Revision 2 process (original issue: March 1996). The other MRB is the original MD-80 MSG-2 Report (Revision "Q" dated March 2, 1993). Initial MD-80 operators may use one or the other, but may not mix the programs. However, existing MD-80 operators, whose maintenance program is based on the MRB MSG-2 Report, may take advantage of the MSG-3 Report and its listed intervals to adjust its existing programs accordingly and in coordination with its FAA Principal Maintenance Inspector (PMI).

Mr. Koegel's testimony at the NTSB's public hearing indicated that the FAA's MRB document is simply an acceptance of the MSG standards. He admitted that the FAA does not get involved in the development process, but allows the industry group to totally direct and control these standards for maintenance programs. It is self-evident that the groups represented benefit from designing these programs to be as economical as possible. Mr. Koegel's testimony describes the shift in philosophy, with the development of MSG-3, to base scheduled inspections or scheduled maintenance on component failure rates. Mr. Koegel further stated that any component failures that were "detectable by the flight crew" do not, under this philosophy, require scheduled maintenance or inspection until such failures are detected. The NTSB Maintenance Records Factual Report also discusses this MSG-3 philosophy and describes the logic as a "from the top down" or "consequence of failure approach." The report also documents that MSG-3 addresses and emphasizes <u>economic</u> issues: *"Several of the potential impact areas that are examined are initial design, maintenance / ownership cost, and premature removal rates."* It is apparent from Mr. Koegel's testimony that the FAA's MRB is not conducting the reviews which the name of the document implies, that the FAA is not a safety net in this process, and that FAA oversight of this entire process is systemically deficient.

C. IN-SERVICE HISTORY OF THE HORIZONTAL STABILIZER

Review of the service history of the MD-80 horizontal stabilizer showed that there were prior failures of both the primary and alternate trim motors. Some of these failures were attributed to frozen condensation within the motor brake. To preclude this problem, the manufacturer designed and installed an electric heater cap. A thermostat located at the motor controlled the heater automatically. The accident airplane was equipped with this feature. Between January 1999 and the date of the accident, there was at least one maintenance writeup within the Alaska Airlines MD-80 fleet that led to the discovery of a fault in the heater cap system. The Alaska Airlines flightcrew training syllabus does not contain any materials on flightcrew guidance in the event of trim motor failures due to frozen motor brakes. All of the facts highlighted above are supporting information to indicate why the flightcrew would not have immediately suspected a mechanical failure of the trim system.

The accident aircraft's trim system was written up in both October and November 1999, just months before the accident. The first write-up, in October, concerned an incident that began with similar behaviors as the accident flight. The Autopilot Trim Light came on during the descent and approach followed by the disconnecting of the autopilot. The flightcrew flew the aircraft manually, but when they attempted to trim the aircraft they found that the alternate trim was inoperative. They continued to attempt to trim the aircraft with the alternate trim system. It finally began working again after turning onto final approach. The trim system was inoperative for several minutes during the flight. It is unclear whether the jackscrew was actually jammed during this event or whether it was simply an electrical anomaly. Maintenance could not duplicate this malfunction, therefore no action was taken.

The second write-up involved an alternate trim system that would not move the stabilizer during the pre-flight check. The primary trim system was functional. Alaska Airlines took the aircraft out of service and replaced the alternate trim switches in the cockpit.

In neither of these instances was the jackscrew physically inspected. Alaska Airlines conducted inadequate fault isolation by not following up on a trim system malfunction with an inspection of the jackscrew.

The NTSB investigation did not find any known maintenance trends or discrepancies of the horizontal stabilizer in its review of the FAA's Service Difficulty Reports (SDR)[22] from 1990 to 2000. The ATA categories reviewed were: autopilot, electrical power, flight controls, hydraulic power, ice and rain protection, and stabilizer. There were no SDR reports filed by Alaska Airlines for the flight control or stabilizer categories from 1985 through 1999. RAP records did indicate that Alaska Airlines experienced mechanical difficulties such as those listed above. Those difficulties are documented in the RAP records of the Maintenance Records Group Field Notes.

The NTSB's Maintenance Records Group review of reports filed with the FAA by all aircraft operators between 1990 and February 2000 revealed 70 horizontal stabilizer SDR's related to the stabilizer control system, stabilizer position indicating system, and stabilizer actuator system. Most were related to malfunctioning electrical components, but three horizontal stabilizers jackscrews were replaced because of corrosion, pitted threads and threads worn beyond wear limits. One was replaced because of a broken upper mechanical stop.

The manufacturer took several steps to deal with these field service discrepancies. In the November 4, 1966 All Operators Letter (AOL), the jackscrew endplay inspection procedure and the acceptable level of tolerance (0.003 to 0.0265 inches) was clarified. The February 28, 1967 AOL improved the inspection procedure by increasing the restraining fixture torque from 150 to 200 inch-pounds, but allowed more endplay tolerance (0.003 to 0.040 inches). Also in that letter, the manufacturer noted that their tests had disclosed an increased wear rate between the jackscrew nut and screw over what was expected, from 0.001 to 0.004 inches per 1,000 flight

[22] Previously termed "Mechanical Reliability Reports". Reference FAR Part 121.703, 704.

hours. It recommended that the endplay check be done between 3,000 and 3,500 flight hours. It also cautioned operators, that, when the jackscrew assemblies measure between 0.034 to 0.040 inches, inspections should be made at intervals not to exceed 1,000 flight hours.

A May 29, 1984 AOL reinforced the lubrication requirements because three jackscrew assemblies had to be replaced prematurely at 6,000 total flight hours. These Acme nut components exhibited severe thread wear indicating inadequate lubrication. As a result, the manufacturer concluded that inadequate lubrication was the cause of the excessive wear and it emphasized the need for an active operator lubrication program. It made reference to its DC-9 and MD-80 recommended OAMP. The OAMP specified 600 flight-hour lubrication intervals.

In their December 6, 1990 AOL, McDonnell Douglas spoke again about wear rates. At this time, another low-time jackscrew assembly was found worn beyond acceptable limits. The manufacturer's in-service reliability data showed a Mean Time Between Repair (MTBR) and a Mean Time Between Unit Replacement (MTBUR) of 25,000 and 30,000 flight hours respectively. It recommended the need to conduct an operator survey on in-service wear rates.

Thus, on September 5, 1991, another AOL with the results of the survey was issued showing that the average lubrication interval for the MD-80 was 804 hours, the MTBR was 24,397 hours, the MTBUR was 28,397, and the wear rate per 1,000 flight hours was 0.0013 inches. The MTBR and MTBUR figures were within the manufacturer’s in-service reliability numbers. However, tests conducted by the manufacturer had disclosed a wear rate of 0.004 inches per 1,000 flight hours. Based on this information, McDonnell Douglas continued to recommend the repetitive 600-hour or sooner lubrication interval with the McDonnell Douglas approved grease. At no time was the McDonnell Douglas recommended lubrication interval extended by McDonnell Douglas. Therefore, Alaska Airlines extended their lubrication intervals based upon non-existent information and the FAA’s oversight allowed these escalations to occur.

IV. CONTINUING AIRWORTHINESS

This section will describe the continuing airworthiness program within Alaska Airlines, and the levels of involvement by the aircraft manufacturer, operator and the FAA.

Conclusions:

- **The fact that the investigative team was unable to establish any single individual who was responsible and accountable for the change in lubricants for the stabilizer jackscrew indicates that specific responsibilities within the organizational structure were either undefined or not complied with.**
- **The flaws in the process for proposing, researching, and implementing changes to the maintenance program (the ME-01 process) allowed the change to a lubricant that was not approved by the FAA or the aircraft manufacturer.**
- **The use of the unapproved lubricant (Aeroshell 33) appears to have not been a factor in the resulting condition of the Acme nut threads.**
- **The cause of the significant wear to the Acme nut threads and the ultimate failure of the component was the result of a lack of lubrication.**
- **The horizontal stabilizer jackscrew components were not lubricated in September of 1999, contrary to the indications on the taskcard.**
- **Inadequate internal and external oversight processes and practices allowed escalations of both inspection and lubrication intervals for the jackscrew components. These escalations were a systemic problem and a significant factor in this accident.**
- **A lack of written procedures in the production control processes at Alaska Airlines (specifically OAK) were a significant factor in the cause of this accident.**
- **All management positions required by FAR were not filled at Alaska Airlines in compliance with the applicable regulations.**
- **The failure of the FAA to follow up on these vacancy issues at Alaska Airlines resulted in key functions not being addressed.**
- **A chain of command was not in place prior to the accident that established accountability for any action.**
- **Command, control, and responsibility for Alaska Airlines Maintenance Department was undefined at the time of the accident.**
- **The reversal of the decision to replace the stabilizer jackscrew assembly during the C5 check of aircraft N963AS in September 1997 at the Oakland Maintenance Facility was a clear indication of a lack of standardized maintenance procedures.**
- **The administrative process established for proposing, researching, and implementing changes to the maintenance program (utilizing form ME-01) is flawed and inadequate.**
- **An effective Reliability Analysis Program (RAP) for the MD-80 might have prevented the catastrophic failure of the horizontal stabilizer jackscrew assembly**

A. ALASKA AIRLINES' MAINTENANCE & ENGINEERING

Alaska's MD-80 maintenance program was approved by the FAA in March 1985, based on the FAA's MSG-2 MRB. Using this document, the airline established its initial minimum inspection and maintenance requirements for the airframe, systems, powerplants and other components for its MD-80 series aircraft (R, A, and C checks).

1. Maintenance & Engineering Department (Organization, Administration, and Staffing)

The NTSB's Maintenance Records Group and the FAA's Special Inspection Team found deficiencies in the Maintenance & Engineering Department's organization, administration, and staffing. FAR Part 119.65, *Management Personnel Required for Operations Conducted Under Part 121*, cites specific requirements for airline positions to be filled. Several of those requirements are:
(a) Each certificate holder must have sufficient qualified management and technical personnel to ensure the highest degree of safety in its operations. The certificate holder must have qualified personnel serving full-time in the following or equivalent positions:
(1) Director of Safety.
(2) Director of Operations.
(3) Chief Pilot.
(4) Director of Maintenance.
(5) Chief Inspector.

Many of these positions were not filled at Alaska Airlines at the time of the accident. This gravely impacted the safety of the company and was directly related to the inadequate oversight by the FAA for allowing such positions to remain open.

a) Director of Maintenance Position

There was no full-time Director of Maintenance as required by FAR 119.65. This position had been vacant for almost two years at the time of the accident. The Director of Line Maintenance and the Director of Base Maintenance were sharing the duties of the Director of Maintenance but there was no explanation on how these duties would be apportioned. However, the Assistant Vice President of Maintenance would report to the Staff Vice President of Maintenance and Engineering, who in turn, would report to the Executive Vice President of Technical Operations and System Control. This arrangement left command, control, and responsibility for the airline's Maintenance Department undefined at the time of the accident.

b) Director of Safety Position

There was no full-time Director of Safety as required by FAR 119.65. At the time of the accident the acting Director of Safety also had the responsibilities of two other positions, Director of Quality Control and Director of Training. The corporate organizational charts at the time of the accident also show that this individual directed the Quality Assurance (QA) Department as well. The organizational charts do not show a department of safety under the Director of Safety or any individuals supervised in a safety capacity. Formal interviews conducted by the NTSB's Maintenance Records Group with several of Alaska Airline's management personnel and with several members of the FAA's Certificate Management Team (CMT) revealed that there was not a formal safety reporting system in effect prior to or at the time of the accident. Interviews indicated that there was no formal division of responsibilities between the part-time Director of Safety and the Director of Flight Safety. Little communication took place between those individuals outside of scheduled meetings.

119.65(B) goes on to state, *"The Administrator may approve positions or numbers of positions other than those listed in paragraph (a) of this section for a particular operation if the certificate holder shows that it can perform the operation with the highest degree of safety under the direction of fewer or different categories of management personnel due to -*
(1) The kind of operation involved;
(2) The number and type of airplanes used; and
(3) The area of operations."

Interviews conducted by the Maintenance Records group on the Alaska Airlines PMI indicated that the Certificate Management Office (CMO) was not satisfied with Alaska Airlines having these positions vacant. No one at the FAA's CMO for Alaska Airlines had approved these vacancies and the PMI stated that he had issued several "ultimatums" to Alaska Airlines management regarding the absence of full-time personnel in these two positions. The FAA failed to follow up on these issues.

c) Maintenance Procedures / Program
Inadequate command, control, and responsibility within the Alaska Airlines maintenance organization were also discovered during the investigation. There were no written procedures for Production Control during heavy checks at the Oakland maintenance facility (violation of FAR 121.135). This lack of written procedures for heavy checks is an important factor in this accident and directly relates to management's reversal of the decision to replace the stabilizer jackscrew assembly during the C5 check of aircraft N963AS (accident aircraft) in September 1997 at the Oakland Maintenance Facility. No written procedures were in place to either allow or to prevent the reversal of the "planned action" written by the lead mechanic on the MIG-4 maintenance form (Nonroutine number 4236374). The NTSB's Maintenance Records Group was unable to establish who had the authority to authorize this change to the planned replacement of the jackscrew assembly on aircraft N963AS.

The administrative process established for proposing, researching, and implementing changes to the maintenance program (utilizing form ME-01) is flawed and inadequate. For example:

- The form used for requesting and implementing a change (Form ME-01) does not require reference to any applicable federal regulatory requirements and/or the aircraft manufacturer's recommendations or specifications.

- It is impossible to determine which signatures are required for approval of a specific requested change by viewing the form. The General Maintenance Manual (GMM) must be consulted.
- There is no signature block indicating an individual with final control, authority, and accountability for approval of the requested change.
- There is no indication on the form of whether FAA approval is required for the requested change.
- There is no indication on the form of whether FAA approval has been received when required.
- There is no formal routing procedure indicated for directing the form to the various management personnel for review and signature. Interviews with management personnel indicated that there is, in fact, no routing procedure in effect.

All of the deficiencies in this process were found on ME-01 #002974 of 2/23/97. This specific ME-01 requested and directed a change in lubricants for flight controls (including the stabilizer jackscrew), doors, and landing gear (except wheel bearings) on MD-80 aircraft. Implementation changed the lubricant from Mobilgrease 28 to Aeroshell 33. This grease did not meet the specifications of the aircraft manufacturer for the MD-80 and additionally the grease had not been approved by the FAA for these applications on MD-80 aircraft.

This specific ME-01 had no signatures in several signature blocks including the block titled "Maintenance Programs/Publications Change Request Accomplished." A review of the form alone would, therefore, indicate that the change had never actually been accomplished, when, in fact, it had. It should be noted that when the task cards were changed specifying Aeroshell 33 instead of Mobilgrease 28, the GMM was not changed and still specified Mobilgrease 28. Thus, a technician consulting the GMM instead of the task card for the particular task would believe that the appropriate lubricant to be used was still Mobilgrease 28. Again, this points to a systemic failure in Alaska Airlines corporate culture and a lack of proper oversight on the part of the PMI.

d) Staffing

Interviews with members of the FAA's CMT indicated that there were an inadequate number of personnel staffing the Maintenance Department. The FAA's former Principal Maintenance Inspector stated, "*And again, that was another function that was very overburdened for the number of people they had. They couldn't do a lot of things that they probably should have been doing because there just wasn't enough of them…they hired a lot of people but it didn't really keep pace.*" The Assistant PMI (acting PMI at the time of the accident) said, "*With regard to quality assurance, I believe they were shorthanded there, that the auditing process could have been better…*" In addition, a conclusion made during the FAA Special Inspection of Alaska Airlines following the accident was, "*They (Alaska Airlines) have a very dedicated group of employees that attempt to make do with what they do have, but their system is incomplete and has no tolerance or redundancy built into it.*"

2. Lubrication Interval Escalation

Lubrication intervals for the stabilizer jackscrew were escalated from an interval of 500 hours in 1987 to an interval of 8 months (approximately 2,550 hours) in 1996. The lubrication intervals prescribed by Alaska's maintenance program can best be described in the following table that compares the MSG-2 OAMP, MSG-3/MRB and Douglas Aircraft Company OAMP:

Date	**ALA Inspection (Hrs)[23]**	**ALA Flt Hrs**	**MSG-2 OAMP Flt Hrs**	**MSG-3 MRB/ OAMP Flt Hrs/C1**	**DAC AOL's Flt Hrs**
March 1985	B2 (B=350)	700	600-900	3,600/15 mos	OAMP 600
March 1987	B1 (B=500)	500	600-900	3,600/15 mos	OAMP 600
July 1988	A8 (A=125)	1,000	600-900	3,600/15 mos	OAMP 600
February 1991	A8 (A=150)	1,200	600-900	3,600/15 mos	OAMP 600
December 1994	A8 (A=200)	1,600	600-900	3,600/15 mos	OAMP 600
July 1996	Max 8 mos.	Est. 2,550	600-900	3,600/15 mos	OAMP 600
October 1996	Max 8 mos.	Est. 2,550	600-900	3,600/15 mos	OAMP 600

Alaska Airlines Horizontal Stabilizer Jackscrew Lubrication Program

There was no lubrication interval identified under MSG-2 or prescribed in the MSG-2 MRB. Lube intervals were not recommended until MSG-3. Prior to MSG-3, the only recommended lube intervals were those in the OAMP of the aircraft manufacturer and reflected in the manufacturer’s published generic task cards. Alaska’s action also conflicts dramatically with the in-service history of the jackscrew and the AOL's published by DAC. The NTSB's Maintenance Records Group Chairman's Factual Report does not state what the lubrication intervals were, nor does it state which MSG documents were used by those operators surveyed by DAC and reported in its summary on September 5, 1991, in AOL 9-2120A. This significant information should have been available to DAC, but evidence does not indicate whether it was reported to operators. Knowing what MSG program and lubrication schedules were used, would likely explain the reasons for the excessive wear reported. The dramatic difference in the extended lubrication intervals used by Alaska and those recommended by the manufacturer would have had a significant effect on the overall wear of the jackscrew components.

3. Lubrication History

A maintenance technician reported in a post-accident interview that he lubricated the stabilizer jackscrew before the second endplay inspection on September 30, 1997. He explained that lubrication is usually the last task that is accomplished in a particular zone before closing all of the inspection panels for that zone. He also indicated that if the grease

[23] Note: Inspection intervals are depicted here as multiples of specific checks. For example, B2 is representative of “every two B Checks” and A8 would be “every eight A Checks”.

fittings were clogged and would be unable to accept grease, he felt that it would have been difficult to pump the grease gun. The procedure, as described during the investigation, is to add grease to the zerk fitting until grease either comes out from around the grease gun nozzle or out of the top of the Acme nut, indicating that enough grease has been added. It is conceivable that if the zerk fitting was clogged, that grease could become visible around the nozzle of the grease gun and the mechanic would believe that the lubrication was complete.

The Maintenance Records Group was unable to determine who ordered the lubrication of the stabilizer jackscrew assembly before the second set of endplay checks were made. The mechanic was questioned as to who ordered him to lubricate the assembly. He stated that he was unable to recall which lead mechanic assigned this task to him. The investigative group also could not determine why the lubrication was ordered out of sequence on a part that, at the time, was scheduled to be replaced.

The last required lubrication of the horizontal stabilizer jackscrew assembly on N963AS was documented on September 24, 1999, at SFO. At the time of this lubrication the task card for this procedure specified Aeroshell 33 as the grease to be used. The Alaska Airlines GMM, however, specified Mobilgrease 28. The Maintenance Records Group was not able to establish which type of grease was actually used for the lubrication. Mechanics interviewed indicated that the assembly was lubricated, and the task cards called for Aeroshell 33. Although the task card for this lubrication in 1999 indicated that Aeroshell 33 was used, the Materials Group found no visible Aeroshell 33 either on the Acme screw or the Acme nut. Nor did the Materials Group find any evidence of Aeroshell 33 in the Acme nut gimbal ring (which is also a component of the jackscrew assembly that would have required lubrication at that time).

While examining the Acme nut gimbal ring, the Materials Group conducted a lubrication of the Acme nut gimbal ring to identify what type of grease was within the component. Aeroshell 33 was added to the Acme nut gimbal ring through the zerk fitting and the grease was observed as it exited the ports once the Acme nut gimbal ring was full. The Materials group noted that red grease was the first to exit the port, followed by green grease[24]. As was mentioned earlier, Mobilgrease 28 is red in color, while Aeroshell 33 is a dull greenish color. This led the investigators to believe that, although the task card indicated that Aeroshell 33 was to be used and the greasing was accomplished, there was none present within the Acme nut gimbal ring. This indicates that either Mobilgrease 28 was used (contrary to the task card), or the component was not greased with Aeroshell 33 as the task card indicated.

4. Grease Change

The McDonnell Douglas MD-80 Maintenance Manual (MM 12-21-00, dated July 1, 1994, page 5) specifies Mobilgrease 28 (MIL-G-81322) as the specified wide temperature range (WTR) grease for general airframe lubrication, including the jackscrew on MD-80 airplanes. In January 1996, Alaska Airlines received Boeing approval towards the use of Aeroshell 33, as an all-purpose grease, on its Boeing B737 airplanes.

[24] Reference Materials Group Factual Report 00-145, page 17.

A request was made by Alaska Airlines on January 16, 1996 through the McDonnell Douglas Field Service Representative (SEA), to substitute Aeroshell 33 for Mobilgrease 28 in suitable areas on MD-80 airplanes to standardize lubricants between the Boeing and Douglas fleets at Alaska Airlines. On February 23, 1996, Douglas Aircraft Company replied that Aeroshell 33 would require laboratory testing for use on Douglas airplanes. On January 24, 1997, McDonnell Douglas stated that laboratory testing of Aeroshell 33 was currently underway; however, no schedule had been set for completion, and it was probably at least a year away. Aeroshell 33 was not currently approved for use on McDonnell Douglas airplanes.

On June 19, 1997, McDonnell Douglas stated that it was pursuing the possibility of a "no technical objection," for Alaska Airlines to use Aeroshell 33 on McDonnell Douglas airplanes. However, it was not a sure thing, considering the liability of providing consent for the use of such an important lubricant on the airplane before it had been fully evaluated. Another option provided to Alaska Airlines by McDonnell Douglas was to conduct its own in-service evaluation of the grease. However, McDonnell Douglas did not provide any specific guidance to Alaska Airlines on how to conduct this lubricant evaluation. Alaska Airlines did begin using Aeroshell 33 on their MD-80 fleet under the lubrication intervals indicated earlier in this report, but no special evaluations took place and no documentation of lubrication characteristics or anomalies were generated as required by the Boeing No Technical Objection (NTO) document. It must be pointed out that an NTO is not an approval by the OEM. It simply is a document indicating that the manufacturer does not have enough technical information to either approve or disapprove. An NTO suggests that the operator document any adverse reactions to such a change and report that to the OEM.

On June 23, 1997, the McDonnell Douglas Field Service Representative sent a message to the manufacturer noting that Alaska Airlines welcomed the offer to conduct an in-service evaluation of Aeroshell 33, and would await guidelines regarding its use.

On July 23, 1997, Alaska Airlines issued a "Maintenance Programs/Technical Publications Change Request," form ME-01 (97-002974), to revise applicable lubrication cards by replacing Mobilgrease 28 with Aeroshell 33, for flight controls, doors, and landing gear (except wheel bearings) on MD-80 airplanes.

On September 26, 1997, McDonnell Douglas issued message number SVC-SEA-0122/MRL (action number 332808) stating that it had "no technical objection" against Alaska using Aeroshell 33 in place of Mobilgrease 28 for lubricating MD-80 airplanes, with one known restriction. The restriction was that Aeroshell 33 may not be used in areas subjected to temperatures in excess of 250° Fahrenheit, including landing gear wheel bearings.

The rationale for this restriction was based upon laboratory testing that was conducted by the OEM. Initial laboratory test results comparing Aeroshell 33 with Mobilgrease 28 indicated that Aeroshell 33 was less resistant to water washout than Mobilgrease 28. The message to Alaska Airlines by McDonnell Douglas[25] also stated that a potential exists that frequency of lubrication could be affected in areas exposed to deicing fluids, outside conditions or airplane washing and cleaning. Additionally, the "no technical objection" was provided before the

[25] Reference Maintenance Records Group Factual Report, Attachment 11H.

completion of the Douglas Aeroshell 33 study, and therefore Douglas could not verify the performance of the grease. The McDonnell Douglas message stated that Alaska Airlines had the responsibility to monitor lubrication areas for any reactions. Furthermore, it would be the responsibility of Alaska Airlines to obtain any FAA approval for use of this grease on its MD-80 airplanes.

On December 18, 1997, task card 24312000 (lubrication of horizontal stabilizer) was revised per ME-01 (97-002974), noting the material change to use Aeroshell 33 instead of Mobilgrease 28.

After switching to Aeroshell 33 for lubrication of the elevators and horizontal stabilizer, Alaska Airlines experienced several elevator flight control problems. As a result, on December 17, 1999 (ASA-SEA-00442F), Alaska Airlines requested comments from Boeing about the performance of Aeroshell 33 lubrication on MD-80 elevators and elevator tabs, while operating in low temperatures. It is clear that Alaska Airlines made a change to the type of grease it was using on its MD-80 fleet prior to asking McDonnell Douglas whether this change would have any negative impact on the operation of the system. It was not until Alaska Airlines began experiencing problems on its MD-80 aircraft during cold-weather operations that they queried the manufacturer.

On December 22, 1999, (ASA-SEA-99-00440H) Boeing responded that Aeroshell 33 had been tested with 25 percent water content. The water-laden grease was subjected to torque testing at the lower end of its operating temperature range, minus 100º Fahrenheit (F), and found to exhibit a 25% increase in friction. However, the increase did not appear to be significant for the operation of the MD-80 elevators and elevator tabs. Assuming a similar friction increase in the water-laden Aeroshell 33 at the lower end of Mobilgrease 28's operating range (minus 65º F), Aeroshell 33 still exhibited significantly less friction than Mobilgrease 28. It was also noted that Mobilgrease 28 is the standard production grease for elevator and elevator tab surface hinge bearings, and has acceptable friction characteristics throughout its operating temperature range when used in these hinges. Boeing also referenced the September 26, 1997, letter of "no technical objection," and Alaska Airlines responsibility to obtain FAA approval to use Aeroshell 33.

The FAA's Principal Maintenance Inspector for Alaska Airlines at the time of this change of lubricants was interviewed by the NTSB Maintenance Records Group. He was asked: "*You're saying that you were not given any justification by Alaska?"* The inspector answered: *"No, I wasn't. No, I wasn't. Now whether or not the fleet manager had any knowledge of it, I don't know. But I certainly didn't know."* The inspector was asked: *"But would that be considered important, changing spec on the lubrication?"* The inspector replied, *"I think it would be, yes. Absolutely. And I don't know that we knew about or approved either one. I don't know…But had we been aware of it, we probably would or should have asked for some justification for it."* He was asked: *"But don't you recall any justifications or anything or asking about that --?"* The inspector replied, *"No."* The PMI added that, *"But changing the type grease on one work card, I don't know that anybody caught that or noticed it or bought off on it or looked into it at all."* Therefore, it would appear that Alaska Airlines had submitted the revised task cards to the FAA that changed the lubricant for flight controls on the MD-80 to Aeroshell 33, but the PMI was not aware that this change had occurred. It would also appear that no supporting justification was either provided by Alaska Airlines or requested by the FAA until after the accident, when the FAA actually realized that the grease change had occurred.

With regard to the significance of an NTO letter, the PMI said: *"If Boeing didn't approve it, I wouldn't let them use it. Because any time Boeing says no technical objection, that means we're subject to liability here if we say yes. That's enough for me to say no."*

The FAA's Assistant PMI was also asked about the significance of an NTO letter. He stated, *"…the no technical objection is just simply saying that they have reviewed the data and they don't necessarily object to it but they're not approving anything."* When asked about the documentation sent to the FAA to provide justification for the change in lubricants, he stated, *"Yes, I have gone back and requested and received all the documentation that they utilized in accomplishing this change."* He was asked: *"That was kind of after the fact, though?"* He replied, *"Definitely after the fact. It was after the accident with my review of the documents."*

The Assistant PMI was also asked: *"In the letter, you stated that your review showed – indicated that there was not enough substantial data to make this change."* He responded: *"…And throughout all the documentation, I tried to find any place that the two – you know, that the data sheets and the specifications given to me would correlate between Boeing spec and the manufacturer's recommended spec, and I could not find that."* He was then asked *"So, none of this correspondence you knew about 'til after the fact?"*. His response, *"Right. None of this came to light until March of this year [2000]."*

In March 2000 (2 months after the accident), the FAA requested and received from Alaska Airlines informational material regarding the substitution of Aeroshell 33 for Mobilgrease 28 that occurred in December 1997. The justification material was to be reviewed to substantiate the lubricant substitution.

On April 5, 2000, the FAA issued a letter to Alaska Airlines stating that the documentation did not support this change, and requested Alaska Airlines to refrain from utilizing Aeroshell 33 in those areas where the airplane maintenance manual specifically recommends the use of Mobilgrease 28, until such time as additional justification for the substitution can be documented. On April 28, 2000, task card 28312000 (lubrication of the horizontal stabilizer) was revised to reflect the return to Mobilgrease 28.

On June 23, 2000 (5 months after the accident), a letter of investigation (LOI) involving lubricants was sent by the FAA to Alaska Airlines. These facts are stated to show the total systemic failure between the FAA, the manufacturer and Alaska Airlines.

The change to Aeroshell 33 from Mobilgrease 28 by Alaska Airlines was significant with respect to the lack of oversight on the part of the FAA and the failure to follow procedures on the part of Alaska Airlines. However, we must add here that the grease change, in and of itself, did not have any significant impact on the lubricating abilities or the wear characteristics of the components. In fact, the NTSB's Grease Group determined that Aeroshell 33 actually provided better friction characteristics than Mobilgrease 28 and mixtures of the two greases had little effect on the lubricating properties[26].

5. Endplay Check Interval Escalation

As the lubrication intervals for the stabilizer jackscrew assembly were being escalated at Alaska Airlines, the inspection and endplay check intervals were not shortened in order to monitor the affects of the decreased frequency of lubrication. The opposite was actually being implemented. As the interval between lubrications increased from an interval of 500 hours in 1987 to an interval of 8 months (approximately 2550 hours) in 1996, the interval between inspections and endplay checks increased from 5000 hours in 1985 to 30 months (approximately 9950 hours) in 1996.

Year	**Interval between Lubrications**	**Interval between Inspections / Endplay Checks**
1987	500 hrs	5000 hrs
1996	~2550 hrs (8 months)	30 months (~9950 hrs)

No special monitoring program or special inspections were established for the Reliability Analysis Program to monitor the affects of decreased lubrication on the MD-80 stabilizer jackscrew assembly.

While the recommended MRB and MSG-2 reports permit extensions of scheduled inspections, Alaska Airlines would have been required to have made these decisions based upon reliable evidence available indicating that it was safe to do so. These decisions depend on sound maintenance practices, reliable quality control and quality assurance programs and robust reliability analyses within the company, for which there were none. During the course of the investigation, Alaska Airlines did not produce any supportive data from its QA, QC or RAP programs to justify the escalation of lubrication intervals for the stabilizer jackscrew assembly.

Approximately three years after beginning to operate the MD-80, Alaska Airlines began to increase the aircraft's utilization rate. The "C" check intervals were escalated from 2,500 flight hours in 1985 to 13 calendar months (about 3,200 hours) in 1988 and to 15 calendar months (about 4,975 hours) in 1996. In conjunction with this increase, Alaska escalated the horizontal stabilizer, Acme screw and nut endplay inspection intervals (C2 check) from 5,000 hours (about 24 calendar months) in 1985, to 26 calendar months (about 6,400 hours) in 1988, and to 30 calendar months (about 9,950 hours) in 1996.

Year	**"C" Check Interval**	**Endplay Inspection Interval (2C)**
1985	2500 hrs	5000 hrs
1988	13 Months (~3200 hrs)	26 Months (~6400 hrs)
1996	15 Months (~4975 hrs)	30 Months (~9950 hrs)

[26] Reference Investigation of the Wear Rate of Grease-Lubricated C95500 Bronze, dated August 5, 2002, prepared for the NTSB Grease Group.

Note that as interval escalations took place at the airline, the intervals changed from hourly requirements to calendar requirements. The hourly requirement was actually dropped with the first escalation in 1988 and the C-Checks and endplay check intervals were subsequently based on calendar months only, with no reference to flight time for all of the escalations after that. This change from hourly intervals to calendar intervals would have required CMO approval. This change was either approved or overlooked by the FAA, even considering the fact that the MSG-2 MRB recommended an endplay check interval of 30 months or 7,000 hours, ***whichever came first***. With the development of the MSG-3 MRB, the recommended interval was 30 months or 7200 hours, ***whichever came first***. These requirements exist today. Therefore, by 1996, Alaska Airlines was exceeding the hourly requirement by approximately 2700 hours.

The NTSB's Maintenance Records Group found no data from the Alaska Airlines Reliability Analysis Program to support the escalation to 30 months, other than the absence of any catastrophic component failures or unscheduled component removals. As previously noted, endplay measurements were not recorded nor were Acme screw and nut wear rates tracked. Had this been a requirement, the accelerated wear rate on the accident component could have been identified and the accident might have been avoided.

Aircraft N963AS had a total airframe time of 26,584:43 hours at the time of the accident. The last endplay check of the stabilizer jackscrew assembly was performed during the C5 check in September 1997; at that time, the aircraft had a total airframe time of 17,699:59 hours. Alaska's next scheduled endplay check on 963 was not scheduled until May 2000, a 32 month interval. Therefore 8885 hours had accumulated on the airframe since the last endplay check. This simple calculation indicates that if the recommendations of either the MSG-2 MRB or the recommendations of the MSG-3 MRB had been adhered to with respect to endplay checks, one additional endplay check would have been accomplished prior to the accident. This additional endplay check **was not** conducted. This was, however, not a violation since the MSG MRB document is guidance for setting up an initial maintenance program. Deviations from this guidance are permitted based upon the FAA approved reliability analysis.

The maintenance program at Alaska Airlines has a mechanism for scheduling special inspections or additional maintenance by issuing an E.O. (Engineering Order) through the Engineering Department. An E.O. can be issued for an aircraft to be re-inspected prior to the next routinely scheduled one if the endplay was found to be at or near the limit at the C5 check. This could have been conveniently scheduled for one of the phased "A" checks or for the C6 check in January of 1999.

The lead mechanic who initially wrote the corrective action recommending replacement of the accident aircraft assembly in 1997 was asked why a re-inspection wasn't scheduled. He stated in the interview, "*…but there's a stigma with having a plane go out with items that are deferrals or things of this nature that for whatever reason perhaps just doesn't look good, but there seems to be, there, that was an issue. I can say that with certainty, having a plane go* *out with an MEL or with some other deferral was not preferred, definitely did not want this to happen*." He was asked if that process was discouraged. His answer: "*yes*."

6. Reliability Analysis Program (RAP)

An effective Reliability Analysis Program (RAP) for the MD-80 might have prevented the catastrophic failure of the horizontal stabilizer jackscrew assembly. However, the RAP used by Alaska Airlines was ineffective. The FAA authorized its use for the MD-80, as part of Alaska's maintenance program under the guidelines of FAA Advisory Circular AC 120-17, "Maintenance Control by Reliability Methods." The objectives of the program are to improve airworthiness, reliability and cost effectiveness of the inspection, maintenance and overhaul programs for a particular aircraft. In view of the complexity and flexibility of such a program, it requires special attention by the FAA before approval is granted because every element of the program must be studied. Alaska Airlines controls its maintenance programs by management decisions based on continuing analysis of operational data. The RAP Control Board was the governing body within the company for the program and it was administratively supported by the Reliability Department.

Investigation by the NTSB Maintenance Records Group disclosed that the Unscheduled Removal Alert report for 1999 (including a three-month rate per 1,000 unit hours, for components related to the stabilizer trim system) contained the removal of only two horizontal stabilizer jackscrews and support assemblies while there had actually been three assemblies removed and replaced. The third unit was removed in November 1999; however, a new unit was not installed until January 2000. Thus, the airplane check and component report was not completed until January 2000. Even though two removals occurred in November 1999, at no time before the accident did the component unscheduled removal rate trigger the alerting system, requiring an investigation. In spite of these three removals, Alaska Airlines did not submit to the FAA SDR's about these assemblies as required by federal regulation.

In view of the previous reported discrepancies and associated horizontal stabilizer and component alert notices issued, the absence of this Control Board information is another indication of the inadequacies in the RAP. Specifically:

1. With the exception of a catastrophic component failure or unscheduled component removal, the RAP contained no concrete data or robust analyses to support Alaska Airline's decisions to escalate the horizontal stabilizer jackscrew endplay inspections and lubrication intervals; and
2. The endplay measurement findings were not recorded nor were Acme screw and nut wear rate data included in the RAP.

With regard to the stabilizer jackscrew assembly, the endplay measurements were not recorded during inspections until 1999. The Reliability Analysis Program therefore had no information available to track average Acme thread wear rates or to alert the program of an increase in wear rate.

7. Continuous Analysis and Surveillance System (CASS)

The factual record shows that Alaska Airlines did not have an effective Continuous Analysis and Surveillance System (CASS) at the time of the accident. This is a violation of FAR 121.373. The regulation requires that "*each certificate holder shall establish and maintain a system for the continuing analysis and surveillance of the performance and effectiveness of its inspection program and the program covering other maintenance, preventive maintenance, and alterations and for the correction of any deficiency in those programs, regardless of whether those programs are carried out by the certificate holder or by another person*." Prior to the accident, the FAA never took any action against Alaska Airlines as a result of this failure to comply with the provisions of 121.373.

An interview with the former Manager of Seattle Base Maintenance for Alaska Airlines (at the time of the accident) conducted by the NTSB's Maintenance Records Group indicated that the Quality Control Department's inspectors were not performing independently. *"…the QC Department always supervised and told mechanics or leads what to do and used their stamps as a source to make it – their point to be done…where the checks and balances were suppose to be there, they weren't there. And that gave them the ultimate authority and the ability to say, you do this or else. And that occurred on a continuous, daily basis."* The manager also testified, *"I brought a lot of issues to ( ) attention dealing with whether it be in document maintenance, going back over work and not voiding out the stamps of other mechanics and inspectors. Other issues that we were dealing with, like I say, the separation between QC and – and supervision was a big one for me…"*

The deficiencies in Quality Control perceived by the Manager of Seattle Base Maintenance may relate directly to the failure to replace the worn stabilizer jackscrew assembly on aircraft N963AS during the C5 check in 1997. FAR 121.369 requires that the maintenance manual contain *"instructions and procedures to prevent any decision of an inspector, regarding any required inspection from being countermanded by persons other than supervisory personnel of the inspection unit, or a person at that level of administrative control that has overall responsibility for the management of both the required inspection functions and the other maintenance, preventive maintenance, and alterations functions."* FAA Advisory Circular 120-16C states *"The Required Inspection Item (RII) requirement causes the operator to separate the inspection organization from the remainder of its maintenance organization to ensure proper accomplishment of RII items."*

Since one of the functions of an effective CASS program is "surveillance of the performance and effectiveness of its inspection program," the deficiencies described in the Quality Control Department should have been discovered and corrected if the program had been functioning properly.

Administration of the CASS system is a function of the Quality Assurance (QA) Department at Alaska Airlines. Interviews conducted with members of the FAA's CMT and with the former PMI for the airline indicated that the QA was not performing its required functions: *"And again, that was another function that was very overburdened for the number of people they had. They couldn't do a lot of things that they should have been doing because there* *just wasn't enough of them."…I always thought that they ought to be out actually looking at a lot of the work that's going on and evaluating the effectiveness of their program. But largely they're stuck with putting out little fires and looking through past records, things like that."* At the time of the accident, the individual responsible for quality assurance was also the person responsible for quality control and the Director of Safety. Because of this individual's multi-layered responsibilities, it would have caused him to be overburdened and made implementation of his duties difficult.

The FAA's Special Inspection of Alaska Airlines reported "a CASS that is not effective." The inspection team found that "*the company's manuals do not contain facsimiles of audit checklists to be used to administer the program" and that "data gathering is not continuous, but periodic.*" It also found that "*audit methods and techniques do not address compliance with regulatory safety standards.*" This deficiency is considered to be directly related to the accident, since the CASS program is required to evaluate the "*…effectiveness of its inspection program and the program covering other maintenance, preventive maintenance, and alterations and for the correction of any deficiency in those programs, regardless of whether those programs are carried out by the certificate holder or by another person."* The CASS program at Alaska Airlines did not detect or correct the deficiencies in the maintenance program that contributed to the failure of the stabilizer jackscrew on the accident aircraft.

8. Inspections and Servicing of N963AS

Proper inspection and maintenance of the horizontal stabilizer jackscrew assembly is critical to the structural integrity and airworthiness of the MD-80. Technical experts of the Boeing Commercial Aircraft Company emphasized this during testimony at the NTSB's public hearing. This is understandable in view of the decisions that had been made by the manufacturer and the FAA during the type design approval process. Maintenance of the assembly consists of periodic visual inspections, periodic endplay checks for thread wear, and routine lubrication of the assembly.

N963AS accumulated a total time of 26,584:43 hrs and a total of 14,315 cycles at the time of the accident. During that period it received only three endplay inspections: 1) on May 27, 1993, at 2,674:43 flight hours; 2) on May 17, 1995, at 9,194:49 flight hours; and 3) on October 2, 1997, at 17,699:59 flight hours. Thus, the inspection interval between May 1993 and May 1995 was 6,520:06 flight hours and from May 1995 to October 2, 1997 it was 8,505:10 hours. At the time of the accident N963AS had flown 8,884:44 hours since the last endplay check.

Based on this information, the flight hours on the horizontal stabilizer jackscrew assembly of N963AS was within the averaged MTBR rate of 24,397 hours and the MTBUR rate of 28,397 hours at the time of the accident. However, Alaska's extended inspection program placed the endplay check 1,884 hours beyond what was recommended by the MRB/MSG-2 reports and the manufacturer's OAMP (every 7000 hours or 30 months – whichever comes first). As a result, one additional endplay check should have been accomplished prior to the accident if the recommendations of either the MSG-2 MRB or the recommendations of the MSG-3 MRB had been taken into account.

Moreover, based on the history of thread wear rate data, the horizontal stabilizer jackscrew would have been well beyond the endplay limits according to DAC test and in-service history data. Once again, without recording the endplay inspection findings, Alaska Airlines had no way of monitoring the wear rates using its RAP from which to establish prudent and acceptable assembly inspection intervals.

The last C-check of N963AS, C5, was initiated on September 27, 1997 at 17,699:59 flight hours. During this C5 check a non-routine work card (form MIG-4) was generated (Non-routine number # 4236374) because the horizontal stabilizer jackscrew endplay measurement was found to be at the maximum allowable limit. The inspector, assisted by a mechanic performed the inspection according to the "Acme Screw and Endplay Check" task card #2462700. This task card required repeating the measurement procedures several times until measurements were consistently within .001 inch. The task card indicates that this repeat of the procedure was conducted. A third individual, the lead mechanic assigned to the task, reviewed the findings and determined that the assembly should be replaced. He wrote, "Replace nut and perform E.O. 8-55-10-01" in the planned action block of the MIG-4 non-routine work card. The maintenance supervisor reviewed the MIG-4 and completed the "authorized by" block of the form.

The original inspector did not sign off on the stabilizer jackscrew assembly, but initiated a non-routine work card (instead of simply stamping the inspection complete). After that it was up to the lead mechanic working the team on that zone (the tail) to come up with a "planned action" for the "discrepancy" on the non-routine card and then for the supervisor to review and approve the action. Up until this point, the system worked as it was supposed to.

Three days later, a second check was conducted by another mechanic and an inspector. The lead mechanic apparently initiated this re-check and was the one who crossed out the original planned action of the original lead mechanic on the work card (the initials "R.H." were found on the revised work card). The inspector then signed off the "inspection buy back." The Maintenance Records Group could not find any documented approved procedures for any of this.

In the formal interview of the original lead mechanic after the accident, he stated, "*…I don't know that we've ever found one that was worn to that extent, especially in the context of aircraft 963 which was a relatively new airplane. I've worked on every MD-80 that Alaska Airlines owns extensively. I have never come across any jackscrew that was worn to that extent. And we have aircraft, at that time we had aircraft that were 15 years old*." He was not aware, prior to the interview, that his planned action, which had been approved by his supervisor, had later been countermanded. He assumed that the worn assembly had been replaced. The Shift Turnover Log for the graveyard shift on September 30th implied that as well: "*Stabilizer Jackscrew MIG for excessive play C/W (complied with)…*"

The original copy of non-routine work card number[27] #4236374 had a yellow highlight in the upper left corner which is a code used at the Oakland facility to indicate parts are needed to accomplish the task. The work card also had an orange highlight in the upper right corner, which is a code used at the Oakland facility to indicate "Priority One". The color-coding was presumably placed on the work card by the original lead mechanic who first measured the endplay of the assembly.

Shift Turnover logs indicated that parts were ordered or that the order had been placed. The log for the graveyard shift on September 29, 1997, stated, "*Continue parts ordering – panic.*" The Shift Turnover log for the swing shift on Monday, September 29, states: "*Pls re-do Acme screw check to confirm problem…*" The "corrective action" of the same MIG-4 form states: "*Rechecked Acme screw & nut endplay per wc 24627000. Found endplay to be within limits. .033 for step 11 and .001 for step 12. Rechecked five times with same result.*" The entry was dated September 30, 1997. The Manager of the Seattle Base Maintenance Facility testified that the Vice-President of Maintenance and Engineering was the individual who actually made the decision not to replace the jackscrew assembly. This exchange between these two individuals took place after the accident. The Vice-President of Maintenance and Engineering as well as the Executive Vice-President of Technical Operations and System Control denied any knowledge of the circumstances surrounding the stabilizer jackscrew inspection discrepancy during that C-check. It is interesting to note that the accident aircraft did have another C-Check (C6) before the accident, but the Alaska Airlines Maintenance Program did not require that an endplay check be conducted at that time.

The investigation showed that all of the visual inspections, endplay checks and lubrication required by the Alaska Airlines MD-80 maintenance program for N963AS were documented. However, and more importantly, it also disclosed that the validity and accuracy of many of these tasks were questionable and inaccurate. There were significant discrepancies in the last endplay inspection measurement, in the restraining fixture that was used, in the lubrication of the assembly, and in witness testimony. Also, many critical documents required to be maintained by the company, particularly immediately following the accident, were reported missing. The most significant of these included:

- The NTSB Maintenance Records Group requested Alaska Airlines provide to the agency the Field Requisition (form PT-17A) required for ordering the parts related to non-routine work card number 4236374 for the September 1997 inspection. **The requested Field Requisition was reportedly missing.**

- The NTSB Maintenance Records Group requested Alaska Airlines provide to the agency all of the Shift Turnover Logs (form MIG-48) for the period of September 27, 1997, thru September 30, 1997. **All of the Shift Turnover Logs for Saturday, September 27th (the day the MIG-4 was generated) were reported to be missing.** Other Shift Turnover Logs reported as missing included the graveyard shift log and the day shift log on Sunday, September 28th; and the day shift log on Monday, September 29th.

[27] Reference Maintenance Records Group Factual Report, Exhibit 11-M for a copy of the work card.

- The NTSB Maintenance Records Group requested Alaska Airlines provide to the agency the manila (3rd) copy of non-routine work card number 4236374. The back of this copy is used for recording "Parts Required and Status" and "Partial Work Accomplished – Job Status." **This copy of the MIG-4 non-routine work card was reported to be missing.**

9. Restraining Fixture and Tooling

Performance of the endplay check of the horizontal stabilizer requires the use of a "restraining device" and a "dial indicator." The McDonnell Douglas MD-80, MSG-2 generic task card for the Acme Screw and Nut Operation (Card number 0855, December 1991) stated that it was the manufacturer of the horizontal stabilizer "restraining fixture" (4916750-1) and Starrett is the manufacturer of the dial indicator (Model 196). However, the card also noted that <u>equivalent substitutes may be used instead of these items.</u>

Until the accident, Alaska Airlines had only one restraining fixture tool in its inventory, and this tool was located in OAK. Prior to the accident, there was no procedure in place to sign-out a measurement tool at the maintenance facilities. The tool was manufactured in-house by Alaska Airlines and did not meet either McDonnell Douglas or Boeing specifications[28]. The restraining fixture tool had been tracked (initial set up) since June 30, 1984. No initial tool inspection documentation was available and there was no documentation to show that it had ever been repaired. The tool was tracked as: ASA part number (P/N): 0-1301-0-0169 and serial number (S/N): 2018; manufacturer's P/N: 4916750-1. This P/N number was the incorrect P/N number tool to use in performing the endplay check on N963AS (line #1995). The McDonnell Douglas engineering drawing of the restraining fixture tool #4916750 (original date of drawing May 25, 1965) had three fixture configurations, 4916750-1, -503, and -505. The -503 configuration is used on MD-80 series airplanes, except MD-87. Therefore the proper Part Number tool should have been #4916750-503.

On April 13, 2000 (3 months after the accident), Boeing sent a message (M-7200-00-00975) to all DC-9, MD-80, MD-90, and 717 operators to ensure that horizontal stabilizer inspection tooling manufactured by operators conformed to the manufacturer's tool drawing requirements. It stated that the wear checks require the use of restraining fixture tool P/N 4916750. Any variation in the tool thread quality, pitch, or amount of thread engagement could affect the wear check results.

On February 28, 2000, the FAA published Airworthiness Directive (AD) 2000-NM-58-AD. In response to the AD, Alaska Airlines manufactured 11 restraining fixtures similar in design to their original fixture, and purchased 7 that were manufactured by Boeing. This was done in order to meet the requirements of an emergency airworthiness directive that had been issued by the FAA after the accident to perform inspections and endplay checks on the horizontal stabilizer assemblies of all DC-9 series aircraft. No one in the Alaska Airlines Maintenance and Engineering Departments recognized at that time that the in-house manufactured restraining fixture did not meet the aircraft manufacturer's specifications.

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[28] Reference the Addendum to the Systems Group Factual Report dated February 28, 2002.

On August 2, 2000, Alaska Airlines reported a concern to the FAA that the restraining fixture tool used by Alaska Airlines and manufactured in-house may not be "an equivalent substitute" for the Boeing/McDonnell Douglas fixture as called for in the MD-80 Maintenance Manual. Among several potential areas of concern was the problem that these tools could bottom out during the check, thus yielding an erroneous measurement. Alaska Airlines then quarantined all the tools that were not manufactured by Boeing.

The NTSB Systems Group performed a series of both laboratory and on-wing tests comparing the accuracy of endplay checks using authentic Boeing tools and Alaska clone tools. They discovered that the force output from the Alaska clone tools was so low that their use could lead to artificially low endplay readings, especially on MD-83s with their heavier tail structures (963 was an MD-83). The worst example using an Alaska clone tool was a measured endplay of .012" when the actual endplay was .023". The investigation could not determine what specific measurement errors could have been made on aircraft 963 using Alaska's sole clone tool in 1997.

V. ORGANIZATIONAL AND MANAGEMENT FACTORS

This section is intended to give an overview of the flaws internal to the Alaska Airlines system and the Safety Culture present.

Conclusions:

- **The motivation for maximum income with minimum operational cost resulted in a high tolerance for risk with regard to safety at Alaska Airlines.**
- **There was not a specific Safety Department within the company to modify this culture.**
- **This culture has been shown to have a direct relationship to several critical decisions that were causal factors for this accident.**
- **The existing Director of Safety had to split his time between two other positions, thereby making it difficult to address these issues.**
- **It is an established fact that almost every commercial enterprise has some degree of inherent risks that require identification so that controllable factors related to the risks may be properly managed.**
- **The FAA was aware of at least some of these indicators, but attempts to regulate or control these factors did not change the basic corporate culture that had developed.**

A. CORPORATE / SAFETY CULTURE

A poignant reflection of the corporate culture is revealed by the flightcrew's conversation within the cockpit during the last thirty minutes of the flight. The crew commented to each other about the pressure placed on them by the company to continue to SFO, the planned destination, and about the failure of the dispatcher to get an instructor pilot on the radio to assist them. It appears that even the "A" flight attendant was aware of the culture when she made the statement (recorded by the CVR): *"So they're trying to put the pressure on you –"*

The previously stated factual data provides a clear picture of the management culture at Alaska Airlines. It is apparent from a review of the factual data collected by the NTSB Accident Investigation Team, the FAA's Special Inspection of the airline, and the audit conducted by the Enders group, that the motivation for maximum income with minimum operational cost resulted in a high tolerance for risk with regard to safety. Because of the pervasiveness of this culture within the organization, it is apparent that it originated at the highest level of management. This high tolerance for risk probably developed insidiously as the airline rapidly expanded, profits rose dramatically, and operational expenses were cut significantly. There were many indicators prior to the accident which developed, and interviews with members of the FAA's Certificate Management Team, particularly the former PMI, indicate the FAA was aware of at least some of these indicators, but attempts to regulate or control these factors did not change the basic corporate culture which had developed.

There was not a specific Safety Department within the company to modify this culture and the existing Director of Safety had to split his time between two other positions. There was no effective Continuous Analysis and Surveillance System within the maintenance structure. A corporate culture with a high level of risk tolerance with regard to safety has been demonstrated at Alaska Airlines, and this culture has been shown to have a direct relationship to several critical decisions that were causal factors for this accident.

This dangerous combination relates directly to the accident as it affected a series of critical decisions made at various levels:

- The decision to countermand the decision to replace the stabilizer jackscrew assembly on the accident aircraft.
- The decision to escalate the inspection intervals and endplay checks for the stabilizer jackscrew assembly.
- The decision to escalate the lubrication intervals for the stabilizer jackscrew assembly.
- The decision to change lubricants for flight controls to a grease specification that had not been approved by the aircraft manufacturer or the FAA.
- The decision to use a tool (restraining fixture) for performing the endplay checks which was manufactured in-house and did not conform to the specifications of the aircraft manufacturer.

This corporate philosophy and culture may also, at least in part, account for the findings of:

- Inadequate numbers of personnel within the Flight Operations and Maintenance and Engineering Departments.
- A Reliability Analysis Program with inadequate data used for justification of modifications to the maintenance program.
- An inadequate training program for maintenance technicians and maintenance controllers.
- The absence of an effective Continuing Analysis and Surveillance System.
- The failure to separate the inspection organization (Quality Control) from the remainder of the maintenance organization to ensure proper accomplishment of Required Inspection Items items.

Correction of <u>ANY</u> of the above-listed failures may have interrupted the chain of events that led to this accident.

In a post-accident interview with the Director of Flight Safety at the time of the accident, he stated*: "The role of both maintenance control and dispatch was to push aircraft. Pilots determined if the aircraft was flyable. This was the philosophy and always has been."*

It is an established fact that almost every commercial enterprise has some degree of inherent risk that required identification so that controllable factors related to the risks may be properly managed. The commercial airline business, by nature, has an unusually high number of inherent risks. Because of this fact and the obvious tragic human consequences of a major aircraft accident, the process of risk management in the airline business should assume a prime level of importance. In this business there should be a very low tolerance for risk and this precept should form the basis for the corporate culture from top to bottom. This conservative culture should influence decisions at all levels of the organization. With respect to direct operational expenses, the results of a philosophy of low risk tolerance may not be apparent in the short term, but long-term savings should be greater by prevention of tragic accidents such as this one, Alaska Airlines Flight 261.

VI. FAA OVERSIGHT

This section is intended to give an overview of the breakdowns in oversight existing at the time of the accident.

Conclusions:

- **The FAA Certificate Management Office (CMO) failed in its oversight of certification, inspection and surveillance responsibilities over Alaska Airlines.**
- **The Seattle CMO of the FAA improperly certified and approved many of the key operating systems within Alaska Airlines, which were deficient and in some cases not in compliance with Federal Regulations.**
- **The systemic deficiencies in maintenance and inspection functions led to unsupportable extensions of maintenance and inspection intervals, which contributed significantly to the failure of the horizontal stabilizer jackscrew assembly.**
- **Inadequate oversight for many years by the Northwest Mountain (NWM) Region Flight Standards Division regarding management position selection, personnel transfers and complaints about the Seattle CMO led to misconduct on the part of key managers within that office and it became dysfunctional.**
- **The Seattle CMO had developed an improper relationship with Alaska Airlines management for which it had a regulatory enforcement responsibility.**
- **The improper relationship between Alaska management and the CMO led to inaction and ineffectiveness on the part of the office and hindered many inspectors from fulfilling their duties and responsibilities.**
- **The improper relationship and misconduct on the part of key CMO managers led to a culture of disrespect for regulatory compliance and the adoption of sound operating practices on the part of Alaska's management.**
- **The systemic deficiencies within the maintenance and inspection functions at Alaska Airlines existed long before the ATOS program was implemented and should have been known to the Principal Inspectors. ATOS would have assisted the Certificate Management Team in identifying these deficiencies prior to the accident.**
- **In the years Alaska had been operating, fundamental and critical deficiencies in its systems, processes and procedures were allowed to exist.**

A. CERTIFICATION AND SURVEILLANCE

The CMO for Alaska Airlines in Seattle approved Alaska's Continuous Airworthiness Maintenance Program (CAMP) in March 1985, based on what appears to have been sound information from the manufacturer and the MSG-2 report. The program required the airline to identify the Required Inspection Items (RII) for the MD-80. These items are critical to the safe operation of the aircraft. However, since the FAA did not authorize the RAP for the MD-80 until April 3, 1995, it appears that Alaska used inadequate and unsupportable data to extend the maintenance and inspection intervals on the aircraft, which included the horizontal stabilizer jackscrew assembly. A note in the Maintenance Inspectors Handbook (Order 8300.10) states for RAP interval adjustments, "*The maximum escalation of a* *particular maintenance interval must not exceed 10% or 500 hours of time in service, cycles, or some other identifiable increment."* It was these unjustifiable extensions that contributed significantly to the failure of this critical assembly.

"*Approving a reliability program is one of the most complex duties of an Airworthiness ASI (Air Safety Inspector), as special attention must be given to each element of the proposed program*."[29] The program establishes the important criteria for determining routine maintenance, overhauls, and inspections and must be initially linked to the manufacturer's recommended maintenance program and the MSG-2 document. Alaska did not incorporate the required maintenance and inspection data necessary from which to make these important and informed decisions. The FAA CMO failed to correct this problem over the many years it was responsible for regulatory oversight.

As with the RAP, the CASS failed to fulfill the safety needs of Alaska's maintenance and inspection departments. It is not unusual for an air carrier Quality Assurance (QA) department to administer the CASS. However, what Alaska management and FAA inspectors failed to ensure was that it functioned independently of the other responsibilities within QA. This independence is an essential check and balance, which reinforces the required separation between maintenance and inspection functions. This failure was manifested, in part, by allowing key management positions to remain vacant. The former PMI admitted that the QA department was overburdened. Yet, despite these obvious deficiencies, neither the PMI nor the Principal Operations Inspector (POI) took any corrective action.

1. Air Transportation Oversight System (ATOS)

The implementation of ATOS could have been instrumental in uncovering these deficiencies if the Principal Inspectors involved had been honest and forthright about their concerns over Alaska's maintenance and inspection functions. The FAA implemented ATOS in the fall of 1998 in a major attempt to re-structure and significantly enhance its surveillance process of the top ten air carriers, of which Alaska Airlines was one.

ATOS is a systems approach to analyze the safety of the seven air carrier systems defined by FAA "*using system safety and risk management to ensure that air carriers have safety built into their operating systems*." [30] The goal is to "make surveillance more systematic and targeted to deal with identified risks" within an air carrier.

The seven air carrier systems defined by FAA are: 1) Aircraft Configuration and Control (19 inspection subsystem elements); 2) Manuals (5 inspection subsystem elements); 3) Flight Operations (13 inspection subsystem elements); 4) Personnel Training and Qualifications (15 inspection subsystem elements); 5) Route Structure (6 inspection subsystem elements); 6) Airman and Crewmember Flight, Rest, and Duty Time (5 inspection subsystem elements); and 7) Technical Administration (6 inspection subsystem elements) for a total of 88 that involve many interrelated supporting actions.

[29] Airworthiness Inspectors Handbook, FAA Order 8300.10
[30] FAA Order 8400.10, Air Transportation Operations Inspector's Handbook, Chapter 1.

Through the use of its two main automated tools, the System Safety Analysis Tool (SSAT) and the Air Carrier Assessment Tool (ACAT),[31] the Certificate Management Team for Alaska could have identified areas of concern and assessed the potential risk posed by any of the eighty-eight subsystem elements within Alaska's seven basic systems. From these results, the Principal Inspectors should have developed the Comprehensive Surveillance Plan (CSP) specific to Alaska Airlines. For example:

a) In completing the SSAT tool, the Principals would have had to ask themselves if they had any concerns about ***Safety Attributes*** (Responsibility, Authority, Procedures, Controls, Process Measurements, Interfaces), ***Safety Culture*** (the priority the company places on safety: how it identifies, analyzes, and prioritizes safety risks; its reaction to warning signs; its philosophy in applying best practices; the existence of a formal internal systems evaluation program; and the effectiveness of that program), ***Accountability*** (extent to which it holds its management and employees accountable for their assigned responsibilities and authority), ***Potential Problem Areas*** (accidents & incidents, enforcement actions, safety complaints, any trends, relationship between organizational interfaces, etc.), and about two other areas for each of the seven systems.

b) In completing the ACAT tool, the Principals would have had to assess the risk potential (high, medium, low) exhibited by any of the eighty-eight subsystem elements against up to 10 attributes within two broad categories: System Stability (Operational Stability and Air Carrier Dynamics) and Operational Risks (Performance History and Environmental Criticality) for both Airworthiness and Operations.

c) In the course of completing the automated tools, the Principal Inspectors are instructed to gather all of the pertinent information available to them to complete their evaluations. This information would consist of FAA policy and guidance material and internal FAA data, such as the use of the Flight Standards Automation System, Safety Performance Analysis System, Program Tracking and Reporting Subsystem, Automated Operations Specifications Subsystem, Vital Information Subsystem, Integrated Safety Information System, SDRs, ADs, Monthly Air Carrier Utilization and Propulsion Reliability Subsystem, Program Tracking and Reporting System (PTRS), National Aviation Safety Inspection Program, and external industry and manufacturer information.

d) The drafts would have been discussed with the entire CMT for their views and input at an annual surveillance planning meeting held by the Principal Inspectors. At the time the PMI retired in November 1999, the CMT should have had its second planning meeting. This would have provided the team with the opportunity to retarget their plan based on their experience the previous year.

e) The final results of the SSAT and ACAT tools would be tallied and used by the Principals to produce the Comprehensive Surveillance Plan and the System Attribute

[31] "SSAT is designed to evaluate six categories of system safety in order to identify potential risks and system deficiencies. ACAT is designed to determine an assessment value that is then used to determine the frequency of element inspections on the CSP."

Inspections (SAI) and Element Performance Inspections (EPI) for Operations and Airworthiness. If an inspector found other discrepancies or significant issues not planned for in the CSP in the course of doing SAIs and EPIs, the inspector must bring them to the attention of the Principal Inspectors immediately. **Therefore**, **ATOS should not stop inspectors from investigating other areas.**

f) If there is a shortage of inspectors on the CMT for performing the CSP completely, the Principal Inspectors are responsible for elevating it to higher authority for resolution. In the case of Alaska, when ATOS was implemented in October 1998, there were a total of 33 inspectors, which included six geographic inspectors, with one position becoming vacant in March 1999. Two of the vacancies were the Cabin Safety Inspector and an analyst position. One geographic inspector position became vacant in July of 1999 and another was subsequently put on an extended detail and would not be available until February of 2000. However, this kind of resource restriction existed for many other CMTs early in the program.

g) Implementation of the program could be considered to have been a significant effort by the FAA. Within about four months, the FAA was determined to put through an initial cadre of Principal Inspectors in a two-week training program before the ATOS could be implemented. Like other Principal Inspectors assigned to other air carriers, the POI and PMI for Alaska attended this training as well.

h) The memorandum of November 12, 1999, from the FAA Certificate Management Supervisor in the CMO to the Regional Flight Standards Division Manager expressing concerns over inspector resources is somewhat misleading as it may apply to the accident. A policy of holding the Airworthiness portion of the CSP hostage to the Operations portion could be shortsighted on the part of the FAA. However, this policy interpretation may very well have been the sole opinion of the supervisor. The accident did not involve cabin safety issues and thus should not have had a bearing on the airworthiness inspections that should have been conducted. The CMS did have assistant POI and PMI positions. It does appear that the CMS could also have had an Assistant Principal Airworthiness Inspector (PAI) and should have had a Partial Program Manager for the B737 and the MD-80 long before ATOS came about. There were two Aircrew Program Managers since 1991. Given that Alaska had been operating the MD-80 since 1985, the CMO failed to ensure that these additional positions were filled long ago.

The FAA's April 2000 Special Inspection of Alaska Airlines conducted by the System Process Audit Program staff[32] reported the significance of its findings based on the ACAT tool. The team was comprised of 15 inspectors and most were from the Seattle CMO. The report disclosed that 22 of its associated findings with the elements in the ACAT "had a HIGH criticality baseline." Of the breakdowns identified in Alaska's systems, 15 (27%) were uncovered in the Maintenance Program alone. The report also showed that if a hazard analysis were to have been conducted, it would have identified such areas as the abuse of the maintenance deferral system, ineffective quality control and assurance departments, vacant

[32] The System Process Audit Program (AFS-40) was established, in part, for the purpose of evaluating the effectiveness of ATOS.

key management positions and aircraft released to service without proper documentation with the following consequences: use of non-airworthy aircraft in service, poor on-time performance, aircraft incidents and accidents.

During the FAA Certification, Surveillance and Evaluation Team (CSET) follow-up examination of Alaska Airlines initiated on September 18, 2000, it concluded that Alaska had not implemented all of the required changes in its systems and would have to be revisited. The CSET found numerous deficiencies in the Heavy Maintenance and Vendor processes, and in the Continuing Analysis and Surveillance and Quality Assurance programs. For example, it found that not all of the Quality Assurance auditors had received the new CASS procedures training, and there was no formal course or syllabus. Even company personnel who attempted to explain the new procedures to the team did not appear to understand their own process for qualifying the auditors. In a presentation to one of the team members on the proposed transition from the General Maintenance Manual to the new General Procedures Manual (GPM) system, nearly 30 deficiencies in the proposed GPM were identified.

The evidence clearly shows that in the years Alaska had been operating, fundamental and critical deficiencies in its systems, processes and procedures were allowed to exist. Many of these deficiencies should have been discovered by the CMO during its initial certification and approval of these activities. ATOS notwithstanding, any subsequent deviation from what was approved should have been detected through surveillance and corrected. The fact that these deficiencies have existed for so long explains why the carrier had developed a culture of non-compliance with regulatory standards and best practices, which the CMO allowed. The PMI involved had spent eight years with the carrier over the period when Alaska Airlines had acquired the MD-80 until the accident. The PMI should have been intimately familiar with the Alaska's maintenance, inspection and engineering functions and its culture. Appropriate guidance was available to Principal Inspectors about growth and aircraft utilization rates from which to monitor the airlines. Yet, in the case of Alaska, its systems were not able to adequately support the carrier's aggressive flight schedule. As summed up in the System Process Audit report, "*…there seems to be a basic lack of understanding regarding the complexity of operating an airline of this size*." The question is why were deficiencies not previously detected and corrected?

Part of the answer lies in the fact that not until inspectors from outside the CMO took a close look at Alaska did these deficiencies come to light. Another part of the answer is revealed in much of the testimony given by previous and present FAA inspectors who worked in the CMO. For example, a former POI reported that the former Staff Vice President for Flight Operations was recalcitrant and had misled him on several matters. He did not get support from the CMO manager for a NASIP inspection of the carrier after explaining the problems he was encountering. He was chastised in front of Alaska officials by FAA management because he was documenting his activities through letters with Alaska. He was instructed to do business over the telephone. In another episode, he was reprimanded by his supervisor in front of Alaska management over a life raft issue. On several occasions his supervisor had permitted Alaska to undertake certain actions, countermanding the POI's decisions and usurping his authority without his prior knowledge. In another incident involving whether windshear training had been conducted, the evidence in support of a violation against Alaska became missing after a previous discussion between the CMO and FAA headquarters.

In a subsequent incident involving the replacement POI, it took a security investigation under the FAA Order on Criminal Investigations to pin down the fact that five pilots had falsified training documents, one of which was the Staff VP for Flight Operations. The U.S. Attorney's office and FAA security personnel had expressed concern about the CMO leaking information to Alaska management. The POI's supervisor was upset because she did not inform him of the investigation and she was later involuntarily re-assigned for two months in April 1994. She filed a complaint to the EEOC and Office of Special Counsel, which resulted, in part, in the FAA National Evaluation Team investigation of the Seattle CMO from May 23 to June 2, 1994.

The Acting Northwest Mountain Regional Division Manager decided to bring in the team to investigate the allegations to which he was aware. The results of the investigation showed a consensus among the staff that the CMO manager as well as his assistant were ineffective. The Geographic Section Supervisor was considered ineffective and not trusted by his staff. The Air Carrier Certification Management Section Supervisor had a poor reputation, was considered ineffective, and was feared by his staff because he had degraded a staff member in the presence of an operator. The Operations Section Supervisor also had a poor reputation and had been distracted with personal problems for a lengthy period, which interfered with his responsibilities and made him ineffective.

There is no doubt that the investigation has disclosed that prior to the accident, there was an inappropriate relationship between Alaska Airlines and the regulatory authority. The former POI stated, "*The FAA, in Seattle, was a shell game. They continue to move people around in the FSDO [CMO] but never out of the office.*" A failure to "clean house" on the part of the division manager allowed problems to fester and resulted in a dysfunctional CMO. This management failure permitted the development of a culture of non-compliance and demonstrated contempt for regulatory standards and best practices on the part of Alaska management. It was this culture that resulted in the numerous systemic deficiencies primarily within the maintenance and inspection functions that led to the failure of the horizontal jackscrew assembly.

Title 49, Section 44702(b) of the US Code places primary responsibility to provide the public with the highest possible degree of safety on the air carrier. It is the responsibility of the FAA to promulgate and enforce adequate standards and regulations. As the subsequent special investigations conducted by the FAA showed, the CMO had the authority, responsibility and justification for suspending Alaska's operating certificate until such time as Alaska had corrected the systemic deficiencies in its operating systems and achieved compliance with regulatory standards. Had this been done long ago, this type of accident might not have occurred. In the Special Audit Team's report under the Surety Model, it proposed that, "*A plan needs to be developed to integrate effective controls and standardize* *all systems and manuals*." One of its proposed potential corrections was, "*Limit growth until all threats have been eliminated*." Clearly, had the CMO taken this action long ago, it could have achieved control over Alaska's operation and established systemic improvement. It chose not to do this, but instead only reacted to Alaska's demands.

VII. CONCLUSIONS

ALPA concludes that the factors involved in the accident should be attributed to the following:

- Deterioration of the Acme nut threads was caused by a lack of lubrication to the Acme screw / nut assembly.

- The total failure of the Acme nut threads resulted in a total mechanical failure of the horizontal stabilizer system and the surrounding aircraft structure. These combined failures allowed the horizontal stabilizer to move to a position beyond full nose down trim that rendered the aircraft uncontrollable.

- The failure of the Alaska Airlines Maintenance and Engineering Department to properly conduct endplay measurements, to properly lubricate this jackscrew assembly and to establish reasonable inspection intervals based upon supportable data was directly causal to this accident.

- The FAA approved a type design for the stabilizer trim system that did not meet several of the applicable portions of both the original Civil Aeronautics Regulations (CAR) and the current FAR Part 25 requirements.

- This type design, along with the failure mode experienced on these components, does not provide adequate redundancy to preclude total mechanical failure of the stabilizer system.

- Organizational shortcomings that existed within the maintenance, engineering and flight operations departments at Alaska Airlines.

- The certification, inspection, and surveillance failures on the part of the Federal Aviation Administration (FAA) Certificate Management Office for Alaska Airlines allowed years of questionable corporate practices at the airline.

- The industry's Maintenance Steering Group Task Force failed to base maintenance recommendations (MSG-2 and MSG-3) for the horizontal stabilizer on established engineering data, thread wear rates, service history, manufacturer's service bulletins, and the FAA's Service Difficulty Reports (SDRs).

- The flawed certification philosophy of the trim system led to an inadequate Abnormal Procedures Checklist that failed to address all of the potential failure modes and risks of an inoperative or failed jackscrew.

VIII. SAFETY RECOMMENDATIONS

Based on the factual analysis of the accident of Alaska Airlines Flight 261, ALPA offers the following safety recommendations:

1. The FAA must deploy its System Process Audit team to monitor the effectiveness of the ATOS program and other means of oversight to identify shortcomings, develop strategies for improved operator oversight and to improve the training and standardization of its inspector workforce.

2. The manufacturer must identify a more thorough and representative horizontal stabilizer endplay check procedure to accurately determine jackscrew component thread wear.

3. In conjunction with an improved endplay check procedure, the FAA and the operator must ensure that mechanics are properly trained in conducting such checks to preclude erroneous measurements.

4. The FAA must require the operators to record, retain and track all horizontal stabilizer endplay check measurements.

5. The FAA and the manufacturer must identify improved horizontal stabilizer jackscrew lubrication procedures to ensure that the Acme nut and screw threads receive a thorough amount of lubrication. Improved lubrication procedures must take into account accessibility, number of grease fittings, lubricant properties and lubrication intervals.

6. In conjunction with improved lubrication procedures, the FAA and the operator must ensure that mechanics are properly trained in conducting such lubrications to preclude inadequate lubrication of critical components.

7. The FAA and the operator must develop additional flightcrew training and guidance materials to address mechanical failures of critical aircraft systems and components.

8. The manufacturer must develop a mechanical system to preclude critical flight components (e.g. horizontal stabilizer, rudder, etc.) from reaching a position of which the flightcrew would be unable to overcome the failure through other means.

9. The concept of Derivative Certifications should be revisited to ensure that when current regulations provide an increased level of safety to aircraft systems or components, that those new regulations are applied and enforced.

10. The FAA's concept of "structural element" should be revisited to ensure that the regulations in place related specifically to structural elements provide the highest level of safety.

11. Continuing Airworthiness programs must be monitored and compared with current certification requirements to identify possible areas of regulatory compliance deficiencies.

12. Operator management structures must be reviewed to ensure that the positions required by Federal Regulation are filled in compliance with the requirements mandated by the FAA.

13. The FAA must ensure that it assigns qualified airworthiness inspectors capable of evaluating, certificating and surveilling air carrier maintenance reliability analysis programs and continuous analysis and surveillance systems through actions, such as, improving present human resource staffing policies, inspector training curriculum, and certificate office management decisions regarding inspector assignments and supervision.

14. The FAA should take an aggressive stance and deploy the use of its expert CSET and System Process Audit teams to examine the status of critical air carrier systems where there is justification to ensure regulatory compliance, improve industry standardization, resolve deficiencies and clarify any regulatory misunderstandings about these systems on the part of certificate holders.

15. The FAA must review and improve its policies with respect to the Flight Standards Service tenure of its inspectors assigned to air carrier certificate management teams as well as its office supervisory staff to prevent improper relationships with their certificate holders and misconduct on the part of inspectors and managers.

16. To assist the industry in identifying maintenance trends, the FAA must strictly enforce the requirement for operators to submit Service Difficulty and Mechanical Interruption Reports.

Appendix A
Glossary of Acronyms

ACAT	Air Carrier Assessment Tool
AD	Airworthiness Directive
ALA	Alaska Airlines
ALPA	Air Line Pilots Association
AND	Aircraft Nose Down
ANU	Aircraft Nose Up
AOL	All Operator Letter
ASB	Alert Service Bulletins
ATOS	Air Transportation Oversight System
CAMP	Continuing Airworthiness Maintenance Program
CAR	Civil Aeronautics Rule
CASS	Continuous Analysis and Surveillance System
CG	Center of Gravity
CMO	Certificate Management Office
CMT	Certificate Management Team
CSET	Certification, Surveillance and Evaluation Team
CSP	Comprehensive Surveillance Plan
CVR	Cockpit Voice Recorder
DAC	Douglas Aircraft Corporation
DFDR	Digital Flight Data Recorder
EEOC	Equal Employment Opportunity Commission
EO	Engineering Order
EPI	Element Performance Inspection
FAA	Federal Aviation Administration
FSDO	Flight Standards District Office
GMM	General Maintenance Manual
GPM	General Procedures Manual
LAX	Los Angeles International Airport
LOI	Letter of Investigation
ME	Maintenance Engineering
MRB	Maintenance Review Board
MSG	Maintenance Steering Group
MTBR	Mean Time Between Repair
MTBUR	Mean Time Between Unit Replacement
NASIP	National Aviation Safety Inspection Program
NTO	No Technical Objection
NTSB	National Transportation Safety Board
OAMP	On-Aircraft Maintenance Planning
OEM	Original Equipment Manufacturer
PAI	Principal Airworthiness Inspector
PMI	Principal Maintenance Inspector
POI	Principal Operations Inspector
PST	Pacific Standard Time
PTRS	Program Tracking and Reporting System
QA	Quality Assurance
QC	Quality Control
QRH	Quick Reference Handbook
RII	Required Inspection Item
RAP	Reliability Analysis Program
SAI	System Attributes Inspection
SB	Service Bulletin
SDR	Service Difficulty Report
SFO	San Francisco International Airport
SSAT	System Safety Analysis Tool
WTR	Wide Temperature Range