Learning from our Mistakes: A Review of Maintenance Error Investigation and Analysis Systems
(with recommendations to the FAA)

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Federal Aviation Administration
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I. EXECUTIVE SUMMARY

Since the ALOHA accident in 1988, the **FAA**, labor unions, aircraft and engine manufacturers, and the U.S. air carrier industry have been working together in a new endeavor called maintenance human factors.[1] With the growing recognition that many accidents may involve maintenance error, the industry has turned to the science of human factors to provide answers to why a technician, ground crew agent, or storeroom clerk could have made an unthinkable accident-causing error. Through human factors, we were to take a new look at technician performance, a look that would lead us to error-provoking factors that, if properly managed, would result in a large reduction in maintenance error.

The problem is that since the Aloha accident in 1988, there has been little quantifiable proof that the science of human factors can provide real reductions in maintenance error. On March 12-13, 1997 in San Diego, the **FAA** held its eleventh industry meeting on human factors in aircraft maintenance and inspection. At the beginning of one conference presentation, the presenter asked all of the air carrier representatives to please stand. He asked his colleagues if they could track each hydraulic pump failure that had occurred in their aircraft fleet during the month of January 1997. He asked if they could find the hours or cycles of each pump when it failed, and if they could find shop reports for each repaired pump. He asked if they could go to their reliability group and find the historical trend on hydraulic pump failures and compare that trend to the failure rate in January. If the answers to these questions were predominately yes, he asked the air carrier representatives to remain standing. If the answers were predominately no, he asked them to please sit down. The result: nearly all air carrier representatives remained standing.

The presenter then asked another question to those air carrier representatives who remained standing. He asked if the air carrier representatives could, within their airline, track each shift-turnover error that had occurred in their operation during the month of January 1997. Could they find an investigation record for each turnover-related error? Could they also go to their reliability group and find historical trends on the shift turnover-related error rate and compare those to the shift turnover-related error rate in January? If the answers to these questions were predominately yes, the air carrier representatives were asked to remain standing. If the answers were predominately no, the air carrier representatives were asked to sit down. The result: all air carrier representatives sat down.

It is telling that all air carrier representatives sat down. While most air carriers could track hydraulic pump failures with precision, in our lifetime the hydraulic pump will likely never again be the cause of a jet transport accident. Yet, when the next maintenance-related accident occurs, there is a reasonable probability that a poor shift-turnover will have been involved in the accident. For this error, however, our industry can show no structured process of investigation, analysis, or corrective action. On the mechanical side of an airline operation, nearly all failures are investigated, analyzed, and monitored for their effect upon reliability and safety. Mechanical reliability programs, engine condition monitoring programs, shop findings - all of these have contributed to making equipment failure a small piece of commercial aircraft accidents. Yet even though maintenance error contributes to 15% of air carrier accidents and costs the U.S. industry more than a billion dollars per year, industry is still unable to track, monitor, and manage what is probably the single largest contributor to maintenance-related accidents: shift turnover errors.

It is the aviation industry's efforts to conduct improved post mishap reviews of human error that are the subject of this report. Whether it's equipment failure or human failure, event investigation and its resulting lessons-learned are the mainstay of system safety. Unfortunately, human error has been tremendously under-served by traditional event investigation methods. It is typical within event investigation today to simply end the investigation at the identification of a human error, without any meaningful attempt to understand WHY the error occurred. It is argued by many that, through the science of human factors and the reporting and investigative tools reviewed in this report, industry can now begin to understand why people make certain mistakes.

This report answers three fundamental questions: 1) What tools and methods are available to improve the fidelity and increase the frequency of maintenance error investigation? 2) What issues stand in the way of accident reduction through maintenance error investigation? and 3) What can **FAA** Flight Standards do to improve flight safety through facilitation and oversight of maintenance error investigation, analysis, and corrective action?

After careful review, the following specific recommendations are made to the **FAA**:

1. The **FAA** should create a full-time position for a Maintenance Error Specialist within the Flight Standards Service.

2. Flight Standards and **FAA** Chief Counsel's Office should prepare a clear and concise policy regarding post-mishap Investigation and corrective action.

3. All flight standards staff responsible for oversight of air carrier and repair station maintenance, including **AFS**-300 and all principal maintenance inspectors and their staff, should be provided human error causal concepts training.

4. **FAR**s 121.373 and 135.431 should be re-interpreted, given industry understanding of human factors, to require more thorough causal investigation of maintenance errors that impact the conformity of dispatched aircraft and/or endanger safety of flight.

5. **FAR**s 121.373 and 135.431 should be reinterpreted, given industry understanding of human factors, to require statistical monitoring and corrective action of systemic contributors to maintenance error.

6. Flight Standards and Chief Counsel's office should co-sponsor research to better understand the effects of air carrier disciplinary systems and **FAA** enforcement policies upon human error reporting, investigation, and overall system safety.

7. With regard to maintenance human factors research and any further regulation of maintenance human factors initiatives, Flight Standards should prioritize its efforts based primarily upon safety-related concerns identified through **FAR** 121.373 and FAR 135.431 systems.

8. For those errors being investigated through an air carrier's 121.373 or 135.431 continuing analysis and surveillance program, The Aviation Safety Reporting System Advisory Circular 00-46D should be amended to change the 10 day reporting requirement to begin upon "discovery" of the **FAR** violation.

9. Flight Standards Service should encourage further use of **ASRS** by maintenance technicians, specifically including those errors first discovered by someone other than the erring technician.

Recommendations 4 and 5 are at the heart of what can be a significant reduction in maintenance error. Recommendation 4 would require that, across the U.S., air carriers and repair stations improve their investigation of the approximately 48,800 maintenance errors per year that make their way onto aircraft dispatched in revenue service. Standing alone, recommendation 4 does not improve aviation safety. It is recommendation 5 that improves aviation safety through the identification and correction of the systemic contributors to error. Admittedly, these recommendations would require a significant increase in human error investigation effort on the part of the U.S. air carrier industry. Yet compared to the manpower and financial resources already directed toward equipment reliability within the typical U.S. carrier, these recommendations represent a comparably small effort. It is not an unreasonable burden to any U.S. carrier, yet it is required for industry to take the next step in safety management through maintenance error reduction.

II. INTRODUCTION

A. Report Purpose

This report covers the state of the art in maintenance error investigation and analysis systems. Its findings are based upon interviews with roughly 40 diverse industry experts, on-site visits to maintenance error management system owners and developers, and analysis conducted by the author. This resulting report serves three purposes:

1. Awareness of the Issues

Learning from our mistakes is perhaps the single most important human factors tool available to us at this time. Yet, there is still substantial debate as to what lessons we should be taking from event investigation and how event investigation should occur within the U.S. This report provides an assessment of the current state of the art in maintenance error investigation and analysis methodology. It discusses what the roadblocks are to more effective human error management, and it provides guidance on how these issues can best be addressed.

2. A Comparison of Maintenance Error Investigation Systems

As maintenance human factors has become more prevalent, maintenance error investigation and analysis systems have begun to enter the marketplace. This report compares error investigation systems that are currently used in maintenance and ground operations, and provides a tangential review of systems in the domains of flight operations and equipment failure.

This report is not intended to provide an "evaluation" of these systems; rather, it is educational in nature. The most significant reason for not picking an "editor's choice" is that performing this research was like performing a review of alternative hammer designs when all of the construction workers at job sites are still using rocks to pound nails. Until these systems are in more prevalent use, there can be little meaningful comparison of their ultimate performance. Further, the differences between systems are overshadowed by the common hurdles that must be overcome if maintenance error investigation is to have a substantial impact on the commercial aircraft accident rate.

3. Recommendations for FAA Action

Lastly, this report makes a set of structured recommendations to **FAA** Flight Standards on how it can better facilitate and, where appropriate, regulate maintenance error investigation in the U.S. Given recent changes within FAA management, it is imperative that the work of the last ten years in maintenance human factors not be overlooked by the new Administrator and new FAA managers who bring in their own new ideas for safety improvement.

B. Scope of this Report

This report is driven by one goal: improvement in the safety of commercial air transportation within the U.S. This report does not include recommendations for general aviation nor does it include recommendations for employee personnel safety within an air carrier or repair station. With regard to commercial aviation safety, this report focuses on the aspects of maintenance and ground operations that impact the continuing airworthiness of the commercial aircraft fleet; that is, any error, maintenance or ground, that can degrade the condition of the aircraft dispatched into revenue service. Personal injury to technicians and ground agents is excluded, not because it is of any less importance, but because the tools, techniques, implementation, and regulatory issues relating to occupational safety and health are significantly different from the airworthiness-centered issues reviewed within this report.

C. A Definition of Maintenance Error

First and foremost, it is necessary to discuss what is meant by maintenance error. For example, maintenance error includes such actions as the backward installation of a hydraulic valve, the failure to tighten an oil filler cap, or missing a crack during inspection of an engine disk. These are the types of events that this report addresses: human errors within a maintenance organization that ultimately lead to an on-aircraft discrepancy.

To define maintenance error, it is first helpful to define "human error." Human error, defined in a social sense (as compared to technical), would be as follows:

> *When there is general agreement that a person should have done other than what they did, then the person has committed an error.*

What can be seen in this definition is that "human error" is defined through an objective outside view. It is not really the determination of the erring individual, but of others looking in. Consider under what circumstances an employee gets called into his supervisor's office to explain his action relating to some undesirable business outcome. Consider when such individuals are typically disciplined: it is almost always when someone believes that the employee did other than what they should have done.

Maintenance error, as an extension, is where there is general agreement that the maintenance system (made up of people) should have done other than what it did. Historically this meant that the technician should have done differently, but the term is now used to include error by any human in the chain of events, whether it be the technician, the maintenance planner, the manager, or the CEO.

D. Scope of the Maintenance Error Problem in the U.S.

1. Safety

Maintenance does have a direct impact on the safety of flight. The United DC-10 accident at Sioux City, the American DC-10 accident at O-Hare, the Continental Express Embraer accident in Texas, and the Aloha 737 accident over Maui, are all examples of accidents in which the National Transportation Safety Board (NTSB) found some maintenance deficiency to be the primary cause of the accident.[2] Further, maintenance has been identified by Boeing as the primary cause of 5.6% of worldwide commercial jet accidents from 1985-1994.[3]

2. Reliability

In addition to maintenance as a primary contributor to accidents, there is an additional contribution that has not been covered in traditional accident analysis. Many equipment failures, including those caused by maintenance or ground crew error, require the flight crew to respond to an abnormal airplane failure condition. An extreme example of this is the 1983 Eastern Airlines L-1011 incident in which a maintenance crew inadvertently left off the O-rings on all three engine master chip detectors.[4] Observing that oil pressure was being lost on all three engines, the flight crew assumed or concluded that the aircraft was experiencing an instrumentation fault because the flight crew considered the loss of oil pressure on all three engines to be an extremely remote possibility. Assuming an indication failure, the flight crew delayed its turn back to Miami, further increasing the accident risk. It is in cases like this, where equipment failure caused by maintenance or ground crew error can lead a pilot to respond in a manner that further endangers the safety of flight.

In the first analysis to consider multiple contributors to aircraft accidents, Boeing found that improper maintenance contributed to 15% of commercial jet accidents.[5] As further evidence of the role of maintenance, data from one engine manufacturer showed that 20-30% of engine in-flight shutdowns and 50% of engine-related flight-delays and cancellations are caused by maintenance error.[6]

3. Economics

The economic toll of maintenance error is also just becoming apparent. Maintenance error has traditionally been lumped under the cost of doing business and not categorized as a specific, quantifiable class of event. Recent anecdotal experience, however, has put the cost of maintenance and ground crew errors at over one billion dollars per year in the U.S. alone. One large U.S. airline has estimated that maintenance error alone costs its operation $100 million dollars per year.[7]

4. The frequency of maintenance error

What does not come across in the previous data is just how often maintenance errors really occur. Do maintenance errors occur on a weekly, daily, hourly basis in a large U.S. airline?

Consider the Boeing study showing that 19.1 % of engine in-flight shutdowns are caused by maintenance error. **NTSB** records show that during the year 1996, part 121 and part 135 scheduled air carriers conducted a total of 11,356,000 scheduled departures.[8] Assuming a typical mechanical dispatch reliability of 98% and using the Boeing data as representative of all maintenance errors, the number of aircraft dispatched with a maintenance error on board in the U.S. is roughly 48,800 per year. (See **Appendix L** for a justification of this number.) Considered on a per aircraft basis, the average airplane would see roughly seven airworthiness-related maintenance errors per year.

Technically speaking, these 48,800 delays translate into 48,800 unairworthy aircraft dispatched per year as the result of maintenance error. While this may sound alarming, this number still represents a tremendously reliable maintenance system. Consider that the maintenance technician pool working on large jet aircraft in the U.S. is roughly 80,000. This means that the average technician will face such an error only once every two years.

It must also be remembered that this number represents only those maintenance errors that impact dispatchability of aircraft. When errors that occur in a hangar or a shop are caught before they get to the airplane are included in the analysis, the number of maintenance errors is even higher. Nevertheless, maintenance error is uncommon when considered against the number of maintenance actions performed in the U.S. per day.

E. Maintenance Error Management Tools

Before reviewing the error investigation systems, it is important to see these systems in light of their competition in terms of maintenance error management strategies. We all have our own ideas about how to manage human error. Whether we're a parent, supervisor, or spouse, we have our own ideas about how the people around us, or reporting to us, might improve their own personal reliability. Therefore, the following tools/error management strategies are reviewed as an introduction into the world of human error management.

1. Preserve the Status Quo

While preserving the *status quo* might not really be an error prevention strategy, it is an option. Aviation maintenance professionals can be proud of what they do. They work in a very complex maintenance system and work on leading-edge aircraft technology. In spite of the complexities, what exists today is a maintenance system that has extraordinary reliability. In some people's minds, to upset the system merely because of a "human factors push," is to put an extraordinary safety record at risk. This is particularly true for those individuals who see human factors not as a scientific tool, but as a further decline in personal responsibility and accountability to a system where every personal error is someone else's fault. After all, isn't human factors really a belief that errors are less a function of individual culpability and more a function of external performance shaping factors?

2. Selection and Training

Selection and training are two obvious remedies for error reduction. To select people who have mechanical aptitude and show an attention to detail is to, by strategy, take those people who will be less error prone. Through proper training, potential technicians receive the knowledge, skills, and experience that will maximize their inherent reliability.

Like most strategies, however, the use of selection and training as error management strategies has both its proponents and opponents. To identify which people will be more error prone in the maintenance environment is no easy task, if possible at all. Then of course the question is whether these are the same people being recruited by other critical jobs that also desire "less error-prone" people. Consider the health care industry, where 180,000 people per year in the U.S. are injured or killed by medical error.[9] What about school bus drivers? Police officers? Just where should our precious, less error-prone people should go?

Additionally, training and experience has in some cases proven to be more of a hindrance than a help. For example, in one European carrier, it was found that troubleshooting errors were made by experienced technicians at a greater frequency than by junior technicians. The reason? The younger technicians were using the manufacturer's fault isolation manual while the more experienced technicians were instead using their sometimes unreliable past experience.[10]

3. Designing Aircraft for Error Reduction

Reducing error through aircraft design has been a mainstay of human error management. Many aircraft design features are intended to prevent or mitigate the consequences of maintenance error. For example, components are designed with dis-similar sized hydraulic connections so that upon installation, hydraulic tubes cannot be misplaced. But while design strategies are helpful, much of the error management problem arises through air carrier maintenance processes. After all, it is often hard to murphy-proof the technician error of mere forgetting to re-install a part. Additionally, as new design strategies become available, such as new lockwiring methods, the cost of retrofitting the commercial fleet is often simply prohibitive.

4. Maintenance Resource Management

In the U.S., it appears that Maintenance Resources Management (MRM) will co-exist with human factors event investigation as one of the two major cornerstones of maintenance error management. Maintenance Resource Management is similar to the Crew Resource Management training programs so effectively used in the flight operations environment. In many ways, MRM is a tool to provide individuals the skills to manage those contributors to error that are in their partial control, such as communication, decision-making, situational awareness, workload management, and team-building. MRM is training, but it's the "soft skills" training of how to be a reliable human within the maintenance system.

5. Maintenance Error Investigation

Error investigation means different things to different people. For the corporate lawyer or **FAA** enforcement attorney, error investigation signals an opportunity to take remedial, and often punitive, action to ensure that the same error is not made again. To the human factors expert, error investigation is a way to find the external contributors to error while freeing the erring individual of any blame. For many people in the industry, the idea of maintenance error investigation as a "new" concept defies their own experience performing maintenance error investigations today. It must be remembered that errors have always occurred and, unfortunately, will always continue to occur. What is really meant by maintenance error investigation today, in the human factors context, is a more formalized and deliberate investigation of error with an eye toward the human factors precursors that shaped the performance of the erring technician. To set the historical stage for development of human error investigation systems, consider the experience of David Huntzinger, a former Boeing safety specialist and now Vice President of Safety at America West Airlines. Mr. Huntzinger recounts a story of a safety discussion he had while providing safety training to a group of employees at a medium-sized foreign carrier. The story is as follows:

> *I was teaching safety program management to a group of airline and government officials. The topic of the hour was the comparison of expected performance with actual experience. The object lesson was that if people did exactly what was expected of them and the results were undesirable, then, all other things being equal, the participants should be absolved of wrongdoing or responsibility.*
>
> *At the break following this lecture, a group of pilots asked my opinion about a recent series of events. At one airport, clearway lines had been painted on the tarmac. The plan was to keep the vehicles parked on one side of the lines while the airplane moved about on the other. The pilots and drivers were well trained on this procedure.*
>
> *On this particular day all the vehicles were properly parked and the flight crew dutifully stopped the airplane at the entrance to the parking area and scanned the ramp for obstructions: all clear. When the pilot pulled into the area the wingtip struck the catering truck. Both the airplane and the truck received substantial damage.*
>
> *The investigating authority performed a cursory investigation and determined that the pilot in command and the truck driver were at fault; both were dismissed. The students noted that this event was repeated a few weeks later with the same results: substantial damage to the airplane and the truck with both the pilot and driver fired. A third event then occurred. This time the offending pilot was a senior captain and was placed on leave without pay. The truck driver was fired.*

I felt that had all the vehicles been in the proper place and all the precautions observed, then the people should not have been punished regardless of how serious the outcome was. I continued asking questions though. I was curious as to why the airplane would contact the truck if both were properly positioned. A group of pilots assured me this was the case. This led us to the aircraft types involved in the events. After much discussion, and remembering who was qualified in what aircraft, it was determined that all the events had occurred on A320 aircraft. A near instantaneous review of this airline's fleet and the airport in question quickly brought us to the fact that the parking stripes were painted to accommodate the B737. Those qualified on the A320 recounted that the A320's wingspan is about 15 feet wider than the 737 and could easily contact a vehicle properly parked behind the line.

The lesson learned was that the investigating authority reacted to outcomes rather than the process and did not progress to the underlying causes. This shortcoming was transmitted immediately to the investigator-in-charge of all three investigations who happened to be sitting in the classroom. Needless to say, his classmates appropriately admonished him.[11]

Experiences like these have led to the development of many of the programs reviewed in this report. In the scenario above, the initial investigation was as far from "human-centered" as one can find. Yet, it is not considerably different from many of the mishap investigations occurring within the U.S. today. In this scenario, as in most, there are two investigative approaches: human factors and discipline. These two error investigative postures are introduced below:

a) Human Factors Investigation

Human factors investigation (i.e., looking for contributing factors that potentially can be managed by the organization), encompasses the view that human error investigation should go deeper in the causal chain than merely "valve installed backwards" to WHY the valve was installed backwards. Determining why errors occur is the focus of each tool reviewed here. (For an example of the factors that might be considered in a human factors investigation, **Appendix A** provides Boeing's 4-page **MEDA** investigation form.)

As discussed earlier, many maintenance error events today are already known and investigated by the maintenance and engineering organization. This is quite different from the flight operations domain where the vast majority of pilot errors are not visible to the organization unless the pilot self reports. For the maintenance organization, the topic of human factors investigation represents a change of investigative approach as much as it represents a distinct new task for the airline organization.

b) Disciplinary Investigation

Events can be investigated for at least two reasons: to learn so that future mishaps may be avoided, or to assign blame. Discipline, the most controversial of the human error management strategies, surely serves the latter, and in some cases, can even serve the first. Some safety specialists would argue that discipline serves no purpose because it can have no effect upon the individuals who did not intend the mishap to occur. Others argue that it is the intentional conduct underlying the error that is the productive target of discipline. One thing is certain, effective event investigation cannot occur unless the issue of discipline - that is, what behaviors will result in disciplinary action - is well understood by the workforce and management.

F. The Systems Under Review

To respond to the need to reduce maintenance error, both from a safety and an economic perspective, the following systems have been developed, adapted, or enhanced to address maintenance error. Review of each consisted of interviews of both system owners/developers and system users to better understand how these systems are used today. There is no hierarchy implied by the order in which these systems are presented.

1. Maintenance Round Table - US Airways

The Round Table is a maintenance error investigative approach developed and used by the US Airways maintenance organization. It is a cooperative effort between the **FAA**, the air carrier, and the labor unions. Essentially, when a technician is involved in an error of interest to the Round Table Committee, he is brought before the committee to further disclose his involvement in the event. The company guarantees the technician that no further punitive sanction will be applied; however, the FAA retains rights to take additional action it deems necessary. Through these round table inquiries, the carrier gains feedback on how to improve the system to prevent future re-occurrence of similar errors. To date, roughly 20 round table investigations have been completed at US Airways.

2. Maintenance Error Decision Aid (MEDA) - Boeing

The Maintenance Error Decision Aid (MEDA) is a maintenance error investigative tool developed by Boeing in cooperation with nine domestic and foreign air carriers, the **FAA**, and the International Association of Machinists. Its initial goal was to re-define, for maintenance, what constitutes adequate human error investigation. The tool is made up of an investigative procedure, reporting form, and investigative training. Design and testing of the tool was completed in 1995 and as of this date 67 carriers are using or have been trained by Boeing to use the tool. (A brochure is attached as **Appendix G**.)

3. Tools for Error Analysis in Maintenance (TEAM) - Galaxy Scientific

Tools for Error Analysis in Maintenance (TEAM) is a software package built by Galaxy Scientific as an adjunct to Boeing's **MEDA** tool. Galaxy was a subcontractor for Boeing's MEDA development program, and hence the TEAM software continues to represent the latest in MEDA evolution. The software allows an air carrier to perform analysis on data collected via MEDA and provides a data-entry screen for direct investigation input using the TEAM software. (A brochure is attached as **Appendix H**.)

4. British Airways Safety Information System (BASIS)

The British Airways Safety Information System (BASIS) is a safety information system developed by British Airways. As of December 1, 1996, fifty-seven air carriers around the world use the system to input, analyze, and manage flightcrew-related errors and discrepancies. As British Airways was one of the original **MEDA** development team members and now a user of MEDA (called Maintenance Error Investigation (MEI) within British Airways), British Airways is currently expanding BASIS to include MEI as its for-purchase maintenance error investigation module. (A brochure is attached as **Appendix J**.)

5. Managing Engineering Safety Health (MESH) - University of Manchester

Managing Engineering Safety Health (MESH) is a program developed by the University of Manchester and first used in aviation by the British Airways Engineering department. It differs from the other programs reviewed in that it is not event-driven; rather, it relies upon global assessments of the factors that may provoke error or create inefficiency in the organization. It is reviewed here along with discrete error investigation systems because it has been used in one international carrier as a method for identifying contributors to maintenance error.

6. Aurora Mishap Management System (AMMS) - Aurora Safety and Information Systems, Inc.

The Aurora Mishap Management System (AMMS) is a commercial human error management system designed for use in the transportation industries. Built by ex-**MEDA** and ex-U.S. Air Force Mishap Prevention Program designers, AMMS provides an array of investigation, analysis, and prevention strategy methodologies through its PC-based platform. Whether positive or negative AMMS is the most sophisticated of the systems reviewed in that it requires both considerable training and computer acumen to effectively use its features. (A brochure is attached as **Appendix K**.)

7. Aviation Safety Reporting System (ASRS) - FAA/NASA

Begun in May 1975, the Aviation Safety Reporting System (ASRS) is an **FAA** self-report program administered by **NASA**, with contractual support from Battelle Memorial Institute. Its goals are two-fold: to identify deficiencies and discrepancies in the National Aviation System, and to provide data for planning and improvement to the National Aviation System. Primarily used by pilots, the system exchanges, under prescribed circumstances, immunity from FAA certificate action for an airman's reporting of his involvement in a FAR violation. The system has now been formally expanded to include a maintenance reporting form. The system is designed to allow ad-hoc user inquiries and to provide the aviation community with alert bulletins and research reports prepared by the NASA/Battelle team. (A brochure is attached as **Appendix I**.)

8. Air Carrier Voluntary Disclosure Reporting Program - FAA (AC-120-56)

Begun in 1992, the Voluntary Disclosure Program provides the opportunity for an organization, as compared to an individual, to report **FAR** violations to the **FAA** in exchange for some level of enforcement immunity. Unlike **ASRS**, the Voluntary Disclosure Program does not include a government-funded database, nor does it provide access to the aviation community. Additionally, Voluntary Disclosure requires a comprehensive corrective action on the part of the air carrier. It this sense, the program might best be described as an event-centered, one-on-one relationship between the violator (the airline) and the enforcement agency (the FAA). Its goal is to replace the hide-and-seek mentality of violations with a more cooperative approach.

9. Aviation Safety Action Program (ASAP) - FAA (AC-120-66)

The Aviation Safety Action Program, previously called Partnership Program, is the **FAA**'s latest journey into a less-punitive, more cooperative relationship with air carriers and major repair stations. Partnership programs have their roots in flight operations demonstration programs conducted over the past few years, including the US Airways Altitude Bust Program and the American Airlines ASAP Program. Like the US Airways Round Table, partnership programs are based upon group review of mishap events. Through such review, the carrier, labor union, and FAA can take appropriate and constructive corrective action. Like Voluntary Disclosure, there is no accompanying database, yet unlike Voluntary Disclosures, ASAP programs are designed to take a more process-oriented approach. That is, a comprehensive fix is not required for each and every event.

10. The Internal Airline Mechanical Reliability Program - (AC-120-17A)

The internal airline mechanical reliability program is reviewed in this report because 1) its processes for event investigation, analysis, and corrective action closely parallel those of human error investigation, and 2) there is much to be gained by observing the success of these programs. In addition, air carriers today already conduct a considerable number of maintenance error investigations. An event as critical as an in-flight shutdown of an engine, if caused by maintenance error, will generally be accompanied by an investigation and a detailed analysis of how to prevent a similar error in the future.

The maintenance and engineering purist recognizes that the term "mechanical reliability program" is somewhat misleading. This report reviews the typical air carrier's approach to the management of on-aircraft equipment failures, whether caused by the equipment itself or caused by human error. This function occurs, for a Part 121 carrier, through an air carrier's response to **FAR** 121.373, its continuous airworthiness maintenance program, and its mechanical reliability efforts.

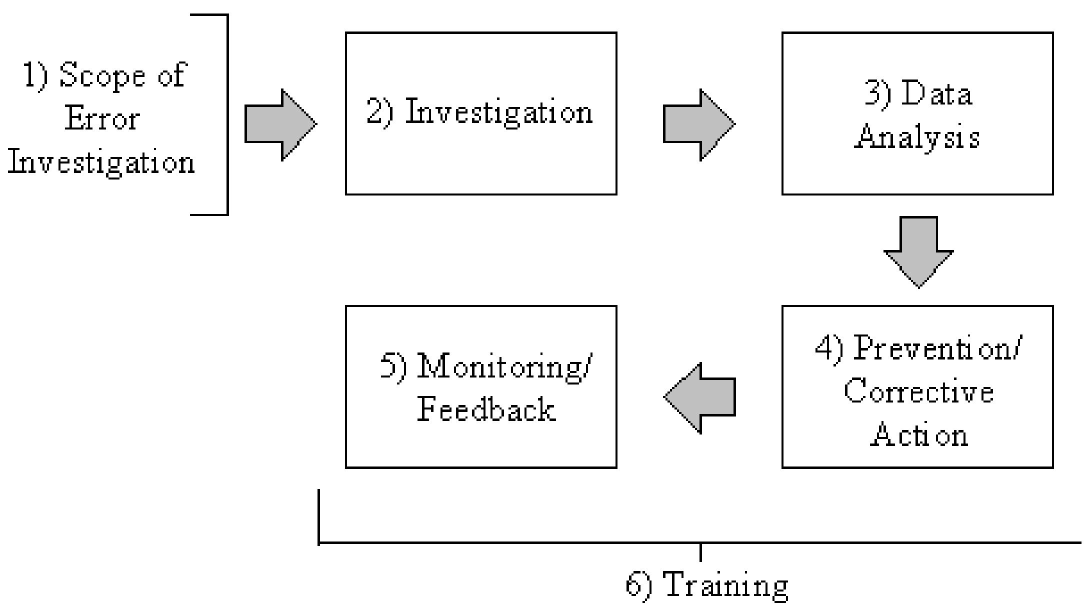
III. SYSTEM COMPARISONS

To more easily compare the features of each system, system functions are compared together. The seven principle systems attempting to bring new techniques to the investigation of maintenance error will be reviewed first, followed by the three **FAA** "facilitation" programs designed to offer immunity or forge partnerships with airmen and air carriers. Lastly, a few programs from the flight operations domain will be reviewed along with the typical mechanical reliability program of today.

A. The Seven Principle Systems (Round Tables, ASRS, MEDA, TEAM, BASIS/MEI, MESH, and AMMS)

1. Design Philosophy

Design philosophy addresses how each tool fulfills its goals; that is, how these tools serve to improve aircraft operational safety and reduce aircraft accidents. The figure below shows the six basic elements reviewed with respect to each system: scope of error investigation, investigation process, data analysis, prevention, monitoring, and lastly, training.



The Six Reviewed Elements of Maintenance Error Investigation, Analysis, and Corrective Action

a) The Scope of Error Investigation (Investigation Triggers)

With every human error investigation system, one must decide on the target population of events to investigate. Unlike single **NTSB** investigations used to identify systemic failures in aircraft design and operations, the systems reviewed here use a large set of lower-level mishaps to provide causal data that may ultimately be used to prevent aircraft accidents. In this sense, they are pro-active: not waiting for an accident to occur before learning can begin. The fundamental question for each system becomes: What is a reportable or investigatable event?

(1) Round Tables (US Airways)

Under the US Airways Round Table approach, investigatable events are determined through a consensus of the **FAA**, the air carrier, and the union committee. Unlike **MEDA**, **BASIS**, or **AMMS**, the Round Table stresses learning from a very small population of events. The events of interest are those where the committee believes there was a strong set of human factors contributors leading to the event; that is, where an otherwise culpable employee seems to have been set up to make the error. Compared to other systems, the number of investigations conducted is quite low (approximately 20 investigations thus far).

(2) ASRS

The goal of **ASRS** is to identify safety concerns through airmen self-reporting. That is, any concern that a pilot or technician may have is open to being reported through the system. ASRS may be termed a "rule-based" system in that its immunity provisions relate to the airman's level of intent with regard to a violation of the Federal Aviation Regulations. Per the ASRS Advisory Circular, an airman will receive immunity if his rule violation was "inadvertent and not deliberate." While this is not the only immunity criteria, it is the one that drives ASRS reporting. At a practical level, the immunity provisions of ASRS strongly influence what is reported; one can easily argue that if the airman did not violate a Federal Aviation Regulation he will have no incentive to report a mishap. If the airman has violated a **FAR**, he must ask himself whether the violation was inadvertent. If it was inadvertent, he benefits by reporting his mishap so that he receives immunity. If his violation was intentional, he will receive no immunity, and hence will likely not report the mishap. Thus, if ASRS promotes the reporting of a certain class of mishap, it is that of the inadvertent FAR violation.

(3) MEDA

The desire to reduce the maintenance contribution to aircraft accidents drove the design of **MEDA**. Thus, MEDA focuses on errors that impact the continued airworthiness of the aircraft. Maintenance error, defined by MEDA, is an aircraft discrepancy caused by the error of a maintenance organization. In choosing this definition, Boeing has focused the attention of MEDA primarily on those maintenance errors that get through the air carrier's defenses and onto the departing aircraft. (While MEDA does identify injury as an undesireable outcome, most carriers have used MEDA for human-error induced discrepancies on the aircraft.)

Unlike **ASRS**, **MEDA** is not intended to be a self-report program. Rather, it is an investigative tool for significant errors already known to the maintenance operation.

(4) TEAM

As the software accompaniment to **MEDA**, **TEAM** shares MEDA's approach to investigatable event classification.

(5) BASIS/MEI

Like **TEAM**, and because **BASIS** is implementing **MEDA** within it's program, at least in the area of maintenance error investigation, BASIS share's MEDA's orientation toward on-aircraft discrepancies.

(6) MESH

MESH takes a unique approach to investigatable events. Rather than performing investigations post-event, MESH asks employees to regularly assess those factors that may provoke error or reduce efficiency in the workplace. MESH is based upon the concept that individuals can, at a global level, identify those factors that may shape error. Thus, there is no investigatable event, but rather a pre-defined list of local and organizational factors that the employee must assess during his weekly or otherwise scheduled use of the MESH system.

(7) AMMS

Given that **AMMS** has been designed for use across a broad range of errors, AMMS has taken a very flexible approach to what constitutes an investigatable event. Essentially, Aurora looks to its customer to define the areas where AMMS will be applied. Nevertheless, AMMS does define a mishap as involving an error plus some undesirable outcome. Further, the AMMS software allows the investigator to select the undesirable outcomes from three broad categories: operational impact, injury, and damage. Once the broad category is identified, the AMMS software then asks the investigator a series of questions applicable to each category of outcome.

b) Investigation Approach

Investigation approach refers to the process for how event information gets compiled into an event investigation record. Each tool has its own process to complete an investigation. In some cases, the reporter himself conducts the investigation through his recollection of what happened in the mishap. In other cases, an investigator is assigned to investigate the mishap with the erring employee becoming the subject of the investigation.

(1) Round Tables (US Airways)

The Round Table essentially uses a group investigative process. That is, the erring employee divulges his involvement in the mishap to the Round Table committee. The round table process does not record data onto any type of permanent investigation record; rather, the round table committee, upon hearing the testimony, assigns action items and takes corrective action based upon its internal committee discussions.

(2) ASRS

ASRS does not involve investigation in the sense that an investigator is assigned to an event. Rather, it is a reporting program where the erring airman reports his own observations and findings related to the mishap. **NASA** reports thus read as testimonials of an individual's involvement in a mishap. ASRS has the capability to call the airman back for additional information or to clarify what has been submitted in the report; however, there is no expectation that the reporting airman either conduct an investigation or develop investigative conclusions. It is a system which prefers that first-hand, raw data be submitted. (The ASRS form is provided as **Appendix B**.)

(3) MEDA

MEDA is an investigative tool. That is, an investigator is assigned to investigate an identified mishap. Investigators are trained through a training program offered by Boeing. Using their training, the MEDA form, and MEDA supplemental information, the investigators interview and fact find in order to develop investigative conclusions. This is an important difference from a testimonial-based system like **ASRS**. Believing that individual testimonials of erring employees will only tell part of the story, MEDA investigation records do not necessarily include raw data provided by an erring employee(s). Rather, MEDA investigators are trained to investigate an event and make assessments as to its causes. For example, an erring employee may claim that he was confused by a procedure; however, it is the MEDA investigator's job to look at the procedure, compare it with others, and test the assertion that procedural confusion was, in the investigator's view, a link in the causal chain. Perhaps, after further investigation, the MEDA investigator finds that the training program is what was inconsistent and caused the technician to become confused by a rather standardized procedural approach. Thus, MEDA (and **AMMS**) share the approach that maintenance error requires investigation, and that the investigative record is really documentation of the circumstances and conclusions of the investigated event. (The MEDA event investigation record is provided as **Appendix A**.)

(4) TEAM

As the software supporting **MEDA**, **TEAM** follows the "investigative" conclusions approach of MEDA.

(5) BASIS/MEI

With **BASIS** currently integrating **MEDA**/MEI within its system, it too will follow the MEDA investigative approach.

(6) MESH

MESH takes a unique investigative approach, best described by its developer's "swamps and mosquitoes" analogy. In the design of MESH, Professor James Reason recognized that individual errors were often really the manifestations of more pervasive contributing factors existing throughout the business organization. In looking at today's error management process, Professor Reason saw many, if not most, of us performing event investigations, making point fixes, and then wondering why the error would re-occur at a later date, perhaps in another hangar or on a different part of the aircraft. Professor Reason analogized this to swatting individual mosquitoes, when the target of corrective action should be the more systemic factors that breed the mosquitoes in the first place (i.e., the "swamps"). Professor Reason's philosophy is that systemic error reduction will occur much better through a focus on draining the swamps rather than by swatting mosquitoes. In MESH, this translates into a direct assessment of the swamps, as identified by those within the maintenance system.

(7) AMMS

AMMS follows an approach similar to **MEDA**. Aurora trains investigators during a 2½-day course so that quality assurance investigators and/or maintenance peer investigators can both investigate and develop investigative conclusions. While trained investigators are AMMS's mainstay; Aurora is developing a number of self-report options through either paper, software, and/or telephone transmission. However, these processes are most likely to be used for less critical (non-airworthiness related errors) and by the flight domain which is more suited to self-reporting.

c) Analysis

Once data is collected and an event record generated, there must be some process for analysis of data to determine both the scope of problems and to devise preventive strategies. Analysis can occur at two basic levels. First, single events can be analyzed to determine if preventive strategies can be developed stemming from one particular mishap. Organizations conduct this type of analysis because they don't want this particular mishap to occur again or they wish to prevent another entire class of event through investigation of this single event. The second type of analysis involves the review of multiple mishap records in order to spot trends and to develop corrective actions that may apply to systemic contributors to error. For each system, both of these analysis options are covered.

(1) Round Tables (US Airways)

Analysis in the Round Table context is relatively simple. Each event under review represents the source of data for determination of error contributors and the development of prevention strategies. The theory is that these contributors to a particular mishap are likely to contribute to other events within the organization. There is no specific structured process for analysis; rather, it is real-time, event-by-event analysis by the Round Table event review team.

(2) ASRS

Under the **ASRS** program, analysis occurs in two ways by two different groups. The ASRS offices at Moffett Field employ a number of analysts to analyze the data and look for trends or individual circumstances that may be a threat to aviation safety. The second type of analysis involves external organizations who request individual records or "data dumps" from the ASRS offices. It is important to note that nearly all ASRS analysis is oriented toward the *identification* of hazards, and not the *quantification* of hazards. Because ASRS is a self-report program, it does not have a baseline from which to determine particular error rates. ASRS does not collect data on successful task accomplishment from which to compare the failures, and it has no real way of determining what percentage of errors or violations are reported to ASRS.

(3) MEDA

MEDA provides for both individual event analysis, and through **TEAM**, analysis of systemic factors. At the individual event level, the analysis really occurs as the investigation is conducted. As discussed in the previous section, MEDA investigators are trained to develop investigative conclusions while performing the investigation itself.

(4) TEAM

TEAM, as a design enhancement to **MEDA**, provides a number of analysis tools for MEDA reports. In addition to the computerized MEDA form, TEAM includes both graphical analysis of structured data and a structured query language (SQL) tool to search narrative data.

(5) BASIS/MEI

BASIS has focused most of its analysis capability upon graphical display of trends and contains a wealth of pre-determined graphs that may be used to spot these trends. BASIS does not currently have any structured processes to analyze single events or to conduct narrative searches of event records. In this regard, BASIS may be considered more of an information system than an analysis or prevention system. BASIS is run on a network where, as an example, British Airways employees can log onto a number of computers to see most individual records (confidential flight human-factors reports are not available to everyone). The safety services staff primarily conducts analysis and publishes it as appropriate in the carrier's internal publications.

(6) MESH

MESH relies exclusively upon its data analysis capabilities. In MESH, changes do not come from single events but from analysis of systemic factors identified by MESH analysts. To facilitate analysis, MESH comes equipped with software that provides graphical display of how the pre-identified performance shaping factors compare in terms of employee concern. MESH uses these graphical displays to identify where resources should be spent.

(7) AMMS

AMMS comes with a large set of analysis tools. AMMS has predefined graphs that can be used to track contributing factors as well as the effectiveness of prevention strategy projects. AMMS also has a graphical display tool allowing the user to build graphs similar to the functionality of a spreadsheet program like Microsoft's Excel. This functionality also includes a capability called "drill-down" that allows the user to click on a graph bar, taking the user to the next lower level of data. In addition to graphical display, AMMS provides a query tool to allow narrative search of the data.

d) Prevention/Corrective Action

(1) Round Tables (US Airways)

Because the Round Table relies on the Round Table event review team for corrective action, there is no specific corrective action methodology. Nevertheless, as an internal airline process, the Round Table team can immediately take action to ensure that deficiencies identified through event reviews are corrected.

(2) ASRS

As a **NASA** administered system, **ASRS** does not have responsibility or authority for making actual changes in an air carrier's maintenance system. Nor does ASRS have a structured process for how to develop prevention strategies through use of ASRS data. ASRS is based on the premise that through the dissemination of data, research findings, and alert bulletins, those having responsibility for the contributors to error will take appropriate action once they have become alerted to their role in error causation.

Because the National Airspace system is largely a government enterprise, **NASA** has been very effective in alerting entities such as airports to possible safety hazards without violating confidentiality. What **ASRS** cannot do, because of confidentiality provisions, is contact an airline about a specific hazard. This provision may be particularly troublesome for maintenance, an activity that is entirely internal to the air carriers and repair stations.

(3) MEDA

MEDA was designed as an aid to help the investigative side of the error management equation: by better understanding the causes of error, better prevention strategies would necessarily follow. Thus, MEDA does not have a structured process for prevention strategy development beyond what is taught in its training program regarding error management philosophies.

(4) TEAM

TEAM follows **MEDA**'s lead. Team, at the systemic level, will help the analyst spot trends, but does not provide additional methodologies to assist in the area of prevention strategy development.

(5) BASIS/MEI

If an element of **BASIS** can be characterized as a prevention strategy process, it is BASIS's process for assigning action items and monitoring progress of action items in the post event setting. BASIS, like most of the other programs reviewed, does not have a specific process to assist in the development of prevention strategies.

(6) MESH

MESH was designed as a tool to directly monitor the contributing factors to error. In terms of prevention strategy development, MESH simply tells the user to fix the problems identified through the tracking of local and organizational factors.

(7) AMMS

AMMS is the only tool among this group that has a structured prevention strategy development process. While limited to prevention strategy development for systemic contributors to error, it is a process that breaks down prevention strategy development into manageable tasks for the analyst. In doing so, the analyst, according to Aurora, will be able to propose and validate the anticipated effectiveness of his prevention strategy through the use of the prevention strategy module. (As a commercial entity, Aurora considers its methodology proprietary and would not allow a detailed description within this report.)

e) Monitoring/Feedback

An important question for each of these systems is how they monitor their own effectiveness. That is, can each system measure its own return on investment, either by economic or safety standards?

(1) Round Tables (US Airways)

Round tables do not involve the quantitative tracking of error; rather the monitoring of success is left to much more qualitative measures such as happiness with the process and resulting corrective actions. The round table committee can also measure overall metrics, such as delays and cancellations.

(2) ASRS

ASRS does not have a formal monitoring process, primarily because ASRS has little visibility as to how air carriers or the **FAA** will make use of the ASRS data. By contrast, in flight operations ASRS officials speak directly to those involved in administration of the national airspace system. For example, they may contact an airport authority to talk about reported problems with an approach pattern. However, ASRS officials will not call an airline regarding a problem related to a particular flight operations procedure. Actually, ASRS will de-identify the self-report once it is received at **NASA** so that even ASRS analysts have no record to identify the carrier from which the report originated. Particularly in the area of maintenance, it is best to think of ASRS as a data resource, providing information that might otherwise be unattainable inside an air carrier or directly by the FAA.

(3) MEDA

The ability to track the effectiveness of prevention strategies associated with **MEDA** investigations, and the ability to track frequency of errors, is largely based upon an air carrier's own implementation of the MEDA process. The Boeing MEDA team does not recommend a specific population of events to measure, but instead relies upon overall performance metrics within the airline to provide feedback on system performance. For example, an airline may choose to investigate only selected delay or dispatch related errors occurring only at their major hub. The airline investigates error this way using MEDA, and while doing this also tracks its overall dispatch reliability. After two years of MEDA investigations, the airline sees a 1% increase in dispatch reliability. By this metric, the MEDA process can claim some credit.

(4) TEAM

While the **TEAM** software contains graphical trend analysis capability, it is limited by how the airline chooses to implement **MEDA**. If the airline chooses to investigate 100% of some class of event, the TEAM software will provide historical tracking of those errors. If an airline chooses to randomly pick errors to investigate, or relies on self-reporting, the TEAM software will lose its ability to do any quantitative tracking of error.

(5) BASIS

Because the **BASIS** designers are still in the process of implementing **MEDA** within the BASIS program, it is unclear what statistical tools BASIS will link to MEDA. Nevertheless, BASIS's method of monitoring flight risk has facilitated one of the best, if not the best, self-reporting programs in the world. Through this reporting process it captures 6000 air safety reports per year from within its airline. Once the BASIS group receives the air safety report, an air safety investigator assigns a risk factor based upon criticality of the event and the likelihood of reoccurrence. By assigning each air safety report its own risk factor, British Airways has the ability to track both frequency of air safety reports and overall risk. And while BASIS has no formal process to track the effectiveness of individual prevention strategies, it can track the performance of its flight operations system through its quantitative risk factors.

(6) MESH

The monitoring element of **MESH** is identical to its investigative element. Given that MESH tracks only *attitudes* toward error provoking factors in the workplace, it provides an organization the ability to continuously monitor those attitudes. In this manner, MESH is not constrained by concerns regarding what level of error reporting or investigation is actually occurring. Within MESH, if tooling support in the hangar has improved from the viewpoint of those entering data into MESH, then the MESH process has done its job.

(7) AMMS

AMMS provides monitoring in two ways, although both depend upon 100% error reporting or investigation at some threshold. In implementation discussions, Aurora emphasizes that the statistical power of AMMS hinges upon a known set of errors. For example, that known set may be flight delay and cancellations involving maintenance error, or it may be damage in the hangar involving a cost greater that $5000. What AMMS can do once a valid set of investigations is conducted is two-fold. First, like **BASIS** and **TEAM**, it can track error on a statistical basis. Secondly and uniquely, it is designed to track the effectiveness of individual prevention strategies. The AMMS software stores prevention strategy data in project files. When an analyst would like to review the effectiveness of a specific prevention strategy implemented last year, he can open the project file and the software will automatically review the data, providing a graphical display of the before and after picture for this class of error.

f) Training

(1) Round Tables (US Airways)

The Round Table is not a commercial product, and correspondingly does not have a formal training package.

(2) ASRS

As a government sponsored self-report program, **ASRS** has no requirement for training investigators or analysts. Rather, through broad dissemination of reporting forms and through the aviation community's embrace, at least on the flight side, ASRS has spread the word that it offers immunity for information.

(3) MEDA

MEDA has three formal training modules. The first is a 2-3 hour briefing for an airline's senior management. The second is a 2-hour briefing for those who will be the MEDA team within the carrier. Lastly, MEDA requires that investigators go through 6 to 8 hours of human factors and investigative skills training.

(4) TEAM

Team does not provide formal training because once an airline is familiar with **MEDA**, use of **TEAM** software is relatively self-explanatory.

(5) BASIS

BASIS does not currently provide formal training on use of their system. This is due primarily to the fact that BASIS, prior to the addition of MEI (**MEDA**) was strictly a safety reporting and information system; investigator training has never been needed in the flight operations environment. However, given that British Airways is now implementing MEDA/MEI, it does have plans to provide investigative training to BASIS users.

(6) MESH

MESH is largely self-explanatory for users so that training is essentially limited to filling out the forms within the MESH program. As part of his support, Professor Reason will provide training as needed to implement the system.

(7) AMMS

AMMS provides, and requires, the most extensive training of all of the programs reviewed here. Each AMMS investigator is taken through a 2½-day course covering use of the AMMS software, investigation and interviewing skills, analysis, and prevention strategy development techniques. Aurora also offers a 1-day advanced analysis course, although it has not yet been taught.

2. Field Experience

One would naturally expect that field experience would be a cornerstone of this report. After all, it is the demonstrated success of these systems which is of ultimate interest and importance. Unfortunately, the maintenance experience with all of the programs is slim. While the availability is there, especially in the U.S., there has been little commitment by either the air carriers, repair stations, or the **FAA** to see human-centered error investigation and analysis become a new way of doing business. Nevertheless, the following describes the use, and where known, the success of these systems to date.

a) ASRS

ASRS may easily be called the hallmark of aviation safety databases. Within the U.S., ASRS has amassed 359,000 self reports through December 1996. In addition, ASRS staff has processed over 4800 search requests, issued over 1800 Safety Alerts and over 200 CALLBACK Safety Bulletins, and conducted over 50 major research studies. From a flight operations perspective (pilot and controller), ASRS has provided invaluable information.

For all of the **ASRS** success in the flight operations environment, however, the ASRS program has been largely unsuccessful in establishing a foothold in the aircraft maintenance domain. Over the past 5 years, the **FAA** has even questioned its own ideas about whether the ASRS program, and its immunity provisions, would apply to maintenance or ground operations personnel. For most of its history, ASRS has been solely marketed as a tool to support the flight operations domain. However, due to the efforts of the International Association of Machinists and others, the FAA has now formally recognized ASRS's application to maintenance, ground, and cabin crew. (See **Appendix D**.)

b) MEDA

MEDA was not formally launched as a Boeing customer support option until the fall of 1995. Since introduction of the tool, 92 carriers and repair stations around the world have been trained to use MEDA, although only six of these have been within the U.S. (Two to three new carriers are trained each month.)

MEDA users have provided promising feedback on use of the system. One foreign user, in particular, having conducted over 400 investigations, has cited a resulting 16% reduction in maintenance delays.

c) Round Tables, AMMS, TEAM, BASIS (MEI module), and MESH

These five systems are grouped together because each has been used at only one or two carriers thus far and none of the tools have gained enough experience to talk to their effectiveness, even in general terms. In the future, it may be possible to share lessons-learned on the effectiveness of different error investigative tools. However, such lessons learned may be more a function of operator implementation than investigative system implementation. For now, field experience for all of these tools is too slim to draw any conclusions.

B. Flight Operations Programs

Compared to flight operations, maintenance and ground operations are relative newcomers to the field of human factors and organized human error management. Whether it is crew resource management, reporting and investigation systems, or support from the **FAA**, flight operations programs have the lead. Three of the flight operations systems worthy of review are **ASRS**, **BASIS**, and American Airline's ASAP program. The philosophy and operation of these three programs is described below. What must be remembered about these programs, however, is that they are flight programs and in many respects not directly transferable to the maintenance or ground operations environment. In many ways, what has been easy for the flight side will be hard for the maintenance and group operations environment; correspondingly, what has been difficult for the flight operations side, in many circumstances will be easier for maintenance.

a) ASRS

From a flight operations perspective (pilot and controller), **ASRS** has proven an invaluable resource of safety-related information. And for pilots who inadvertently violate the **FAR**s, ASRS has been a tremendous haven from sometimes unwarranted **FAA** enforcement action.

Yet for all its accolades, it must be remembered that **ASRS** is not a corrective action program. That is, unless ASRS staff see an immediate threat to safety for which they have an opportunity to help fix without endangering the confidentiality of the program, there is no formal process for use of ASRS data for corrective action purposes.

b) BASIS

Created by British Airways in 1990, **BASIS** began as a computerized system to replace hard-copy incident investigation files. BASIS has now grown into the most widely used internal air carrier safety information system in the world. The center of BASIS is its air safety report. Every year through mandatory reporting requirements, British Airways pilots submit over 6000 air safety reports telling the "what" of the incident or flight discrepancy. In response to receiving an air safety report, British Airways Safety Services will send a voluntary confidential human factors questionnaire to each crewmember.

Today, **BASIS** contains nine different investigative modules covering ground handling, maintenance error, air safety, human factors and personnel safety reports, as well as flight data recorder exceedances and flight instrument replay. By any measure, within British Airways the program has both flourished and provided proven benefit. As a software program designed to run on a network, BASIS, more than any other system reviewed, is truly a safety information system. Any pilot can log on a computer terminal and view air safety reports. Additionally, BASIS is used inside British Airways as an information system to assign and track action items resulting from a single mishap report. And finally, because BASIS assigns a risk factor to each mishap, BASIS has been able to track what it believes is an overall, quantifiable measure of risk within the British Airways flight operations system.

c) ASAP (American Airlines version)

The American Airlines's ASAP program is the precursor to the **FAA**'s new Aviation Safety Action Program described in AC 120-66. ASAP is a partnership between American Airlines, its pilot labor union, and the FAA. Begun in June 1994, it is a program that has resulted in literally thousands of pilot self-reports. It has achieved such reporting success for a number of reasons. One is that when a pilot completes an **ASRS** report, he is offered limited immunity from FAA enforcement action. A second reason is that ASAP has enjoyed avid support from both management and the labor union.

C. Report Facilitation Programs

In addition to the data capturing and analysis systems reviewed above, the **FAA** has created three specific programs to help facilitate improved airman reporting of mishaps and **FAR** violations as well as improved honesty in the investigative process. In order of presentation, these programs represent the FAA's increasing willingness to partner with air carriers and labor unions. (Uniquely, **ASRS** is both a database and a report facilitation program. As the database aspect of ASRS has already been discussed, what follows is that portion of ASRS intended to facilitate event reporting.)

1. ASRS

In order to gain self-reports of airmen who violate **FAR**s, the **FAA** established a limited immunity program for those who submit a report through the **ASRS** system. While it is far from "blanket" immunity, the immunity provided has ensured that many human errors can be reported through ASRS without fear of punitive sanction. While the entire advisory circular is enclosed as **Appendix D**, the salient portions of the immunity provisions are as follows:

> "The filing of a report with **NASA** concerning an incident or occurrence involving a violation of the Act or the Federal Aviation Regulations is considered by the **FAA** to be indicative of a constructive attitude. Such an attitude will tend to prevent future violations. Accordingly, although a finding of a violation may be made, neither a civil penalty nor certificate suspension will be imposed if:
>
> 1) The violation was inadvertent and not deliberate;
>
> 2) The violation did not involve a criminal offense, or accident, or action under section 609 of the Act which discloses a lack of qualification or competency, which are wholly excluded from this policy;
>
> 3) The person has not been found in any prior **FAA** enforcement action to have committed a violation of the Federal Aviation Act, or of any regulation promulgated under that Act for a period of 5 years prior to the date of the occurrence; and
>
> 4) The person proves that, within 10 days after the violation, he or she completed and delivered or mailed a written report of the incident or occurrence to **NASA** under **ASRS**."

2. Voluntary Disclosure

It does not take much imagination to predict that if individual airmen could receive some level of immunity by being cooperative with the **FAA** through **ASRS**, then organizations as a whole would also want to join in the process. Voluntary Disclosure programs do just that: provide limited immunity to the organization that voluntarily submits its **FAR** violations to the FAA. Compared with ASRS which only requires airman reporting of the event, with Voluntary Disclosure the air carrier or major repair station must show the FAA a comprehensive fix. The entire Advisory Circular is provided as **Appendix E**, however, the salient portions of the immunity provisions are shown below:

> "The **FAA** believes that the open sharing of apparent violations and a cooperative as well as an advisory approach to solving problems will enhance and promote aviation safety. Certificate holders will receive a letter of correction in lieu of civil penalty action for instances of noncompliance that are voluntarily disclosed to the FAA in accordance with the procedures set forth in this **AC**. Once the letter of correction is issued, the case will be considered closed unless the agreed upon comprehensive fix is not satisfactorily completed by the certificate holder.
>
> (a) In evaluating enforcement action for a certificate holder's actual or apparent failure to comply with **FAA** regulations, the FAA will ensure that the following five conditions are met:
>
> > 1) The certificate holder immediately notified the **FAA** of the apparent violation after detecting it and before the agency learned of it.
> >
> > 2) The apparent violation must have been inadvertent.
> >
> > 3) The apparent violation does not indicate a lack, or reasonable question, of basic qualification of the certificate holder.

4) Immediate action must have been taken, or begun to have been taken, upon discovery to terminate the conduct that resulted in the apparent violation.

5) The certificate holder must develop and implement a comprehensive fix satisfactory to the **FAA**.

(b) Ordinarily, the **FAA** will not forego legal enforcement action if the certificate holder informs the FAA of the apparent violation during routine FAA investigations/inspections, or in association with accidents and incidents.

3. ASAP

The Aviation Safety Action Program, authorized in January 1997, represents the latest advance in air carrier/**FAA** partnership. Through a partnership among the carrier, labor unions, and the FAA, all three groups can co-manage the contributors to safety-related mishaps. In its efforts to facilitate reporting, ASAP has established its own immunity provisions, coined "enforcement-related incentives" by the Advisory Circular. Although the entire Advisory Circular is provided as **Appendix F**, the pertinent provisions of its enforcement related incentives follow:

"Administrative action may be taken in lieu of legal enforcement when all of the following elements are present:

1) Applicable law does not require legal enforcement action.

2) Lack of qualification or competency was not involved.

3) The violation was inadvertent and not deliberate.

4) The violation was not the result of a substantial disregard for safety or security and the circumstances of the violation are not aggravated.

5) The alleged violator has a constructive attitude toward complying with the regulations.

6) The alleged violator has not been involved previously in similar violations.

7) After consideration of items (1-6), a determination is made that administrative action will serve as an adequate deterrent.

Substantial disregard means:

a) In the case of a certificate holder, the act or failure to act was a substantial deviation from the degree of care, judgment, and responsibility normally expected of a person holding a certificate with that type, quality, and level of experience, knowledge, and proficiency.

b) In case the violator is not a certificate holder, the act or failure to act was a substantial deviation for the degree of care and diligence expected of a reasonable person in those circumstances."

D. The Equipment Side of Aviation

While this report is about maintenance error (i.e., human error in the maintenance domain), it would be unjust not to discuss how maintenance and engineering organizations have been managing both equipment and human failure through, what may be broadly termed, the mechanical reliability program. While engineering and maintenance professionals may all have different ideas about what constitutes a mechanical reliability program and what the **FAA** requires through its regulations for "continuing analysis and surveillance," there would likely be agreement that these programs have been successful.

1. The Elements of a Mechanical Reliability Program

Like error management programs, the mechanical reliability program has the same core elements: investigation, analysis, prevention, and feedback. Each of these is discussed below.

a) Event investigation

Investigation of mechanical failure occurs at many levels within an airline today. If the component does not relate to airworthiness, or the failure is considered normal and expected, there will be little formal investigation. A technician will likely write in a maintenance log that a failed component (e.g., check valve) was replaced in order to correct the system anomaly (e.g., gear will not retract).

If the component is refurbishable, a shop report will likely identify the cause of the component failure at a more detailed level (e.g., spring fatigue). If the failure is considered more critical, the air carrier's engineering department might get involved and initiate additional post-event investigation. The **FAA** will likely see or be involved in only critical failures. For example, for an engine disk failure which is not supposed to occur, the FAA will likely work with the carrier to arrive at an acceptable corrective action. If the failure is benign, however, the FAA will likely be informed of the failure only through the FAA's review of performance at the system level (e.g., graph of **ATA** chapter 32 cancellations).

b) Data Analysis

In addition to developing corrective actions in response to individual events, carriers will also analyze data in order to spot trends that may result in a degradation of safety or result in unnecessary economic harm. These data analyses might be at the level of a specific component (e.g., air condition packs), at the system level (e.g., air conditioning), or at the level of performance metrics such as delays or cancellations. In the U.S., **FAR**s 121.373 and 135.431 (Continuing Analysis and Surveillance) require some level of systems analysis.

c) Prevention/Corrective Action

Through continuing trend analysis, air carriers develop corrective actions in response to equipment failure, whether caused by the equipment itself or caused by human error. These corrective actions will either occur at the air carrier's own initiative, through a service bulletin or letter from a manufacturer, or through the suggestion or mandate of the **FAA**.

d) Monitoring/Feedback

Through continuing data analysis, air carriers also have a method of monitoring the effectiveness of their corrective actions. If a redesigned seal is used to reduce hydraulic pump O-ring failures, the carrier can track the hydraulic pump failure rates both before and after prevention strategy development in order to confirm that the strategy has worked as intended.

2. *Experience and Gains*

The improvement in equipment reliability over the last 30-50 years through the cooperation of the manufacturers, the air carriers, and the **FAA** has been remarkable. In some systems, failure rates have decreased by orders of magnitude. It must also be recognized that while oriented toward mechanical failures and conducted by technically-oriented people, work in the area of equipment reliability has not been without its effect on human reliability. Purists would say that a mechanical reliability program and a good engineering department are equally concerned about all aircraft discrepancies, whether caused by equipment or human failure. This assertion is valid. Many improvements to both aircraft design and internal airline process have come through efforts to reduce maintenance error. Nevertheless, most of these investigative efforts have had an "engineering flavor" in that they did not, in most cases, directly involve the erring technician. Rather, in many airlines today, engineers are left to determine how to Murphy-proof the system, while the erring technician's management is left to clean up the mess (e.g., reprimand the technician).

E. Bringing It All together

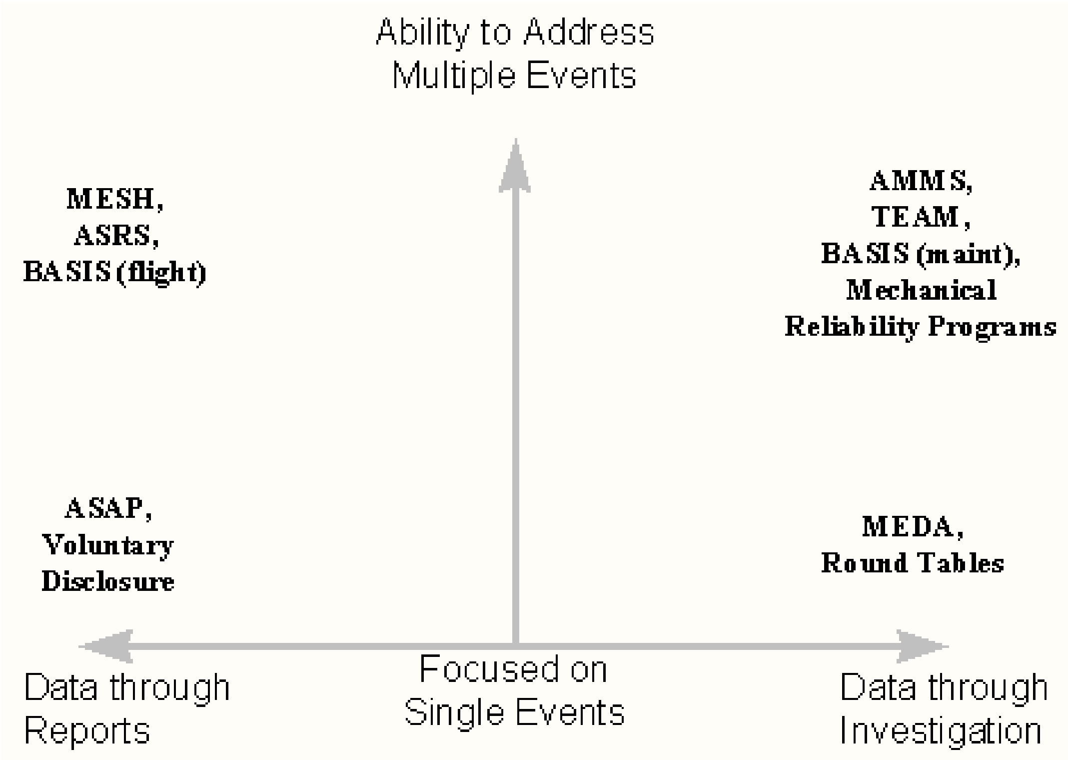
Each system has its unique characteristics, which are summarized in the following table.

System Comparisons

Name	Characterization	Owner	Scope of Investigation	Investigative Approach	Structured Data Analysis?	Structured Prevention Strategy Development?	Structured Monitoring and Feedback?
US Airways Round Table	Selective Error Investigation	US Airways	Selected High Visibility Events	Committee Investigation	None	None	None
Aviation Safety Reporting System (ASRS)	Event Reporting, Analysis, and Immunity	NASA and FAA	Inadvertent FAR Violations	Self Reporting	Graphical and Narrative Search	None	Event Trending
Maintenance Error Decision Aid (MEDA)	Error Investigation Methodology	Boeing	Maintenance Error-Induced On-Aircraft Discrepancies	Assigned Investigators	None	None	None
Tools for Error Analysis in Maintenance (TEAM)	Error Analysis	Galaxy Scientific Corporation	Maintenance Error-Induced On-Aircraft Discrepancies	Assigned Investigators	Graphical and Narrative Search	None	Event Trending
British Airways Safety Information System (BASIS)	Error Investigation, Analysis, and Action Item Tracking	British Airways	Maintenance Error-Induced On-Aircraft Discrepancies	Assigned Investigators	Graphical and Narrative Search	None	Risk Trending

Managing Safety Engineering Health (MESH)	Event Precursor Identification and Analysis	University of Manchester	Not Event Driven - Regularly Scheduled Input Instead	Technicians and Managers Periodically Self Reporting	Graphical Analysis	None	Precursor Trending
Aurora Mishap Management System (AMMS)	Event Investigation, Analysis, and Corrective Action	Aurora	Determined by Customer	Assigned Investigator	Single Event, Graphical, and Narrative Search	Prevention Strategy Builder	Event and Cost Trending
Voluntary Disclosure Program (AC-120-56)	Event Corrective Action/Immunity	FAA	High Visibility FAR Violations	Organizational Self Reporting	Single Event Focus	None	None
Aviation Safety Action Program (AC 120-66)	Partnership and Immunity	FAA	FAR Violations	Airman Self Reporting Followed By Group Investigation	Single Event Focus	None	None
Internal Airline Mechanical Reliability Program	Event Investigation, Analysis and Corrective Action	FAA	Significant Aircraft Equipment Discrepancies	Assigned Investigation	Single Event, Graphical	None	Event Trending

There are two characteristics that most distinguish the systems reviewed. First is whether the system relies upon self-reporting or whether it relies upon the investigation of known events. For example, **ASRS** is entirely a self-reporting system. Conversely, the **MEDA** program is designed as an investigative process for errors that would be known to the airline through the requirement to repair the aircraft discrepancy caused by the maintenance error. The second important characteristic is whether the system is designed to gain its knowledge through single events or through a population of events. For example, Self-Disclosure is a system that focuses entirely on corrective actions for single events. The strength of Aurora's **AMMS**, on the other hand, is its analysis and subsequent prevention strategies generated from a large and statistically valid set of maintenance errors. The graph below shows where each reviewed system stands with respect to these factors.



What must be recognized about all these systems, however, is that they all purport to provide a structured process for the identification of contributing factors that may ultimately lead to an accident.

IV. DISCUSSION AND EVALUATION

Most in the aviation industry recognize that error investigation could be improved through structured human-centered investigative techniques. Thus, at the last industry level, **FAA** sponsored meeting on maintenance error, Dr. Bill Shepherd, the FAA's then chief maintenance human factors researcher, asked the audience why U.S. carriers were not making better use of those maintenance error analysis systems already on the market? Although some programs like **MEDA** are being offered free of charge, they are not yet widely used in the U.S. For example, of the 92 carriers trained to use MEDA, only six were within the U.S.

Unfortunately, the answer to Dr. Shepherd's question will not come from a review of the detailed design characteristics of these systems. There is no common feature that makes these systems strangely unsuited to application in the U.S. Rather, there is a large set of contributing factors, addressed below, that make troublesome the decision to reduce human error through the approach offered by these systems. It would be easy to merely list a myriad of reasons why the **FAA**, labor unions, and carriers are unwilling or unable to proceed with wholesale adoption of human-centered investigation. Instead, these issues will be addressed through the following series of assertions about the nature of maintenance error and its manageability.

A. Causation is the Key

At the root of maintenance error management efforts is a tension that goes beyond aviation. It goes to our personal view of why individuals make mistakes, whether it's professional colleagues, friends, or family. Under the old school of thought, error investigation was easy because we could merely point to the erring individual as the one to blame. Now, through human factors, it may be the CEO's pressure to make schedule, or the technician's home life, or a designer's poor placement of switches. The problem is that both responses are within us: the temptation to blame the erring employee and the temptation to see the erring person as merely an unfortunate product of his environment. Just how we balance these competing responses is a key to human performance improvements.

1. "Professionals can make mistakes without being 'unprofessional'."

If we all believed that human error was always the result of careless or reckless individual behavior, managing human error would be quite simple. Anyone committing an error would be counseled on the error of his ways and then given time off without pay or terminated. Words like *willful, wanton, careless, reckless, unprofessional, and negligent* would dominate event investigation records. Maintenance errors, while generally not intended, would simply be lumped in with other "unprofessional" behavior such as intentional falsification of maintenance records or working on aircraft without the required license.

History has shown, however, that the maintenance system not only shapes technician performance, but that the system can be manipulated to increase or decrease human reliability. The development of the systems reviewed in this report is testament to the growing recognition that contributors to error can be managed.

The human reliability curve shown below further illustrates the "human factors" philosophy. The principal line on the graph shows that as factors affecting human performance improve, the reliability of the task increases. It is important to conceptualize, however, that the curve is asymptotic with the 100% line. That is, the best we can hope for is to approach 100% reliability while never actually achieving it.

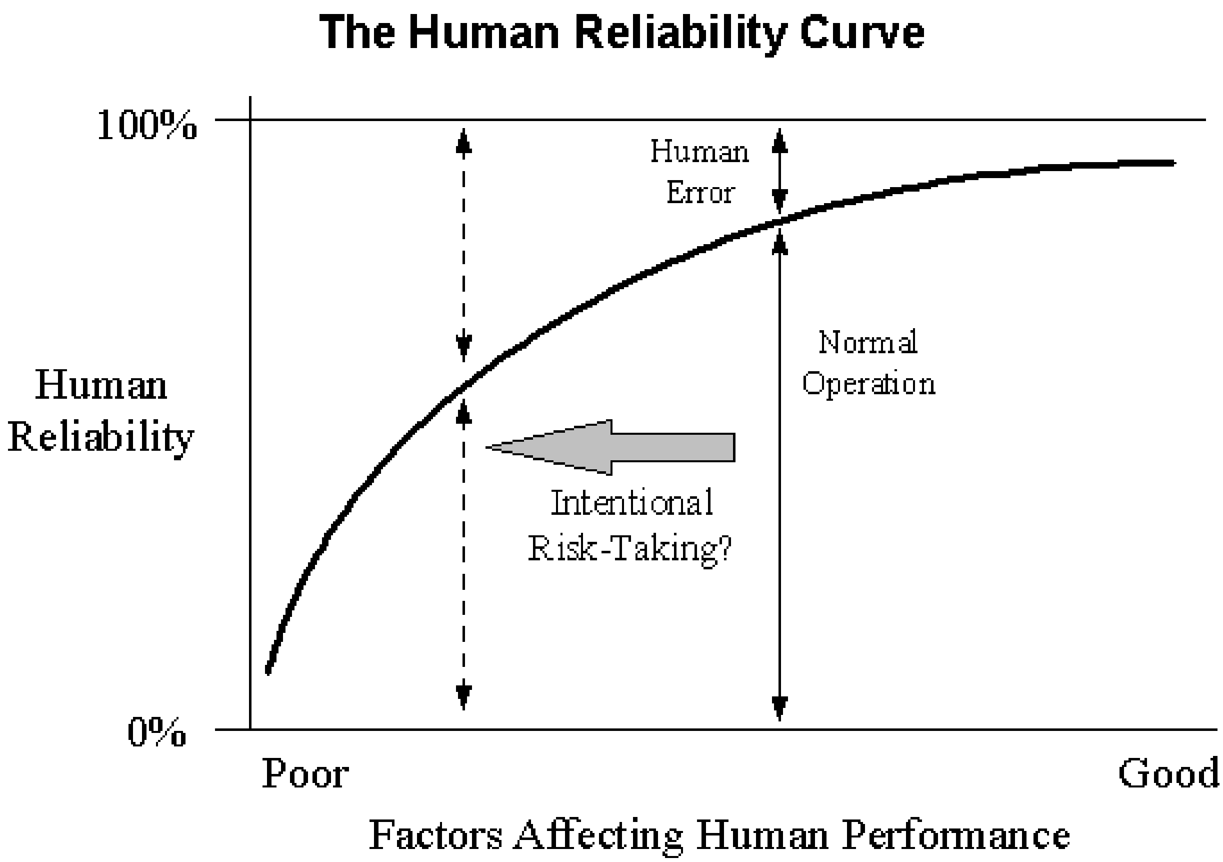
What becomes important to the human factors investigation then is 1) where is our operation on the curve and 2) what can be done to shift the operating line to the right? It is not "what can be done so that this person does not do something so unthinkable again?" but what in the design of the task, process, and environment can be done to improve task reliability? The human factors philosophy views human error as normal and expected, even under the best of circumstances and under the strictest of regulations. People will always make errors and organizations must design systems that take such errors into consideration. This is what the systems reviewed in this report all share: the belief that human reliability can be improved through design of the systems in which humans work.

2. "Some mistakes involve culpable, blameworthy behavior on the part of the erring individual(s)."

Managing human error would be equally simple if we all believed that the responsibility for human error always lay within the system, and never with the individual. Old words like reckless and unprofessional would be replaced by new words like *stress, fatigue, crew-coordination, heat, cold, wind, distraction, perception, vertigo, knowledge, saturation, confusion, noise, vibration, situational awareness, vigilance, motivation, mood, phraseology*, and others. Event investigation, rather than being an adversarial process, would simply be a scientific inquiry limited to the identification of factors that management and the **FAA** could change in order to improve future technician performance.

This perspective, however, implies that the individual is never responsible for his actions. It further implies that both **FAA** and internal organization enforcement and discipline would become obsolete, with errors managed only through employee incentives and system design. Accountability would only fall upon those whose job it was to produce improved human reliability.

The problem with this view is that we all take risks in our daily activity - whether we're working around the house, driving a car, or maintaining a commercial aircraft. It might be our decision to use a table saw without safety goggles or to drive a car without fastening our seat belt. It is assumed that when we are working on an aircraft we understand the consequences of risk taking - and therefore work to much more exacting standards. Yet even in aircraft maintenance, some degree of risk taking will be inevitable. In addition to asking how the system set up the employee to make an error, there is another question illustrated by the graph below: Did the technician knowingly and unjustifiably increase the probability that the error would occur?



Consider this scenario: On the overnight a technician is assigned to do a detailed inspection for cracks around rivet heads on a portion of the external side of a 737 fuselage. It is night and the aircraft is parked on the tarmac. In accordance with his airline's policy, he diligently brings out a work stand to get close to the structure and brings out large lamps to provide adequate lighting. Now consider that even though the technician followed all applicable procedures, he has still made an error by missing a crack that ultimately led to an in-flight depressurization. Should the technician be punished for merely making the error? Should he be punished for making an error that led to an in-flight depressurization?

Growing human factors wisdom says that, instead of dispensing discipline, maintenance organizations should strive to understand "why" the error occurred. So the organization uses a tool like Boeing's **MEDA** investigation technique to better understand the contributing factors to the error. In this case, an investigator may determine that a rushed overnight, poor lighting and fatigue all helped to decrease the inherent reliability of this task. For these contributing factors, the organization will stand accountable.

Even though the technician did not intend to miss the crack, in every mishap investigation the question remains whether the individual technician also bears some of the blame. Not because he or she made an error, but because we all have some control over our personal human reliability. In the vast majority of errors, an investigation will find that the technician was merely working within the norm of the air carrier's maintenance organization. In such a case, the erring technician was merely the unlucky one to be hit by the "normal and expected" human error.

Yet, would our attitude change if we knew that the technician stood on the ground to do this same inspection with his flashlight pointed up at rivets that were six feet away? This technician made the same error, missing the crack, as the technician who diligently followed the procedure and used an adequate work stand and the proper lighting. In neither scenario did the technician *intend* to miss the cracked structure. Yet, while theoretically not guaranteed of failure, the flashlight-equipped technician standing on the ground significantly and unjustifiably increased the risk that the error would occur.

It's important to recognize that under some circumstances, the erring employee will share some of the blame. Many of the systems reviewed in this report recognize this fact. **ASRS**, for example, does not provide immunity for the erring airman who intentionally violates a federal aviation regulation. **BASIS** takes a unique approach in that it advertises that a "fundamental principle" of its system is an "open, penalty-free reporting culture," yet it has drawn a definitive line where mere human error ends and culpable behavior begins. At British Airways, the internal BASIS policy is that the company will consider initiating disciplinary action where, "in the Company's opinion, an employee has acted recklessly, or omitted to take action, in a way that is not in keeping with his/her responsibilities, training, and/or experience." Further, Aurora's **AMMS** addresses the issue of culpability by providing two investigative tools: one for use by human factors investigators, and one for use by a disciplinary review board.

3. "Human error investigation is an inherently adversarial endeavor."

There should be no argument that investigations of human error are very different than investigations of equipment failure. In the case of human error investigation, some degree of blame generally falls squarely upon the human who last touched the broken object, a fact well known to technicians and ground agents. The designers of the systems reviewed in this report all attempted to address the adversarial nature of event investigation by focusing their efforts on system improvement. Most systems reviewed in this report endorse a "penalty-free" approach so that no one will feel threatened through use of the system.

Such a view, however, oversimplifies the complexities of event investigation. To tell the erring technician that it is no longer a blame-oriented process is to oversimplify the nature of error investigation. When the focus shifts away from the technician, doesn't another target of blame appear? Doesn't the identification of a confusing procedure place blame for the mishap on another individual, perhaps the procedure writer? Might not the procedure writer, attempting to deflect blame, point toward his management who required him to write that procedure in less time that he thought was needed? How would the procedure author react if someone showed up at his desk telling him that they were there to investigate his error?

It did not take long for the designers of **MEDA** (Boeing and air carriers) to realize that what would really happen in many event investigations is that the blame would merely shift from the erring employee to the air carrier organization or the aircraft manufacturer. Such a realization brings many concerns to mind. Might the air carrier be putting itself at risk by generating error investigation reports that point the finger at manageable factors within the carrier's control? Would error investigation reports be subject to Freedom of Information requests? With all of the misguided press coverage of Service Difficulty Reports, might error investigation reports be even more sensational? If we do not punish the employee, will a plaintiff associated with a future related mishap view our previous mishap response as soft?

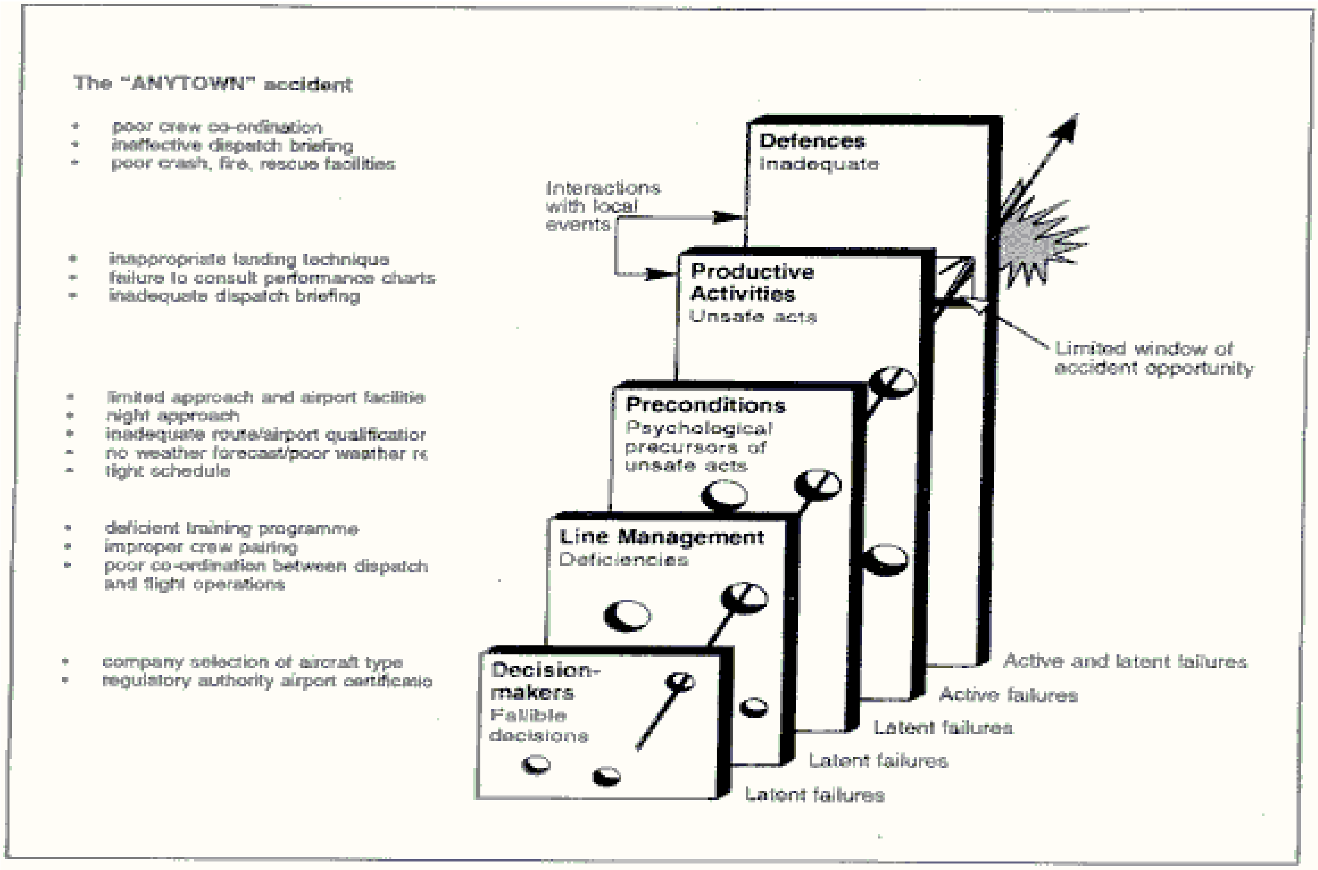
Human error investigation is inherently adversarial. There are a variety of interests that impact the proliferation of human factors investigation, many of which go well beyond a pure concern with safety. Particularly when the air carrier or repair station takes internal responsibility for error investigation, the risks of mis-use of a human-centered system lean strongly toward preserving the *status quo*. It is not so simple as hiring a human factors specialist to walk up to erring employees and say, "I'm here to help."

4. *"Error investigation, though reactive, is the most pro-active tool we have."*

The objective of maintenance error reduction, from the point of view of the **FAA**, is that maintenance error reduction must lead to overall accident reduction. Fifteen percent of large commercial jet accidents have maintenance and inspection as a causal factor. In most cases, this simply means maintenance error. Yet, the question remains whether maintenance error can be reduced simply by correcting the deficiencies found through accident investigation? Modern safety theory, as well as common sense, say that the answer is no. This is particularly true where humans are involved. One accident tells us how the human erred under one set of circumstances. Yet to prevent future, yet unknown accidents, we must be able to predict how humans will err in a variety of settings. Second, can prevention strategies be designed based upon our current body of human error knowledge, thereby bypassing the sometimes-ugly world of human factors event investigation? The answer here, too, is largely no. There is not a human factors specialist in the world today who can walk into an airline's maintenance operation and spot the precursors to that air carrier's most likely future maintenance-error related accident. The maintenance environment is simply too complex to lend itself to effective human error auditing. This is not to say that "human factors" audits cannot provide value; rather it is the quantifiable tie to specific human error reduction that is so illusive.

The figure below shows an accident model created by Professor James Reason of the University of Manchester.[12] The International Civil Aviation Organization and many governments and airlines around the world have adopted this model which serves two useful purposes. First, it illustrates how accidents are not merely the result of unsafe acts of pilots, technicians, or ground crew agents. Rather, there are a host of upstream factors that eventually lead to an accident. The decisions of executives, managers, designers, and trainers create an environment that allows the accident to occur.

This model, in part, describes today's view of human factors. That is, human errors near the pointed end of the arrow (e.g., pilots, and technicians) are ultimately shaped or affected by the system in which they work. This necessarily takes some focus off of the technician or pilot and onto the system and its creators.



For accident reduction to ultimately occur, these precursors to error must be identified and fixed. Yet while Professor Reason's model has gained universal approval, the model does not necessarily describe how the precursors to accidents are to be identified in the first place. It is this quandary that the systems reviewed in this report are designed to address. **MEDA**, **ASRS**, **MESH**, Round Tables, **BASIS**, **AMMS** - none of these systems are accident investigation tools. Rather, in terms of accident reduction, they are all intended to help identify and manage those factors that might ultimately be the precursors to accidents. All but MESH share a common approach in this regard; all use lower level event investigation to spot contributors to errors that may ultimately be contributors to an accident.

MESH is based upon the same assumption that the precursors to incidents and other lower impact events are the same precursors that would lead to an accident. Yet, rather than look for contributors to error via event investigation, MESH asks technicians and managers to spot the precursors directly. The difficult question regarding MESH is whether people can naturally spot what might eventually be a precursor to an accident. British Airways' has found that analyses from MESH are at such a high level that they do not provide the necessary specificity from which to build real-world prevention strategies.

Because the science of human factors has not progressed to the level of sophistication where error-provoking factors can be readily spotted *before* an incident occurs, even by human factors experts, we are left to event investigation. Ironically, it is event investigation that will ultimately provide the data and experience such that performance shaping factors could both be better understood and hopefully quantified.

B. Who, What, When, and Where?

If event investigation is one of our best hopes for reducing maintenance error contributions to aircraft accidents, the next task is to answer how event investigation should be implemented. That is, what events should be investigated, what analysis should be conducted, and how should prevention strategies be developed and monitored?

1. "Maintenance error is the problem; human factors is one possible solution."

Throughout this report, two terms have been linked: "maintenance error" and "human factors." It is critical to distinguish between the two. Maintenance error, as defined earlier, is about bad outcomes caused by human error.

In comparison, human factors is defined as:

> "the technology concerned to optimize the relationship between people and their activities by the systematic application of the human sciences, integrated within the framework of systems engineering."[13]

By this definition, it is clear that human factors can be concerned with much more than error. For example, the **FAA**'s Maintenance Human Factors Guide covers not only error management, but workplace design to reduce carpal tunnel syndrome, methods to improve maintenance efficiency, and even includes a chapter about sexual harassment in the workplace.

The distinction between human error and human factors has caused problems in interpretation for many within the industry. To clarify, many of the groups who are working to prevent aircraft accidents are changing the language of their programs to focus on error management. For example, Frank Tullo, Chairman of the **ATA** Human Factors sub-committee and flight operations executive at Continental Airlines announced that Continental has redefined their human factors program as a "human error management" program.

2. "We must think in terms of reliability, not violations."

From a regulatory perspective, the focus of human error inquiry has largely been the unintentional **FAR** or procedural violation. The **FAA**, especially in its legal view, considers each human error event a serious breach of an airman's fundamental duties as delineated in FAR 43.13 governing maintenance. The pertinent portions are as follows:

> § 43.13 Performance rules (general).
>
> (a) Each person performing maintenance, alteration, or preventive maintenance on an aircraft, engine, propeller, or appliance shall use the methods, techniques, and practices prescribed in the current manufacturer's maintenance manual or Instructions for Continued Airworthiness prepared by its manufacturer, or other methods, techniques, and practices acceptable to the Administrator…
>
> (b) Each person maintaining or altering, or performing preventive maintenance, shall do that work in such a manner and use materials of such a quality, that the condition of the aircraft, airframe, aircraft engine, propeller, or appliance worked on will be at least equal to its original or properly altered condition (with regard to aerodynamic function, structural strength, resistance to vibration and deterioration, and other qualities affecting airworthiness).

By these rules, one can easily argue that dispatch of an aircraft with a discrepancy caused by maintenance error is in fact a violation of the **FAR**s. This rule quite literally requires perfection. The problem is that roughly 48,800 air carrier and repair station technicians make mistakes that put them in violation of FAR 43.13 each year. Based on the following **FAA** Enforcement and Compliance Handbook statement, each and every one of these errors, if known by the FAA, should result in a FAA investigation.

> "Every apparent or alleged violation must be investigated [by an **FAA** inspector] and appropriately addressed. … The agency has a wide range of options available for addressing violations … from simple counseling and administrative action to formal legal enforcement."[14]

The **FAA** considers each of these 48,800 violations of such consequence that it has offered, through its voluntary disclosure program, to provide immunity to those carriers who report these violations to the FAA and develop comprehensive fixes for each event.

The reality, however, is that even with the immunity incentive only a tiny percentage of **FAR** violations involving maintenance error are submitted through the voluntary disclosure program. A pessimist would suggest that only those events that might be discovered by the **FAA** and result in a significant fine will be reported. An optimist, however, would suggest that both the carriers and the local FAA inspectors realize that in the final analysis not all maintenance errors are of equal importance. That is, most maintenance errors do not warrant a full-scale investigation and corrective action as required by the voluntary disclosure advisory circular.

Juxtapose this violation-oriented view with that of how the **FAA** has designed its oversight of equipment failure. Each failure of an aircraft part does not represent a violation of the **FAR**s. A hydraulic pump failure does not result in enforcement action against the pump manufacturer. The hydraulic pump manufacturer is not required to self disclose this failure to the FAA and develop a comprehensive fix or face punitive enforcement action by the FAA. This is not to say that hydraulic pump failures are not “managed.” Rather, pumps are designed in anticipation of failure. Aircraft are given three hydraulic systems to ensure that loss of one or even two systems will not result in an aircraft disaster. Failure rates are tracked through an air carrier’s reliability program, with careful consideration of unanticipated failure rates or failure modes. Thus the vast majority of a large carrier’s 10,000 or more on-aircraft equipment failures per year are tracked, monitored, and managed at the process level. It is only those that endanger safety of flight, a very narrow set, that are managed at the individual event level.

The important point is that on the human side, where human errors themselves are considered **FAR** violations, it is both advantageous and necessary to distinguish between benign and flight-critical errors. Not every maintenance error and corresponding FAR violation warrants a detailed review by a partnership program team nor does it warrant a comprehensive fix. To suggest that by addressing a single event all related future failures can be avoided would be to suggest that after the first mis-set O-ring this particular type of event should never again occur. Perhaps corporate lawyers would argue such, but this is not within the realm of reality. The failure to properly seat a chip detector O-ring is best managed at the process level through the analysis of systemic, error-provoking factors that lead to this class of event, whether it be an engine chip detector O-ring or a hydraulic pump reservoir O-ring. As stated earlier, a large carrier may have tens of thousands of errors involving undesirable consequences (primarily economic). Of those, roughly seven per year per airplane involve conformity of the dispatching aircraft. And of those, only a small percentage directly endanger safe operation of the aircraft.

3. “It is the maintenance errors involving on-aircraft discrepancies that are those most critical to flight safety.”

The preceding section argued that not all maintenance errors are of equal importance. Consider the pyramid below. There are three levels of error: those resulting in an accident or major incident, those resulting in on-aircraft discrepancies, and those resulting in no on-aircraft discrepancy.

Clearly, it is the class of event at the top of the pyramid that we are all trying to prevent. Yet one can easily argue that safety improvement will not come merely out of reactive investigation of these events. Each system reviewed herein supports the notion that the contributing factors to the accidents at the top of the pyramid may be identified through the contributors to the less critical events lower on the pyramid. Further, no system reviewed was designed to be an accident investigation tool. Rather, they were all designed as methods to uncover the contributors to events of lesser criticality, thereby uncovering the potential contributors to the more critical accident or incident.

The question for each system of course is, what events, below the level of accident and major incident, are worthy of human factors investigation? To answer this question, first consider the size of the two lower levels of error. As stated earlier, the typical aircraft averages seven on-aircraft maintenance error-related discrepancies per airplane per year. Taking numbers published by Northwest Airlines, those not leading to on-aircraft discrepancies would be in the neighborhood of 25 to 50 per airplane per year.[15]

The distinction between those errors that do and do not result in an aircraft discrepancy is important. In typical U.S. carriers, the vast majority of aircraft discrepancies resulting from maintenance error are already tracked and monitored through an air carrier's program of continuing analysis and surveillance pursuant to **FAR**s 121.373 and 135.431. It is not that these errors are all subject to a human factors investigation (actually the vast majority are not), but air carriers track the delays, cancellations, and required rework stemming from these errors.

For large-scale error management to have real credibility, particularly within engineering circles, the population of events investigated must provide for statistical tracking of error. For example, to say that 200 investigations have been performed and prevention strategies have been developed for 90 percent of these errors is not enough. The data must be able to predict what future reduction in error or reduction in cost will be realized. This is what is required to justify a new more reliable hydraulic pump, and it is what will be required to justify a new shift-turnover procedure.

The lower level of errors that do not eventually lead to an aircraft discrepancy represent additional cost for the carrier, and ultimately may reveal the possible contributors to an accident. However, from an error management perspective they suffer from a lack of statistical validity and are more remote in terms of aircraft safety. In terms of aircraft safety, the fact that these errors did not make their way onto a departing aircraft means that in some regard the air carrier's process control has worked. It could be because the error was readily apparent to the technician, or because an inspection or functional check caught the error before it could impact revenue service.

It is the errors that result in on-aircraft discrepancies that should be the focus of expanded error investigation. If we believe that all learning is to come from **NTSB** accident reports, we will be on a tenuous foundation for achieving "zero accidents." Yet, the next level of event on the pyramid is not mere random reporting of events by technicians. It is instead those errors that get onto aircraft resulting in some level of aircraft discrepancy that represent the next most critical class of error. These errors are more safety critical in that they have made their way onto a departing aircraft, and they are more critical to the cost conscious air carrier who will likely pay a delay or cancellation price for the error. These are also errors that today need little extra investigation. The technician who corrected to aircraft discrepancy has already investigated the event. What is missing in today's typical post event investigation is WHY the error occurred.

4. "Maintenance error investigation, analysis, and corrective action belongs inside the airline and repair station."

As part of this research, most of the interviewees were asked a basic question: where does maintenance error management belong? To answer this question, many of the interviewees were shown the graph below.

Maintenance Error Investigation, Analysis, and Corrective Action

Where does it belong?

None of the interviewees suggested that the **FAA** was the place for greater investigation and analysis of maintenance error. The Service Difficulty Reporting System is of course an option for additional data on human error causation; however, the ability of the data to be mis-used by the media and the general lack of resources within the FAA preclude it as the source of greater investigation or analysis of maintenance error. Even in the view of current and former FAA employees interviewed, the FAA does not have a great track record in making productive use of data reported to it. Rather, it is the FAA's partnership with air carriers and manufacturers that has provided the most benefit to the equipment side of aviation.

Interviewees did suggest that **ASRS**, the principal third party system in use today, is valuable in both its ability to gain "truthful" information and offer needed protection against the strict liability imposed by **FAR** 43.13. Notwithstanding the strength of ASRS, however, the nearly universal agreement of all interviewees was that error investigation, analysis, and corrective action belongs inside air carrier and repair station operations. The reasons are simple: it is where the problems lie and it is where the changes must occur. This is not to suggest that the **FAA** should completely turn over the reigns to the air carriers. Rather, it is to say that it is the FAA's job to set the standard, but it is the air carrier's job to put in place methods and tools to meet the standard.

5. "Human error management should not be a stand-alone function - but should be integrated into existing processes."

Human factors has many meanings for air carriers, manufacturers, and the **FAA**. To an aircraft designer, human factors may mean that he is supposed to design his component taking the human user into consideration. It may also mean that he is supposed to have a Ph.D. in human factors reviewing his work.

In most U.S. air carriers, human factors is viewed as a special project. A few carriers have hired human factors specialists, while others have assigned focal points for the job. Yet this should not imply that engineers, planners, and managers are not working human factors issues. Well before most maintenance professionals heard the term "human factors," engineering and maintenance professionals were working to improve the reliability of the human process. Required inspection items, Murphy-proofing, and fatigue reduction through better shift patterns were all concepts that existed before our knowledge of "human factors." The pertinent question here is "where does maintenance error investigation fit into the maintenance and engineering organization?"

Overwhelmingly, the response to this question was that human error investigation should be integrated into the quality assurance function of air carriers. Quality assurance organizations are already responsible for the overall effectiveness of the maintenance system; additionally, they are often well schooled in the methods and techniques of reliability analysis. It is only in the area of modern concepts of human error causation that the typical quality assurance organization falls short.

6. "Technician and ground crew use of ASRS should be increased."

ASRS holds a critical key to near term success of internal airline maintenance-error investigative systems. ASRS provides the technician and ground crew agent the ability to share data he would not otherwise share within his airline and also provides protection from **FAA** enforcement unavailable anywhere else. Because many inadvertent maintenance errors result in a violation of **FAR** 43.13, there must be an additional incentive for the technician to come forward to truthfully divulge his involvement in a mishap. One can hardly profess that errors are shaped by factors in the workplace and still hold a technician legally liable regardless of the circumstances of the error. In the near term, it is through ASRS that technicians may gain the protection needed to participate in internal airline event investigations without fear of unwarranted FAA enforcement action. As discussed later, this can largely be achieved by simply informing technicians of the ASRS incentives.

V. RECOMMENDATIONS TO THE FAA

One purpose of this report is to make recommendations on what the **FAA** can do to improve flight safety through facilitation and oversight of maintenance error investigation, analysis, and corrective action. The specific recommendations that follow are provided with a few very large caveats. It is imperative that whatever the FAA does, it does it in partnership with the air carriers and the labor unions. To that end, should the FAA decide to proceed with any of the recommendations below, it should first put the recommendations to industry critique. However, partnership does not mean taking a back seat. The FAA, especially over the last ten years, has taken a passive operational approach to maintenance human factors and maintenance error management. If the FAA is serious about zero accidents, or even an order of magnitude reduction in the accident rate, then it must consider a more assertive approach to fostering improved human error management. Significant reductions in maintenance error will not occur through the FAA's maintenance human factors research alone, but will only occur through the commitment of resources to make maintenance error management more than a mere special project within U.S. air carriers. It is not that the FAA should be telling air carriers how to best manage safety, but it is the FAA's role to move the U.S. air carrier industry toward more productive human error management processes.

1. A Maintenance Error Specialist

The **FAA** should create a full-time position for a Maintenance Error Specialist within its Flight Standards Service.

Within the **FAA**, human factors has largely been centered on the research efforts of the Office of Aviation Medicine. Within the Aircraft Maintenance Division of Flight Standards (AFS-300), the industry has been faced with a number of maintenance human factors focal points attempting to squeeze maintenance human factors into their already demanding jobs. As maintenance error begins to be a more critical element of safety management for U.S. carriers, the role of Flight Standards Service in facilitating air carrier maintenance error management efforts cannot be overlooked. Particularly in the area of post-mishap error investigation, it is Flight Standards and Chief Counsel's office that can set the tone for how maintenance error events shall be addressed in a new human-centered environment. The Maintenance Error Specialist would provide leadership to the human side of FAA analysis and surveillance initiatives (e.g., **FAR**s 121.373 and 135.431) as well as provide guidance on FAA maintenance human factors research initiatives. The Maintenance Error specialist would be responsible for promoting improved human error management techniques within air carriers and repair stations, would provide training and be a resource for maintenance inspectors in the field, and would work closely with Chief Counsel's office and the Office of Aviation Medicine to ensure that all maintenance-error related regulatory, enforcement, and research needs are uniformly addressed. Through this position, the FAA would project a clear philosophy toward maintenance error management.

2. A Clarified Vision

Flight Standards and **FAA** Chief Counsel's Office should prepare a clear and concise policy regarding post-mishap Investigation and corrective action processes.

Since the inception of the Aviation Safety Reporting System, the **FAA** has helped carriers facilitate improved event reporting, analysis, and corrective action. Today, systems like SPAS and GAIN are in development to help the FAA internally and the industry as a whole learn from the everyday mistakes of its certified airmen. Additionally, the FAA must begin to more actively assist air carriers with the implementation of internal air carrier event investigation systems. The Aviation Safety Action Program is an example of this work.

Nevertheless, it is important for the **FAA** to occasionally wear the hat of a certified technician. In **Appendix C**, a sample letter describes for the typical employee what the air carrier and the FAA could implement today to support improved error management. While it may be an uncomplimentary characterization of our approach to enforcement and discipline, the bottom line is that, the typical airman simply does not understand what the FAA is trying to say. For the benefit of the typical airman, there is no simple explanation of what he or she should do in response to their involvement in a mishap. Instead they are forced to work with a complex network of Advisory Circulars and regulations that simply tell technicians that they should be fearful of the FAA. To the technician, there can be little partnership until the FAA can clarify and articulate just what, in the interests of safety, it desires to see in the way of post-mishap investigation and corrective action.

A comparison can be made with the United Kingdom's Mandatory Occurrence Reporting Scheme (CAP382). By way of introduction to the program's information and guidance is this statement by the Chairman of the Civil Aviation Authority:

> "The Authority gives assurance that its primary concern is to secure free and uninhibited reporting and that it will not be its policy to institute proceedings in respect of unpremeditated or inadvertent breaches of the law which come to its attention only because they have been reported through the Scheme, except in cases involving dereliction of duty amounting to gross negligence.
>
> Where a reported occurrence indicated an unpremeditated or inadvertent lapse by an employee, the Authority would expect the employer to act responsibly and to share its view that free and full reporting is the primary aim, and that every effort should be made to avoid action that may inhibit reporting. The Authority will accordingly make it known to employers that, except to the extent that action is needed in order to ensure safety, and except in such flagrant circumstances as are described … above, it expects them to refrain from disciplinary or punitive action which might inhibit their staff from duly reporting incidents of which they may have knowledge."[16]

These words, as compared to the varied guidance of the **FAA**, represent a relatively clear and concise statement of policy. Also, the CAA has taken a leadership role by also providing guidance to air carriers within its regulatory control.

3. Human Error Causal Concepts Training

> All flight standards staff responsible for oversight of air carrier and repair station maintenance, including AFS-300 and all principal maintenance inspectors and their staff, should be provided human error causal concepts training.

The most important thing the **FAA** can do to promote maintenance human factors and formalized maintenance error management is to lead by example. The most obvious place to start is in the FAA's response to maintenance error events. Will the FAA now look beyond the fact that a technician erred, to WHY the technician erred? Will the FAA consider the balance between the needs of human factors investigation and individual accountability when it decides to take punitive action against an airman?

A very real problem today is that air carriers receive mixed messages from the **FAA** regarding maintenance human factors, particularly with regard to post-mishap investigation. Most FAA inspectors, if not most of us in the industry, understand the benefits of a "human-centered" or "human factors" approach. However, a "human-factors" philosophy does little to provide guidance on how human factors is to be integrated into the real-world operational setting. Does it mean that technicians are no longer accountable for their actions? Does it mean that FAA inspectors should be looking for and correcting Jim Reason's error-provoking "swamps?"

With the help of the Office of Aviation Medicine and Chief Counsel's office, the Maintenance Error Specialist would create a one-day course on maintenance error management. The training would include:

- An introduction to the science of human factors

- An introduction to maintenance error management systems and initiatives

- Detailed instruction on modern event investigation techniques, both from a human factors and a disciplinary/ enforcement perspective

- Introduction to, or review of, **FAA** policy regarding mishap investigation and corrective action.

Starting with AFS-300, the Maintenance Error Specialist would train **FAA** principal maintenance inspectors and their inspection staffs. A primary goal of this training would be to change long entrenched attitudes about why maintenance error occurs. The training would provide a balance between external causation and individual responsibility leading to the FAA's maintenance staff developing a more uniform and reasoned approach to human error management. The training would further provide the foundation necessary for implementation of the recommendations that follow.

4. Air Carrier Human Factors Investigation

FARs 121.373 and 135.431 should be re-interpreted, given industry understanding of human factors, to require more thorough causal investigation of maintenance errors that impact the conformity of dispatched aircraft and/or endanger safety of flight.

Virtually all **FAR**s are designed to promote people doing their job right the first time. It is FARs 121.373 and 135.431 that recognize that both equipment and humans will sometimes fail. Through FAR 121.373(a) and FAR 135.431(a), air carriers and repair stations working for air carriers, must have a system of continuing analysis and surveillance that monitors and takes corrective action in response to system deficiencies. FAR 121.373 is as follows:

§ 121.373 Continuing analysis and surveillance.

(a) 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.

(b) Whenever the Administrator finds that either or both of the programs described in paragraph (a) of this section does not contain adequate procedures and standards to meet the requirements of this part, the certificate holder shall, after notification by the Administrator, make any changes in those programs that are necessary to meet those requirements.

(c) A certificate holder may petition the Administrator to reconsider the notice to make a change in a program. The petition must be filed with the **FAA** Flight Standards District Office charged with the overall inspection of the certificate holder's operations within 30 days after the certificate holder receives the notice. Except in the case of an emergency requiring immediate action in the interest of safety, the filing of the petition stays the notice pending a decision by the Administrator.

(Note: **FAR** 135.431 is identical to this regulation.)

It is through these regulations that the **FAA** should require enhanced human error investigation. That is, air carriers should be required to adopt a human-centered perspective to the maintenance-error-related failures investigated under the 121.373 system. It is here that maintenance error has been under-served by investigations falling short in terms of human factors causal explanation. For example, where today an air carrier may stop an event investigation at the identification of a human error (e.g., engine in-flight shutdown caused by B-nut not torqued), through an enhanced 121.373 or 135.431 program, the air carrier would be required to investigate WHY the human error occurred.

It is important to recognize that not all equipment failures and not all human errors within an air carrier's operation are currently investigated or analyzed under 121.373. Nor does this recommendation suggest that all human errors in an engineering and maintenance organization be subject to formal human factors investigation. Rather, in conjunction with the **FAA** maintenance inspectors from the air carrier's certificate managing office and guidance from the Maintenance Error Specialist, the carrier would recommend what class(es) of maintenance error would receive enhanced human factors investigation through its continuing analysis and surveillance system. Statistics provided earlier show that errors reflected in mechanical dispatch reliability (i.e., those impacting airworthiness) are on the order of 7 per aircraft per year. This would likely be the outer limit of the FAA requirement.

Recognizing that nearly all of these events might technically involve **FAR** violations, air carriers and repair stations should be encouraged to have each technician under investigation avail himself of the protection afforded by the Aviation Safety Reporting System (ASRS). ASRS would gain valuable information that could be used at the national level, and carriers could rest assured that their technicians would not be subject to strict liability enforcement action resulting from their participation in an event investigation.

Further, in recognition that human error causal data makes for sensational headlines, the data collected via a 121.373 or 135.431 program would remain the property of the air carrier and would only be viewed by the **FAA** Certificate Managing Office for the purposes of regulatory safety oversight. This level of review would be adequate for the FAA's oversight function and yet would bypass many of the data-sharing concerns of internal FAA databases.

Should an air carrier and **FAA** Certificate Managing Office so decide, it could use the current Aviation Safety Action Program Advisory Circular (120-66) as the basis for such a continuing analysis and surveillance program. However, it should be noted that no re-regulation is required for this or the following re-interpretation of **FAR**s 121.373 and 135,431. Rather, through paragraph (b) of FAR 121.373, the FAA would merely announce its recognition that today's continuing surveillance and analysis programs are inadequate to meet the challenge of the industry's accident reduction goals.

5. Air Carrier Human Factors Analysis

> **FAR**s 121.373 and 135.431 should be reinterpreted, given industry understanding of human factors, to require statistical monitoring and corrective action of systemic contributors to maintenance error.

In addition to requiring improved causal investigation of maintenance error, air carriers should adopt methods to track both the contributors to error and the prevention strategies used to manage these errors. Such a system for monitoring human error and its contributors would closely parallel today's system of mechanical reliability. For example, a carrier may find that poor shift turnover is the most often occurring contributor to maintenance-error related aircraft discrepancies. Through its continuing analysis and surveillance system, an air carrier would be in a position to develop and track the effectiveness of its prevention strategies for shift-turnover errors. Adoption of this recommendation would ensure that the underlying systemic contributors to error, rather than the events themselves, are the primary focus of an air carrier's maintenance error management program.

It should be noted that neither of these recommendations relating to 121.373 and 135.431 systems requires the use of any particular error investigation system reviewed in this report. Rather, each carrier must have a basic understanding of human factors and an agreed upon set of causal explanations that will now be allowed within the context of error investigation. That is, if we are willing to say that the technician himself is not the probable cause of the event, then what will be allowed as the causal explanation for a human error event? The climate created by the CEO, the technician's poor upbringing, or a more narrowly defined class of possible explanations? Once this has been resolved, the typical U.S. air carrier's engineering and reliability group has more than enough skill, in this author's opinion, to integrate human error causation into their existing reliability programs.

6. Disciplinary and Enforcement Research

> Flight Standards and Chief Counsel's office should co-sponsor research to better understand the effects of air carrier disciplinary systems and **FAA** enforcement policies upon human error reporting, investigation, and overall system safety.

The subject of discipline has unfortunately been left to rhetorical debate, rather than scientific method or analysis. It is time that Flight Standards and **FAA** attorneys explore the nature of discipline and enforcement through structured research. Professor Jim Reason of Manchester University has said that to have a safety culture, you must have a reporting culture, and to have a reporting culture you must have a just culture. Just what constitutes a "just culture", however, has been largely left to unscientific debate. That is, when does a person's mistake move from mere human error into more culpable, blameworthy behavior? The author of this report is currently researching the issues surrounding discipline in cooperation with a number of U.S. air carriers, labor unions, and FAA Flight Standards. (FAA Chief Counsel's Office opted not to participate.) Preliminary results of this research indicate that:

1) people have more similar attitudes toward discipline than the rhetoric suggests, and

2) accountability and discipline definitely have their place in the world of human error management.

Nevertheless, the **FAA** should conduct its own disciplinary research so that the debate regarding the role of discipline continues to grow more analytical and empirical, and less emotional and philosophical. To establish a safety culture, air carrier disciplinary and FAA enforcement standards must be developed that will be understandable to the workforce and facilitate human factors investigation, yet still preserve and foster individual responsibility. The **ASRS** immunity provisions will work for now; however, as the issue of discipline becomes more data-driven, more effective and easily understood disciplinary designs could be developed for use by both the FAA and air carriers.

7. Data-Driven Human Factors Research

> With regard to maintenance human factors research and any further regulation of maintenance human factors initiatives, Flight Standards should prioritize its efforts based primarily upon safety-related concerns identified through **FAR** 121.373 and FAR 135.431 systems.

Given the distinction between "human factors" and "maintenance error" discussed earlier, is recognized that the **FAA** maintenance research program may have many priorities that extend well beyond the reduction of aircraft accidents caused by maintenance error.

Nevertheless, Flight Standards priority is flight safety. Through the continuing analysis and surveillance of 121.373 and 135.431 programs, air carriers will have a wealth of data on how often particular factors contribute to error. From a Flight Standards safety perspective, it is this data that should drive a large part of the **FAA** maintenance human factors research dollars.

Again, this recommendation is not designed to change the current focus of the **FAA**'s maintenance human factors research program, but only that Flight Standards itself establish its priorities for accident reduction through the data collected and air carrier experience with 121.373 and 135.431 programs.

8. ASRS Reporting

> For those errors being investigated through an air carrier's 121-373 or 135.431 continuing analysis and surveillance program, The Aviation Safety Reporting System Advisory Circular 00-46D should be amended to change the 10 day reporting requirement to begin upon "discovery" of the **FAR** violation.
>
> Flight Standards Service should encourage further use of ASRS by maintenance technicians, specifically including those errors first discovered by someone other than the erring technician.

ASRS provides two benefits to aviation safety. The first is the data on the *frequency* of particular **FAR** violations. This data, especially in the flight operations realm, is hard to gain except through voluntary reporting such as in ASRS. The second benefit of ASRS, and perhaps its most significant benefit for maintenance error reduction, is that ASRS provides additional data on *why* errors occur. This data, especially when used as a supplement to the much more statistically valid data of a 121.373 or 135.431 program, will provide information as to why certain events occur that might not be so forthcoming through an internal air carrier reporting or investigation program. Yet, the current ASRS Advisory Circular requires that the airman report his violation to ASRS within 10 days of the actual violation in order for the airman to receive the enforcement-related incentive of ASRS. It is this 10-day reporting period that is a barrier to reporting many maintenance errors. In particular, it is a potential barrier to the maintenance errors that most endanger flight safety (i.e., those that get onto an aircraft without the knowledge of the erring individual). In many cases, the technician will simply not know of his own error until after the 10 day reporting period has lapsed. Understandably, the technician will be reluctant to divulge what he knows if the underlying event does not come to his attention until after the 10 day window of opportunity. For this reason, the ASRS provisions should be modified to allow reporting to ASRS within a 10-day window *after* the airman's discovery of his FAR violation.

One potential problem associated with expanding the 10-day window to discovery of the violation is that technicians may hide their errors until discovered by someone else. For this reason, the discovery rule should be tied to the implementation of enhanced 121.373 and 135.431 systems. In this regard, only errors unknown to the technician, until discovery, would be allowed protection. Aircraft discrepancies caused by technician error and knowingly dispatched with the aircraft would be excluded through the "inadvertent and not deliberate" exception to the **ASRS** immunity provisions.

VI. CONCLUSION

Maintenance human factors in some respects has unfortunately become the flavor of the month in safety management ideas. There are many **FAA**, air carrier, and airframe manufacturer personnel wondering how to fill the maintenance human factors box in what they do. They wonder how this new philosophy of human factors is to be integrated into their individual jobs. What has been missing in maintenance human factors efforts over the past 10 years is a proper definition of the problem. In regard to safety, this is where the FAA must take the lead.

We have become stymied by our efforts to quantify accident reduction because maintenance-related accidents already occur at an extremely low frequency and because maintenance and maintenance error are so complex that is it nearly impossible to tie individual prevention strategies to an overall reduction in accidents. Yet, accidents like Aloha and Continental Express demonstrate that the potential for maintenance error is alive and well in U.S. air carrier operations.

The problem today is one of the chicken and the egg. Maintenance error cannot be quantifiably managed unless the culture and systems are put in place to collect the data from which productive and quantifiable prevention strategies will spring. Yet error management systems will not be put in place until business managers can be convinced of the savings.

The systems reviewed in this report are far enough along in their evolution that little further development is needed. That is, the problem is not one of technology, but one of process and commitment. Every year in the U.S., roughly 48,800 commercial aircraft are dispatched in a technically unairworthy condition, with discrepancies caused by maintenance error. It is this population of data, if properly investigated and analyzed, that can provide the basis for quantifiable maintenance error management programs. It is these events that will lead to the precursors of, and prevention of, the future Aloha and Continental Express accidents.

The real question is where does industry want to be? On the one hand, U.S. commercial aviation is already one of the safest forms of transportation. On the other hand, if industry wants to achieve zero accidents, improved maintenance error management must be a part of the solution. The recommendations in this report provide the first steps toward broad-scale, quantifiable, and scientific management of maintenance error.

APPENDIX

Appendix A - The MEDA Investigation Form

Maintenance Error Decision Aid
Results Form

Section I -- General

Reference #: ___ ___ ___ ___ ___	Analyst Name ________________
Airline: ________________	Analyst Telephone #: (___) ___-____
Station of Error: ________________	Date of Investigation: __/__/__
Aircraft Type: ________________	Date of Event: __/__/__
Engine Type: ________________	Time of Event: __:__ am pm
Reg. #: ___ ___ ___ ___ ___ ___ ___	Shift of Error (circle): 1st 2nd 3rd
Fleet Number: ___ ___ ___ ___ ___ ___	Type of Maintenance (Circle):
ATA #: ___ ___ ___ ___	1. Line--IF Line, what type? ________
Aircraft Zone: ________________	2. Base--IF Base, what type? ________
Ref. # of previous related event: ___ ___ ___ ___ ___	Date Changes Implemented: __/__/__

Section II -- Event

A. Please check the Event

( ) Flight Delay (write in length) __ days __ hrs. __ min.	( ) Aircraft Damage
( ) Flight Cancellation	( ) Injury
( ) Gate Return	( ) Diversion
( ) In-Flight Shut Down	( ) Rework
( ) Air Turn-Back	( ) Other (explain below)

Describe the incident/degradation/failure (e.g., could not pressurize) that caused the event.

Section III -- Maintenance Error

A. Please check the type of maintenance error (check only one):

1. Improper Installation
( ) a. Required equipment not installed
( ) b. Wrong equipment/part installed
( ) c. Wrong orientation
( ) d. Improper location
( ) e. Incomplete Installation
( ) f. Extra parts installed
( ) g. Access panel not closed

( ) **3. Improper/Incomplete Repair** (explain below)

4. Improper Fault Isolation/ Inspection/Testing
( ) a. Degradation not found
( ) b. Access panel not close
( ) c. System or equipment not deactivated/reactivated
( ) d. Not properly tested

6. Actions Causing Equipment Damage
( ) a. Equipment used improperly
( ) b. Defective equipment used
( ) c. Struck by/against
( ) d. Other (explain below)

7. Actions Causing Personal Injury
( ) a. Muscle strain

installed
( ) c. Wrong orientation
( ) d. Improper location
( ) e. Incomplete Installation
( ) f. Extra parts installed
( ) g. Access panel not closed
( ) h. System/equipment not reactivated/deactivated
( ) i. Damaged
( ) j. Other (explain below)

2. Improper Servicing
( ) a. Insufficient fluid
( ) b. Too much fluid
( ) c. Wrong fluid type
( ) d. Required servicing not performed
( ) e. Other (explain below)

Inspection/Testing
( ) a. Degradation not found
( ) b. Access panel not close
( ) c. System or equipment not deactivated/reactivated
( ) d. Not properly tested
( ) e. Fault not properly isolated
( ) f. Not properly inspected
( ) g. Other (explain below)

5. Actions Causing Foreign Object Damage
( ) a. Material left in airplane/engine
( ) b. Debris on ramp
( ) c. Debris falling into open systems
( ) d. Other (explain below)

( ) c. Struck by/against
( ) d. Other (explain below)

7. Actions Causing Personal Injury
( ) a. Muscle strain
( ) b. Hazard contacted
( ) c. Slip/Trip/Fall
( ) d. Hazardous substance exposure
( ) e. Improper use of personal protective equipment
( ) f. Caught in/on/between
( ) g. Other (explain below)

8. Other (explain below)

Describe the specific maintenance error (e.g., auto pressure controller installed in wrong location).

Section IV -- Contributing Factors Checklist

N/A __

A. Information (e.g., work cards, procedures, maintenance manuals, service bulletins, maintenance tips, non-routines, IPC, etc.)

__ 1. Not understandable
__ 2. Unavailable/Inaccessible
__ 3. Incorrect
__ 4. Too much/conflicting information
__ 5. Update process is too long/complicated
__ 6. Incorrectly modifying manufacturer's MM/SB
__ 7. Information not used
__ 8. Other (explain below)

Describe specifically how the checked <u>information</u> contributed to the error.

N/A __

B. Equipment/Tools/Parts

__ 1. Unsafe
__ 2. Inaccessible
__ 3. Unreliable
__ 4. Poor layout of controls or displays
__ 5. Mis-calibrated
__ 6. Unavailable
__ 7. Inappropriate for the task
__ 8. Can't use in intended environment
__ 9. No instructions
__ 10. Too complicated
__ 11. Incorrectly labeled
__ 12. Not used
__ 13. Other (explain below)

Describe specifically how the checked <u>equipment/tool/part</u> contributed to the error.

N/A __

C. Airplane design/configuration

__ 1. Complex
__ 2. Inaccessible
__ 3. Not user friendly
__ 4. Configuration variability between models/airplanes
__ 5. Other (explain below)

Describe specifically how the checked <u>airplane design/configuration</u> contributed to error.

N/A __

D. Job/Task

__ 1. Repetitive/monotonous
__ 2. Complex/confusing
__ 3. New task or task change
__ 4. Boredom/complacency
__ 5. Technician's inadequate planning/prioritization of tasks
__ 6. Different from other similar tasks
__ 7. Other (explain below)

N/A __

D. Job/Task

__ 1. Repetitive/monotonous
__ 2. Complex/confusing
__ 3. New task or task change
__ 4. Boredom/complacency
__ 5. Technician's inadequate planning/prioritization of tasks
__ 6. Different from other similar tasks
__ 7. Other (explain below)

Describe specifically how the checked job/task contributed to the error.

N/A __

E. Technical Knowledge/Skills

__ 1. Inadequate skills
__ 2. Inadequate task knowledge
__ 3. Inadequate airline process knowledge
__ 4. Inadequate airplane system knowledge
__ 5. Other (explain below)

Describe specifically how the checked technical knowledge/skills contributed to the error.

N/A __

F. Factors Affecting Individual Performance.

__ 1. Physical health (including hearing and sight)
__ 2. Fatigue
__ 3. Time constraints
__ 4. Peer pressure
__ 5. Body size/strength
__ 6. Personal event (e.g., family problem, car accident)
__ 7. Workplace distractions/interruptions during task performance
__ 8. Other (explain below)

Describe specifically how the checked factors affecting individual performance contributed to the error.

N/A __

G. Environment/Facilities

__ 1. High noise levels
__ 2. Hot
__ 3. Cold
__ 4. Humidity
__ 5. Rain
__ 6. Snow
__ 7. Lighting
__ 8. Wind
__ 9. Vibrations
__ 10. Cleanliness
__ 11. Hazardous/toxic substances
__ 12. Power sources
__ 13. Inadequate ventilation
__ 14. Other (explain below)

Describe specifically how the checked environment/facilities contributed to the error.

N/A __

H. Organizational Environment Issues

__ 1. Quality of support from technical organizations (e.g., engineering, planning, technical pubs)
__ 2. Company policies/work processes
__ 3. Unions
__ 4. Unstable work force
__ 5. Other (explain below)

Describe specifically how the checked organizational environment issues contributed to the error.

N/A __

I. Leadership/Supervision

__ 1. Poor planning/organization of tasks
__ 2. Inadequate prioritization of work
__ 3. Inadequate delegation/assignment of task
__ 4. Unrealistic attitude/expectations
__ 5. Excessive supervision
__ 6. Other (explain below)

Describe specifically how the checked leadership/supervision contributed to the error.

N/A __

J. Communication Issues

__ 1. Between departments
__ 2. Between people
__ 3. Between shifts
__ 4. Between crew and lead
__ 5. Between lead and management
__ 6. Other (explain below)

N/A __ **J. Communication Issues**

__ 1. Between departments
__ 2. Between people
__ 3. Between shifts
__ 4. Between crew and lead
__ 5. Between lead and management
__ 6. Other (explain below)

Describe specifically how the checked communication issues contributed to the error.

N/A __ **K. Other Issues (explain below)**

Describe specifically how this other issue contributed to the error.

Section V – Error Prevention Strategies

A. What current existing procedures, processes, and/or policies in your organization are intended to prevent the incident, but didn't?

( ) **Maintenance Policies or Processes** (specify) ____________________

( ) **Inspection or Functional Check** (specify) ____________________

Required Maintenance Documentation

( ) Maintenance manuals (specify) ____________________
( ) Logbooks (specify) ____________________
( ) Work cards (specify) ____________________
( ) Engineering documents (specify) ____________________
( ) Other (specify) ____________________

Supporting Documentation

( ) Service Bulletins (specify) ____________________
( ) Training materials (specify) ____________________
( ) All-operator letters (specify) ____________________
( ) Inter-company bulletins (specify) ____________________
( ) Other (specify) ____________________

( ) **Other** (specify) ____________________

B. List recommendations for error prevention strategies.

MEDA Results Form Rev. e 4 7/10/97

Appendix B - The ASRS Reporting Form

IDENTIFICATION STRIP: *Please fill in all blanks to ensure return of strip. NO RECORD WILL BE KEPT OF YOUR IDENTITY.*
This section will be returned to you.

(SPACE BELOW RESERVED FOR ASRS DATE/TIME STAMP)

TELEPHONE NUMBERS where we may reach you for further details of this occurrence:

HOME Area ______ No. ________ - __________ Hours _____

WORK Area ______ No. ________ - __________ Hours _____

NAME ______________________________

ADDRESS/PO BOX ______________________________

____

CITY ______________ **STATE** ____ **ZIP** ________

TYPE OF EVENT/SITUATION ____________

____

DATE OF OCCURRENCE ____________

LOCAL TIME (24 hr. clock) ____________

DO NOT REPORT AIRCRAFT ACCIDENTS AND CRIMINAL ACTIVITIES ON THIS FORM.
ACCIDENTS AND CRIMINAL ACTIVITIES ARE NOT INCLUDED IN THE ASRS PROGRAM AND SHOULD NOT BE SUBMITTED TO NASA.
ALL IDENTITIES CONTAINED IN THIS REPORT WILL BE REMOVED TO ASSURE COMPLETE REPORTER ANONYMITY.

PLEASE FILL IN APPROPRIATE SPACES AND CHECK ALL ITEMS WHICH APPLY TO THIS EVENT OR SITUATION

EXPERIENCE

Describe your qualifications: ○ A & P ○ A ○ P ○ repairman ○ inspection authority ○ FCC other ____________

What is your technician/maintenance experience in years? lead technician ________ technician ________ repairman ________ avionics ________ other ______________________

FACTORS

Location ______________________________

Was training a factor? ○ yes ○ no ○ I was instructing ○ I was receiving training

What other factors may have contributed? ○ lighting ○ weather ○ work cards ○ manuals ○ briefing ○ other_______

Check items which were involved in the event:

inspection	○ yes	○ no	installation	○ yes	○ no
testing	○ yes	○ no	scheduled maintenance	○ yes	○ no
repair	○ yes	○ no	MEL	○ yes	○ no
logbook entry	○ yes	○ no	* other ____________		
fault isolation	○ yes	○ No			

("Describe in the "Describe Event/Situation" sector)

FIRST FOLD

Component/System/Subsystem involved: ______________________________

Was maintenance deferred? ○ yes ○ no

When was problem detected? ○ routine inspection ○ in-flight ○ taxi ○ while aircraft was in service at gate ○ pre-flight ○ other_______

CONSEQUENCES/OUTCOME

○ flight delay ○ flight cancellation ○ gate return ○ in-flight shut down ○ aircraft damage ○ rework ○ improper service ○ air turn back ○ other_______

AIRCRAFT/AIRWORTHINESS STATUS

- ○ aircraft released for service
- ○ aircraft records completed
- ○ aircraft required documents aboard
- ○ not released for service
- ○ unknown

MISSION

- ○ passenger
- ○ cargo
- ○ business
- ○ training
- ○ pleasure
- ○ other_______

OPERATOR

(Check all that apply)

- ○ air carrier
- ○ commuter
- ○ corporate
- ○ air-taxi
- ○ charter
- ○ FBO
- ○ flight school
- ○ government
- ○ military
- ○ part 121
- ○ part 135
- ○ repair station
- ○ self employed
- ○ other_______

TYPE OF AIRCRAFT (MAKE/MODEL) AND ENGINE TYPE

type of aircraft __________ series __________ ATA Code __________

aircraft zone __________ engine model __________ other __________

DESCRIBE EVENT/SITUATION

Keeping in mind the topics shown below, discuss those which you feel are relevant and anything else you think is important. Include what you believe really caused the problem, and what can be done to prevent a recurrence, or correct the situation. (CONTINUE ON THE OTHER SIDE AND USE ADDITIONAL PAPER IF NEEDED)

Keeping in mind the topics shown below, discuss those which you feel are relevant and anything else you think is important. Include what you believe really caused the problem, and what can be done to prevent a recurrence, or correct the situation. (CONTINUE ON THE OTHER SIDE AND USE ADDITIONAL PAPER IF NEEDED)

CHAIN OF EVENTS	HUMAN PERFORMANCE CONSIDERATIONS
- How the problem arose - How it was discovered - Contributing factors - Corrective actions	- Perceptions, judgments, decisions - Actions or inactions - Factors affecting the quality of human performance

NASA ARC #277D

MAINTENANCE

Rev Date: 08/1/96

National Aeronautics and Space Administration

Ames Research Center
Mail Stop 262-4
Moffett Field, CA 94035-1000

Official Business
Penalty for Private Use $300

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 12028 WASHINGTON, D.C.

POSTAGE WILL BE PAID BY NASA

NASA AVIATION SAFETY REPORTING SYSTEM
PO BOX 189
MOFFETT FIELD CA 94035-9800

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AVIATION SAFETY REPORTING SYSTEM

NASA has established an Aviation Safety Reporting System (ASRS) to identify issues in the aviation system which need to be addressed. The program of which this system is a part is described in detail in FAA Advisory Circular 00-46D. Your assistance in informing us about such issues is essential to the success of the program. Please fill out this postage free form as completely as possible, fold it and send it directly to us.

The information you provide on the identity strip will be used only if NASA determines that it is necessary to contact you for further information. THIS IDENTITY STRIP WILL BE RETURNED DIRECTLY TO YOU. The return of the identity strip assures your anonymity.

Section 91.25 of the Federal Aviation Regulations (14 CFR 91.25) prohibits reports filed with NASA from being used for FAA enforcement purposes. This report will not be made available to the FAA for civil penalty or certificate actions for violations of the Federal Air Regulations. Your identity strip, stamped by NASA, is proof that you have submitted a report to the Aviation Safety Reporting System. We can only return the strip to you, however, if you have provided a mailing address. Equally important, we can often obtain additional useful information if our safety analysts can talk with you directly by telephone. For this reason, we have requested telephone numbers where we may reach you.

Thank you for your contribution to aviation safety.

NOTE: AIRCRAFT ACCIDENTS SHOULD NOT BE REPORTED ON THIS FORM. SUCH EVENTS SHOULD BE FILED WITH THE NATIONAL TRANSPORTATION SAFETY BOARD AS REQUIRED BY NTSB Regulation 830.5 (49CFR830.5).

DESCRIBE EVENT/SITUATION (continued):

SECOND FOLD

SECOND FOLD

Appendix C - Sample Letter to Employees - Enforcement Related Incentives

June 1, 1997

To: All ABC Airlines Employees
Subject: Maintenance Error Event Investigation

As you are aware, our organization has adopted a new method for the investigation of maintenance mishaps. (By mishap, we mean an error by an employee or employees that jeopardizes aircraft airworthiness or causes economic harm unacceptable to the organization.)

This new investigation system will not work without your full participation. It is recognized that previously the threat of punitive action associated with mishap investigations has led to distrust and a breakdown of communication within our organization. To address this concern, our carrier, labor union, and the FAA have worked together to provide a set performance-related incentives that will make mishap investigation less punitive and more of a learning experience for the organization. To acquaint yourself with the new process, the salient features of these programs are described below:

Our New Air Carrier Disciplinary Policy

It is ABC Airline's primary concern in the interests of safety to ensure the full, free and uninhibited reporting of all incidents that affect flight safety, including all ground damage incidents, however minor. It is therefore, the responsibility of every ABC employee to report any circumstances of aircraft ground damage affecting flight safety and to co-operate fully throughout the investigation.
It is not normally the policy of ABC to institute disciplinary proceedings in response to the reporting of any incident of aircraft damage. Only in the rare circumstances where an employee has taken action or risks which, in the Company's opinion, no reasonably prudent employee with his/her training and experience would have taken, will ABC consider initiating such disciplinary action. The fact that the employee has co-operated fully throughout any investigation will weigh in his/her favor in the Company's consideration of the matter. However, in the event of an employee failing to report a mishap that they have caused or discovered, they will be exposed to full disciplinary action.

The NASA Aviation Safety Reporting System

Through an FAA-sponsored program called the Aviation Safety Reporting System, you can report your involvement in a mishap directly to NASA. The filing of a report with NASA concerning an incident or occurrence involving a violation of the Act or the Federal Aviation Regulations is considered by the FAA to be indicative of a constructive attitude. Such an attitude will tend to prevent future violations. Accordingly, although a finding of a violation may be made, neither a civil penalty nor certificate suspension will be imposed if:

(1) The violation was inadvertent and not deliberate;
(2) The violation did not involve a criminal offense, or accident, or action under section 609 of the Act which discloses a lack of qualification or competency, which are wholly excluded from this policy;
(3) The person has not been found in any prior FAA enforcement action to have committed a violation of the Federal Aviation Act, or of any regulation promulgated under that Act for a period of 5 years prior to the date of the occurrence; and

The person proves that, within 10 days after the violation, he or she completed and delivered or mailed a written report of the incident or occurrence to NASA under ASRS.

the Federal Aviation Act, or of any regulation promulgated under that Act for a period of 5 years prior to the date of the occurrence; and

The person proves that, within 10 days after the violation, he or she completed and delivered or mailed a written report of the incident or occurrence to NASA under ASRS.

Voluntary Self Disclosure

Should you be involved in a mishap where, in addition to yourself, the organization may be at risk of FAA enforcement action, we may choose to submit a voluntary self disclosure with the FAA. The FAA believes that the open sharing of apparent violations and a cooperative as well as an advisory approach to solving problems will enhance and promote aviation safety. Certificate holders will receive a letter of correction in lieu of civil penalty action for instances of noncompliance that are voluntarily disclosed to the FAA in accordance with the procedures set forth in this AC. Once the letter of correction is issued, the case will be considered closed unless the agreed upon comprehensive fix is not satisfactorily completed by the certificate holder.

a. In evaluating enforcement action for a certificate holder's actual or apparent failure to comply with FAA regulations, the FAA will ensure that the following five conditions are met:

(1) The certificate holder immediately notified the FAA of the apparent violation after detecting it and before the agency learned of it.

(2) The apparent violation must have been inadvertent.

(3) The apparent violation does not indicate a lack, or reasonable question, of basic qualification of the certificate holder.

(4) Immediate action must have been taken, or begun to have been taken, upon discovery to terminate the conduct that resulted in the apparent violation.

(5) The certificate holder must develop and implement a comprehensive fix satisfactory to the FAA.

Ordinarily, the FAA will not forego legal enforcement action if the certificate holder informs the FAA of the apparent violation during routine FAA investigations/inspections, or in association with accidents and incidents.

Aviation Safety Action Program

In addition to the options of ASRS and Voluntary Self Disclosure, our carrier has formed a partnership with the FAA and your labor union. Within this partnership, you are encouraged to come forward to our new event review committee. If you do report your mishap to the ASAP event review committee, administrative action may be taken in lieu of legal enforcement when all of the following elements are present:

1) Applicable law does not require legal enforcement action.
2) Lack of qualification or competency was not involved.
3) The violation was inadvertent and not deliberate.
4) The violation was not the result of a substantial disregard for safety or security and the circumstances of the violation are not aggravated.
5) The alleged violator has a constructive attitude toward complying with the regulations.
6) The alleged violator has not been involved previously in similar violations.
7) After consideration of items (1-6), a determination is made that administrative action will serve as an adequate deterrent.

Substantial disregard means:

a) In the case of a certificate holder, the act or failure to act was a substantial deviation from the degree of care, judgment, and responsibility normally expected of a person holding a certificate with that type, quality, and level of experience, knowledge, and proficiency.
b) In case the violator is not a certificate holder, the act or failure to act was a substantial deviation for the degree of care and diligence expected of a reasonable person in those circumstances.

Please note that this new disciplinary standard and process apply only to event investigations. Discipline associated with everyday administrative issues (e.g., tardiness, insubordination) will be administered by management through existing processes.

We are confident that these new disciplinary standards and processes applied to mishap investigations will allow us to improve communication throughout our organization and ultimately make changes in your environment that will improve safety and reduce the economic burden of maintenance mishaps.

Sincerely,

allow us to improve communication throughout our organization and ultimately make changes in your environment that will improve safety and reduce the economic burden of maintenance mishaps.

Sincerely,

Company President

Appendix D - ASRS Advisory Circular

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject:	**AVIATION SAFETY REPORTING PROGRAM**	**Date:** May 15, 1996 **Initiated by:** ASY-300	**AC No:** 00-46D **Change:**

1. PURPOSE.

This circular describes the Federal Aviation Administration (FAA) Aviation Safety Reporting Program (ASRP) which utilizes the National Aeronautics and Space Administration (NASA) as a third party to receive Aviation Safety Reports. This cooperative safety reporting program invites pilots, controllers, flight attendants, maintenance personnel, and other users of the National Airspace System (NAS), or any other person, to report to NASA actual or potential discrepancies and deficiencies involving the safety of aviation operations. The operations covered by the program include departure, en route, approach, and landing operations and procedures, air traffic control procedures and equipment, crew and air traffic control communications, aircraft cabin operations, aircraft movement on the airport, near midair collisions, aircraft maintenance and recordkeeping, and airport conditions or services. The effectiveness of this program in improving safety depends on the free, unrestricted flow of information from the users of the NAS. Based on information obtained from this program, FAA will take corrective action as necessary to remedy defects or deficiencies in the NAS. The reports may also provide data for improving the current system and planning for a future system.

2. CANCELLATION.

Advisory Circular 00-46C dated February 4, 1985, is canceled.

3. BACKGROUND.

a. The primary mission of the FAA is to promote aviation safety. To further this mission, the FAA instituted a voluntary ASRP on April 30, 1975, designed to encourage the identification and reporting of deficiencies and discrepancies in the system.

b. The FAA determined that the ASRP effectiveness would be greatly enhanced if the receipt, processing, and analysis of raw data were accomplished by NASA rather than by the FAA. This would ensure the anonymity of the reporter and of all parties involved in a reported occurrence or incident and, consequently, increase the flow of information necessary for the effective evaluation of the safety and efficiency of the system. Accordingly, NASA designed and administers the Aviation Safety Reporting System (ASRS) to perform these functions in accordance with a Memorandum of Agreement (MOA) executed by the FAA and NASA on August 15, 1975, as modified September 30, 1983, and August 13, 1987. Current ASRS operations are conducted in accordance with an MOA executed by FAA and NASA on January 14, 1994.

System (ASRS) to perform these functions in accordance with a Memorandum of Agreement (MOA) executed by the FAA and NASA on August 15, 1975, as modified September 30, 1983, and August 13, 1987. Current ASRS operations are conducted in accordance with an MOA executed by FAA and NASA on January 14, 1994.

4. NASA RESPONSIBILITIES.

a. NASA ASRS provides for the receipt, analysis, and de-identification of aviation safety reports; in addition, periodic reports of findings obtained through the reporting program are published and distributed to the public, the aviation community, and the FAA.

b. A NASA ASRS Advisory Subcommittee, composed of representatives from the aviation community, including the Department of Defense, NASA, and FAA, advises NASA on the conduct of the ASRS. The subcommittee conducts periodic meetings to evaluate and ensure the effectiveness of the reporting system.

5. PROHIBITION AGAINST THE USE OF REPORTS FOR ENFORCEMENT PURPOSES.

a. Section 91.25 of the Federal Aviation Regulations (FAR) (14 CFR 91.25) prohibits the use of any reports submitted to NASA under the ASRS (or information derived therefrom) in any disciplinary action, except information concerning criminal offenses or accidents which are covered under paragraphs 7a(1) and 7a(2).

b. When violation of the FAR comes to the attention of the FAA from a source other than a report filed with NASA under the ASRS, appropriate action will be taken. See paragraph 9.

c. The NASA ASRS security system is designed and operated by NASA to ensure confidentiality and anonymity of the reporter and all other parties involved in a reported occurrence or incident. The FAA will not seek, and NASA will not release or make available to the FAA, any report filed with NASA under the ASRS or any other information that might reveal the identity of any party involved in an occurrence or incident reported under the ASRS. There has been no breach of confidentiality in more than 20 years of the ASRS under NASA management.

6. REPORTING PROCEDURES.

Forms in the NASA ARC 277 series have been prepared specifically for intended users (including ARC 277 A for air traffic use and 277B for flight crew use) and are preaddressed and postage free. Completed forms or a narrative report should be completed and mailed only to ASRS at NASA, Aviation Safety Reporting System, P.O. Box 189, Moffett Field, CA 94035-9800.

7. PROCESSING OF REPORTS.

a. NASA procedures for processing Aviation Safety Reports ensure that the reports are initially screened for :

(1) Information concerning criminal offenses, which will be referred promptly to the Department of Justice and the FAA;

(2) information concerning accidents, which will be referred promptly to the National Transportation Safety Board (NTSB) and the FAA; and

Note: Reports discussing criminal activities or accidents are not de-identified prior to their referral to the agencies outlined above.

(3) time-critical information which, after de-identification, will be promptly referred to the FAA and other interested parties.

b. Each Aviation Safety Report has a tear-off portion which contains the information that identifies the person submitting the report. This tear-off portion will be removed by NASA, timestamped, and returned to the reporter as a receipt. This will provide the reporter with proof that he/she filed a report on a specific incident or occurrence. The identification strip section of the ASRS report form provides NASA program personnel with the means by which the reporter can be contacted in case additional information is sought in order to understand more completely the report's content. Except in the case of reports describing accidents or criminal activities, no copy of an ASRS form's identification strip is created or returned to the reporter as a receipt. This will provide the reporter with proof that he/she filed a report on a specific incident or occurrence. The identification strip section of the ASRS report form provides NASA program personnel with the means by which the reporter can be contacted in case additional information is sought in order to understand more completely the report's content. Except in the case of reports describing accidents or criminal activities, no copy of an ASRS form's identification strip is created or

retained for ASRS files. Prompt return of identification strips is a primary element of the ASRS program's report de-identification process and ensures the reporter's anonymity.

8. DE-IDENTIFICATION.

All information that might assist in or establish the identification of persons filing ASRS reports and parties named in those reports will be deleted, except for reports covered under paragraphs 7a(1) and 7a(2). This de-identification will be accomplished normally within 72 hours after NASA's receipt of the reports, if no further information is requested from the reporter.

9. ENFORCEMENT POLICY.

a. The Administrator of the FAA will perform his/her responsibility under Title 49, United States Code, Subtitle VII, and enforce the statute and the FAR in a manner that will reduce or eliminate the possibility of, or recurrence of, aircraft accidents. The FAA enforcement procedures are set forth in Part 13 of the FAR (14 CFR Part 13) and FAA enforcement handbooks.

b. In determining the type and extent of the enforcement action to be taken in a particular case, the following factors are considered:

(1) nature of the violation;
(2) whether the violation was inadvertent or deliberate;
(3) the certificate holder's level of experience and responsibility;
(4) attitude of the violator;
(5) the hazard to safety of others which should have been foreseen;
(6) action taken by employer or other government authority;
(7) length of time which has elapsed since violation;
(8) the certificate holder's use of the certificate;
(9) the need for special deterrent action in a particular regulatory area, or segment of the aviation community; and
(10) presence of any factors involving national interest, such as the use of aircraft for criminal purposes.

c. The filing of a report with NASA concerning an incident or occurrence involving a violation of 49 U.S.C. Subtitle VII, or the FAR is considered by FAA to be indicative of a constructive attitude. Such an attitude will tend to prevent future violations. Accordingly, although a finding of violation may be made, neither a civil penalty nor certificate suspension will be imposed if:

(1) the violation was inadvertent and not deliberate;
(2) the violation did not involve a criminal offense, or accident, or action under 49 U.S.C. Section 44709 which discloses a lack of qualification or competency, which is wholly excluded from this policy;
(3) the person has not been found in any prior FAA enforcement action to have committed a violation of 49 U.S.C. Subtitle VII, or any regulation promulgated there for a period of 5 years prior to the date of occurrence; and
(4) the person proves that, within 10 days after the violation, he or she completed and delivered or mailed a written report of the incident or occurrence to NASA under ASRS. See paragraphs 5c and 7b.

Note: Paragraph 9 does not apply to air traffic controllers. Provisions concerning air traffic controllers involved in incidents reported under ASRS are addressed in FAA Order 7210.3.

10. OTHER REPORTS.

This program does not eliminate responsibility for reports, narratives, or forms presently required by existing directives.

This program does not eliminate responsibility for reports, narratives, or forms presently required by existing directives.

AC 00-46D

11. EFFECTIVE DATE.

This modified Aviation Safety Reporting Program described by this Advisory Circular was effective October 1, 1996.

12. AVAILABILITY OF FORMS.

a. Copies of reporting forms (NASA ARC Form 277, Aviation Safety Report, series) may be obtained free of charge from FAA Flight Standards District Offices or Flight Service Stations, or directly from NASA, ASRS, P.O. Box 189, Moffett Field, CA 94035-9800.

b. The NASA ARC 277 forms will be stocked at the FAA Depot (AML-640) and will be available to FAA organizations and offices through normal supply channels (NSN 0052-00-845-4003, unit of issue: sheet).

Linda Hall Daschle
Acting Administrator

Appendix E - Voluntary Disclosure Advisory Circular

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: AIR CARRIER VOLUNTARY DISCLOSURE REPORTING PROCEDURES
Date: 1/23/92
Initiated by: AFS-200
AC No: 120-56
Change:

1. PURPOSE.

a. This advisory circular (AC) provides information and guidance material that may be used by air carrier certificate holders operating under Federal Aviation Regulations (FAR) Parts 121 and 135 when electing to voluntarily disclose apparent violations to the Federal Aviation Administration (FAA). The procedures and practices outlined in this AC can be applied to maintenance, flight operations, and security aspects of an air carrier's organization. Voluntary disclosure procedures for certificate holders other than those operating under FAR Parts 121 and 135 may be issued separately in the future.

b. Air carriers are encouraged, but not required, to develop Internal Evaluation Programs that continually monitor company policies and procedures and ensure that the highest level of safety compliance is maintained. However, operators may voluntarily disclose apparent violations in accordance with the procedures set forth in this AC even if an Internal Evaluation Program has not been established. Certificate holders seeking guidance on Internal Evaluation Programs should refer to advisory materials on the subject for further information.

2. BACKGROUND. The FAA's enforcement program has always been considered a means, not an end, to achieving compliance with the FAR through remedial and punitive measures. However, the negative incentive of deterrence, as served by civil penalties, is not always effective. The public interest is served also by positive incentives to promote and achieve compliance. Indeed, the FAA believes that aviation safety is well served by incentives to certificate holders to identify and correct their own instances of noncompliance by investing more resources in efforts to preclude their recurrence. The FAA's newly adopted policy of foregoing civil penalty actions when a certificate holder detects violations, promptly discloses violations to the FAA, and takes prompt corrective action to ensure that the same or similar violations do not recur, is designed to encourage

compliance with the FAR, foster safe operating practices, and promote the development of Internal Evaluation Programs.

3. KEY TERMS. The following key terms and phrases are defined to ensure a standard interpretation and understanding of the FAA s voluntary disclosure policy.

a. Evidence. For the purpose of voluntary disclosure, evidence generally should be in the form of written documentation or reports that support an air carrier s analysis of the disclosed apparent violation and the resulting elements of the proposed comprehensive fix. Evidence generally comes from the following four elements:

(1) Documents or manuals reviewed.

(2) Equipment examined.

(3) Activities observed.

(4) Interview data.

b. Comprehensive Fix.

(1) A comprehensive fix is an action, or actions, proposed by the certificate holder, acceptable to the principal inspector, to preclude recurrence of the apparent violation that has been voluntarily disclosed under this program.

(2) A schedule of the dates and events encompassed by the comprehensive fix must be established and included in the letter of correction.

c. Satisfactory Fix. A satisfactory fix is a comprehensive fix in which all corrective measures recommended by the certificate holder have been completed in a predetermined period of time and to the satisfaction of the FAA.

4. VOLUNTARY DISCLOSURE POLICY. The FAA believes that the open sharing of apparent violations and a cooperative as well as an advisory approach to solving problems will enhance and promote aviation safety. Certificate holders will receive a letter of correction in lieu of civil penalty action for instances of noncompliance that are voluntarily disclosed to the FAA in accordance with the procedures set forth in this AC. Once the letter of correction is issued, the case will be

considered closed unless the agreed upon comprehensive fix is not satisfactorily completed by the certificate holder.

a. In evaluating enforcement action for a certificate holder's actual or apparent failure to comply with FAA regulations, the FAA will ensure that the following five conditions are met:

(1) The certificate holder immediately notified the FAA of the apparent violation after detecting it and before the agency learned of it.

(2) The apparent violation must have been inadvertent.

(3) The apparent violation does not indicate a lack, or reasonable question, of basic qualification of the certificate holder.

(4) Immediate action must have been taken, or begun to have been taken, upon discovery to terminate the conduct that resulted in the apparent violation.

(5) The certificate holder must develop and implement a comprehensive fix satisfactory to the FAA.

b. Ordinarily, the FAA will not forego legal enforcement action if the certificate holder informs the FAA of the apparent violation during routine FAA investigations/inspections, or in association with accidents and incidents.

c. The procedures to be followed when applying the voluntary disclosure policy are further described in the following paragraphs.

5. NOTIFICATION BY THE CERTIFICATE HOLDER. When a certificate holder notifies the FAA of an apparent violation, contact shall be made with, or directed to, the appropriate principal inspector. This contact must be made immediately after the apparent violation was discovered. The form of notification may be verbal, written hard copy, or written electronic copy. The FAA believes that it is more important for the initial notification to be immediate than for all the information to be complete. Therefore, the certificate holder should not delay

notification and should cover, only to the extent possible, the following items with the principal inspector:

a. Brief description of the apparent violation, including an estimate of the duration of time that it remained undetected, as well as how and when it was discovered.

b. Verification that no additional violations occurred after the initial one was identified.

c. Brief description of the immediate action taken after the apparent violation was identified, the immediate action taken to terminate the conduct that resulted in the apparent violation, and the person responsible for taking the immediate action.

d. Verification that an evaluation is underway to determine if there are any systemic problems and a description of the corrective steps necessary to prevent the apparent violation from recurring.

e. Identification of the person responsible for preparing the comprehensive fix.

f. Acknowledgment that a detailed written report will be provided to the principal inspector within 10 calendar days.

6. FAA RESPONSE TO CERTIFICATE HOLDER NOTIFICATION. The principal inspector responds with a written acknowledgment of the certificate holder's initial notification. This acknowledgment includes the request for a written report and serves in lieu of a letter of investigation, provided the written report is completed in accordance with the voluntary disclosure reporting procedures set forth in this AC and appendix 1.

7. CERTIFICATE HOLDER'S WRITTEN REPORT. The written report should be provided to the principal inspector by the certificate holder within 10 calendar days after the initial notification was made. A sample format to be followed when completing this report is provided as appendix 1. In summary, the written report should include the following information:

a. A list of the specific FAR that may have been violated.

b. A description of the apparent violation, including the duration of time it remained undetected as well as how and when it was detected.

c. A description of the immediate action taken to terminate the conduct that resulted in the apparent violation, including when it was taken, and who was responsible for taking the action.

d. An explanation that shows the apparent violation was inadvertent.

e. Evidence that demonstrates the seriousness of the apparent violation and the certificate holder's analysis of that evidence.

f. A detailed description of the proposed comprehensive fix, outlining the planned corrective steps, the responsibilities for implementing those corrective steps, and a time schedule for completion of the fix.

g. Identification of the company official responsible for monitoring the implementation and completion of the comprehensive fix.

8. REVIEW BY THE FAA. The FAA works with the certificate holder in order to ensure that the certificate holder's fix is acceptable to the FAA.

a. If a proposed comprehensive fix is not fully developed within 10 calendar days, the certificate holder should provide at least an overview of its comprehensive fix plans. In any event, a detailed description of the comprehensive fix should be provided to the principal inspector within 30 calendar days after the certificate holder initially notified the principal inspector of the apparent violation.

b. If the principal inspector determines that the proposed fix is acceptable, he/she will prepare a letter of correction that includes the date at which the comprehensive fix will be implemented and completed.

c. Following issuance of the letter of correction, the case is closed but remains subject to reopening in the event that the agreed upon actions covered in the comprehensive fix are not completed to the satisfaction of the FAA.

d. The principal inspector has the authority to close the case. Consultation with regional specialists, the Assistant Chief Counsel for the region, or other inspectors may be accomplished when deemed appropriate by the principal inspector.

9. IMPLEMENTATION OF A COMPREHENSIVE FIX.

a. During the implementation period, the FAA and the certificate holder should continue to work together. The FAA has the latitude to advise and assist the certificate holder in correcting any identified systemic problems. Changes can be made to the corrective action plan outlined in the comprehensive fix when the need is identified and the FAA concurs with the change. When a change to a comprehensive fix has been agreed upon, the principal inspector, or the inspector assigned to the case at the direction of the principal inspector, will prepare an amended letter of correction that reflects this change.

b. The FAA monitors the implementation of the corrective steps. Throughout the implementation period, the FAA assesses the certificate holder's corrective efforts and top management's awareness of these efforts. If, during this period, the FAA determines that the actual corrective steps accomplished are contrary to those documented in the comprehensive fix, the letter of correction may be rescinded and the investigative report reopened and appropriate legal enforcement action initiated.

c. At the conclusion of the implementation period, the principal inspector makes a final assessment. If all elements of the comprehensive fix have been adequately accomplished, the principal inspector deems the fix satisfactory. A statement of follow-up investigation, confirming that the comprehensive fix was satisfactorily implemented and completed, shall be prepared to complete the FAA's investigative package.

d. If the same or similar violations are discovered subsequent to the FAA's completion of an investigative package, the FAA does not reopen the case unless it determines that the certificate holder failed to comply with all the elements of the comprehensive fix. Additionally, if a certificate holder decides to make further changes to programs or systems identified in a comprehensive fix once it becomes classified as satisfactory, these changes are not required to receive separate FAA approval under the terms of this disclosure policy.

10. INFORMAL APPEALS PROCESS. When disagreements occur regarding the acceptance of a proposed comprehensive fix, or changes to a comprehensive fix prior to its classification as satisfactory, the principal inspector and certificate holder may request that the issue be resolved at the next level of management within the FAA. This procedure will provide for an independent assessment of the areas in disagreement.

11. SEPARATE ACTIONS AGAINST AIRMEN.

a. The voluntary disclosure policy applies to individual airmen or other agents of a carrier when the carrier makes a disclosure and is the focal point of a case, and the following conditions are met:

(1) The apparent violation occurred while the airman or agent was acting on behalf of a certificate holder involved in FAR Parts 121 or 135 operations.

(2) The airman immediately must make the first report of the apparent violation to the employing certificate holder.

(3) The FAA is notified immediately. The employing certificate holder must notify the FAA of the apparent violation immediately after the airman reports it to the carrier.

b. If all the above conditions are not met, the principal inspector will review all facts associated with the case and determine what action is appropriate for individual airmen or other agents of the carrier.

12. FREEDOM OF INFORMATION ACT (FOIA), 5 U.S.C. § 552.

a. Records submitted to the FAA for review pursuant to the voluntary disclosure policy are protected, to the extent allowed by law, under Exemption 4 of the FOIA. Exemption 4 protects commercial or financial information submitted to it in confidence, if disclosure would, in this case: (1) impair the Government's ability to collect similar information in the future, or (2) cause harm to an "identifiable" governmental interest (5 U.S.C. § 552(b)(4)).

b. The FAA has determined that both of the tests described in paragraph 12a apply to reports submitted to the FAA under the voluntary disclosure policy. The FAA is responsible for explaining to requesters why the records are exempted under FOIA. Guidelines for such responses can be found in Departmental Regulations, 49 CFR Part 7, Public Availability of

Information. If the FAA is sued for the records, claims of "competitive harm" can be raised at that time.

13. SUBSEQUENT VIOLATIONS. If a subsequent violation occurs even though a comprehensive fix was satisfactorily completed and followed, the procedures outlined in this AC will apply. If the certificate holder does not disclose the subsequent violation to the FAA and it then is discovered by the FAA, or if the FAA independently uncovers a subsequent violation during routine surveillance, legal enforcement action will be initiated.

14. CONCLUSION. Development of Internal Evaluation Programs should help to ensure that any apparent violations are promptly identified, corrected, and reported to the FAA. While not required, the FAA strongly encourages certificate holders to make Internal Evaluation Programs an integral part of their everyday management process so that the full benefits of voluntary disclosure can be realized. Aviation safety is best served by programs that allow certificate holders to identify and correct their own instances of noncompliance and invest more resources in efforts to preclude their recurrence, rather than pay civil penalties.

David R. Harrington
Acting Director, Flight Standards Service

APPENDIX 1. SAMPLE FORMAT TO BE FOLLOWED BY CERTIFICATE HOLDERS WHEN SUBMITTING THE WRITTEN REPORT

The following sample is only a suggested format to be followed when preparing the written report that will be submitted to the FAA. While a certificate holder should include at least all the elements specified below, the structure of the written report can be modified by the certificate holder to fit the certificate holder's particular needs.

I. General

A. Date

B. Certificate type

C. Certificate number

D. Company name

E. Company address

F. Company official filing report

1. Name

2. Position

3. Phone

II. Description of Apparent Violation

A. Applicable FAR

B. Date apparent violation was discovered

C. Location of discovery

D. Company official who discovered apparent violation

1. Name

2. Position

3. Phone

APPENDIX 1. SAMPLE FORMAT TO BE FOLLOWED BY CERTIFICATE HOLDERS WHEN SUBMITTING THE WRITTEN REPORT (Continued)

E. Date and time of initial notification to FAA

F. Name of FAA official notified (Principal Inspector)

G. Company official making notification

1. Name

2. Position

3. Phone

H. Duration of time apparent violation remained undetected

1. Hours

2. Cycles

3. Days

I. Summary of apparent violation

(The summary should be a brief statement that describes the nature of the apparent violation and identifies the specific aircraft, engines, appliances, facilities, and/or individuals associated with the apparent violation.)

III. Immediate Action

A. When immediate action was taken

B. Description of immediate action

(This description should outline the immediate steps that were taken to cease the violative action.)

C. Company official responsible for immediate action

1. Name

2. Position

3. Phone

APPENDIX 1. SAMPLE FORMAT TO BE FOLLOWED BY CERTIFICATE HOLDERS WHEN SUBMITTING THE WRITTEN REPORT (Continued)

IV. Analysis

A. Summary of evidence

(This summary should describe the scope of the apparent violation and explain how it was detected. In addition, conclusions reached regarding possible or probable systemic deficiencies should be described.)

B. Reasons why the apparent violation was inadvertent

C. Supporting documentation

(The evidence associated with the apparent violation should be attached. This evidence should include a statement regarding how it determined the extent of the apparent violation.)

V. Comprehensive Fix Proposal

The proposed long term corrective steps to be taken by the certificate holder to preclude recurrence of the apparent violation should be listed in this section. Each corrective step should identify the individual or department responsible for implementing and completing the corrective step as well as the time allotted for completion of each corrective step.

Examples of types of questions or issues that a comprehensive fix proposal should address are as follows:

- Whether the apparent violation includes equipment, facilities, or individuals beyond those addressed in the initial notification and immediate action taken.

- Whether procedural or organizational changes are necessary.

- How will it be determined whether any procedural or organizational changes are effective?

- What procedures will be developed to ensure that the affected area periodically is reviewed in the future so that concerns can be identified before a violation occurs?

APPENDIX 1. SAMPLE FORMAT TO BE FOLLOWED BY CERTIFICATE HOLDERS WHEN SUBMITTING THE WRITTEN REPORT (Continued)

- Who will be responsible for performing periodic reviews?

- To whom in the certificate holder's organization will the results of these periodic reviews be reported, and how will they be documented?

VI. Responsibility for Monitoring the Implementation of the Comprehensive Fix

A. Name

B. Position

C. Phone

D. Signature

VII. FAA Acceptance (To be completed by the FAA)

A. Name

B. Position (Principal Inspector)

C. Date

D. Office

E. Signature

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: AVIATION SAFETY ACTION PROGRAMS (ASAP) | **Date:** 1-8-97 | **Initiated by:** AFS-200 | **AC No:** 120-66 | **Change:**

1. **PURPOSE.** This Advisory Circular (AC) provides guidance for establishing air transportation Aviation Safety Action Programs (ASAP). As an outcome of the safety conference held on January 9-10, 1995, the Secretary of Transportation and the Administrator of the Federal Aviation Administration (FAA) announced that standardized policies and procedures would be provided for the use of these programs.

a. These programs, which are entered into by the FAA and entities of the air transportation industry, are intended to generate safety information that may not otherwise be obtainable.

b. These programs provide a vehicle whereby employees of certain air carriers and repair station certificate holders can identify and report safety issues to management and the FAA for resolution without fear of punitive legal enforcement action being taken against them, under certain circumstances. These programs are designed to encourage participation from employee groups, such as flight crewmembers, mechanics, flight attendants, and dispatchers.

c. The elements of ASAP are set forth in a Memorandum of Understanding (MOU) between the FAA, certificate holders, management, and employee groups or their representatives.

2. **BACKGROUND.** In recent years, the FAA and the air transportation industry have sought alternative means for addressing safety problems and identifying potential safety hazards. To this end, the FAA, in cooperation with industry, established several demonstration ASAP in an effort to increase the flow of safety information to both the air carrier and FAA. Among these programs were the USAir Altitude Awareness Program, the American Airlines Safety Action Program, and the Alaska Airlines Altitude Awareness Program. These programs included incentives to encourage employees of air carriers participating in the programs to disclose information and identify possible violations of the Federal Aviation Regulations without fear of punitive legal enforcement sanctions. Events reported under a program that involved an apparent violation by the air carriers against the Regulations were handled under the voluntary disclosure policy, provided that the elements of the policy were satisfied. The FAA is expanding the use of ASAP through the implementation of a 2-year demonstration program. The information and data collected and analyzed can be used to measure their effect on aviation safety.

3. KEY TERMS. The following key terms and phrases, for the purposes of ASAP, are defined to ensure a standard interpretation of the guidance.

a. Administrative Action. Under paragraph 205 of FAA Order 2150.3A, Compliance Enforcement Program, administrative action is a means for disposing of violations or alleged violations that do not warrant the use of legal enforcement sanctions. The two types of administrative action are a warning notice and a letter of correction. Administrative action may be taken in lieu of legal enforcement action when all of the following elements are present:

(1) Applicable law does not require legal enforcement action;

(2) Lack of qualification or competency was not involved;

(3) The violation was inadvertent and not deliberate;

(4) The violation was not the result of a substantial disregard for safety or security and the circumstances of the violation are not aggravated;

NOTE: Substantial disregard means:

(a) In the case of a certificate holder, the act or failure to act was a substantial deviation from the degree of care, judgment, and responsibility normally expected of a person holding a certificate with that type, quality and level of experience, knowledge and proficiency.

(b) In case the violator is not a certificate holder, the act or failure to act was a substantial deviation from the degree of care and diligence expected of a reasonable person in those circumstances.

(5) The alleged violator has a constructive attitude toward complying with the regulations;

(6) The alleged violator has not been involved previously in similar violations; and

(7) After consideration of items (1-6), a determination is made that administrative action will serve as an adequate deterrent.

b. Air Carrier. A person who undertakes directly by lease, or other arrangement, to engage in air transportation.

c. Certificate Holder. Refers to a person authorized to operate under Title 14 of the Code of Federal Regulations (14 CFR) part 121, or who holds a certificate issued under 14 CFR part 145.

d. Certificate Holding District Office (CHDO). The Flight Standards District Office (FSDO) having overall responsibility for all FAA reporting requirements, technical administration requirements, and regulatory oversight of a certificate holder.

e. Enforcement-Related Incentive. Refers to an assurance that lesser enforcement action will be used to address certain alleged violations of the Regulations to encourage participation by certificate holder employees.

f. Event Review Committee (ERC). A group comprised of a representative from each party to an ASAP reviews and analyzes reports that are submitted under an ASAP. The ERC may share and exchange information and identify actual or potential safety problems from the information contained in the reports. The ERC usually is comprised of a management representative from the certificate holder, a representative from the employee group, and an FAA inspector from the CHDO. Previous demonstration ASAP used the ERC concept. However, the parties may agree to use an alternative process.

g. Major Domestic Repair Station. Refers to a part 145 repair station located in the United States certificated to perform airframe and/or engine work on transport category aircraft having a maximum takeoff gross weight of 75,000 lbs. or greater.

h. Memorandum of Understanding (MOU). Refers to the written agreement between two or more parties setting forth the purposes for, and terms of, an ASAP.

i. Party/Parties. Refers to the certificate holder, the FAA, and any other person or entity (e.g., labor union or other industry or Government entity) that is a signatory to the MOU.

j. Person. A person refers to an individual, firm, partnership, corporation, company, association, joint stock association, or government entity; including a trustee, receiver, assignee, or similar representative of them.

k. Safety-Related Report. Refers to a written account of an event that involves an operational or maintenance issue related to aviation safety reported through an ASAP.

l. Voluntary Disclosure Policy. A policy under which 14 CFR parts 121, 135, and 145 certificate and production approval holders may voluntarily report apparent violations of the Regulations and develop corrective action satisfactory to the FAA to preclude their recurrence. Certificate holders who satisfy the elements of the voluntary disclosure policy, receive a letter of correction in lieu of civil penalty action. Voluntary disclosure reporting procedures are outlined in AC 120-56, Air Carrier Voluntary Disclosure Reporting Procedures.

4. APPLICABILITY. ASAP's are intended for air carriers that operate under part 121. They are also intended for major domestic repair stations certificated under part 145. ASAP's are entered into voluntarily by the FAA, a certificate holder, and if appropriate, other parties.

5. DEVELOPMENT. Certificate holders may develop programs and submit them to the FAA for review and acceptance in accordance with the guidance provided. The FAA will determine whether a program is accepted. The FAA may suggest that a certificate holder develop an ASAP to resolve an identified safety problem.

6. RESOURCES. An ASAP can result in a significant commitment of resources by the parties to the program. During the development of a program, it is important that each party is willing to commit the necessary personnel, time, and monetary resources to support the program.

7. ENFORCEMENT POLICY.

a. Enforcement-Related Incentive. ASAP may include an enforcement-related incentive to encourage participation by certificate holder employees. Any enforcement-related incentive should be limited to what is needed to achieve the desired goal and results of the program. Apparent violations of the Regulations by certificate holder employees disclosed through safety-related reports will ordinarily be addressed with administrative action, provided that the apparent violations do not involve deliberate misconduct; a substantial disregard for safety or security, as defined in the key terms; criminal conduct; or conduct that demonstrates or raises a question of a lack of qualification. Such violations are specifically excluded from the program. Any enforcement-related incentive will not apply to these violations. Failure of any individual to complete corrective action in a manner acceptable to the FAA may result in the reopening of the case and referral of the apparent violation for legal enforcement action.

b. Repeated Instances of Misconduct. Notwithstanding the guidance in paragraph 205 of FAA Order 2150.3A, repeated instances involving the same or similar type of misconduct previously addressed with administrative action, may also be covered under the program. The determination whether a repeated violation will be covered under a program, will be made by the FAA on a case-by-case basis, upon consideration of the facts and circumstances surrounding the misconduct.

c. Use of Safety-Related Reports. All safety-related reports should be fully evaluated and, to the extent appropriate, investigated by the FAA. Any safety-related report that concerns an apparent violation(s) that is excluded from ASAP, will be referred to an appropriate office within the FAA for any additional investigation and reexamination and/or legal enforcement action, as appropriate. A closed case involving a violation addressed with the enforcement-related incentive, or for which no action has been taken, may be reopened and appropriate legal enforcement action taken if evidence later is discovered that establishes that the violation should have been excluded from the program. For apparent violations not excluded under an ASAP, neither administrative action nor punitive legal enforcement action will be taken against an individual for an apparent violation reported under the program unless there is sufficient evidence of the violation, other than the individual's safety-related report. Sufficient evidence means evidence gathered by an investigation not caused by, or otherwise predicated on, the individual's safety-related report.

d. Violations of Certificate Holders. Apparent violations of certificate holders disclosed through a safety-related report under an ASAP will be handled under the voluntary disclosure policy, provided the certificate holder voluntarily reports the apparent violations to the FAA and the other elements of that policy are met. (See AC 120-56, FAA Order 2150.3A, and Compliance/Enforcement Bulletin No. 90-6).

e. **Examples.** The following are examples of events that might be reported under an ASAP and the probable action that would be taken by the FAA for an apparent violation disclosed by the safety-related report:

(1) Examples of events where an apparent violation ordinarily would be addressed by the enforcement-related incentive:

(a) A pilot reports an altitude deviation where the aircraft was assigned by ATC to climb to an altitude of 10,000 ft. MSL, but actually levels off at 11,000 ft. MSL. Evidence of the violation, other than the safety-related report, (e.g., air traffic control tape, air traffic controller's statements) is gathered by an investigation not caused by, or otherwise predicated on, the filing of the safety-related report. The pilot's apparent violation does not involve conduct that is excluded from the ASAP. The apparent violation therefore would be addressed by the enforcement-related incentive.

(b) A repair station technician reports that he/she was assigned to accomplish a required inspection (RII); however, he/she inadvertently neglected to sign the check sheet that the inspection was completed. Evidence of the apparent violation, other than the technician's safety-related report, reveals that the inspection was accomplished and the check sheet was not signed. This evidence was gathered by an investigation not caused by, or otherwise predicated on, the filing of the safety-related report. The apparent violation does not involve conduct that is excluded from the ASAP. The apparent violation therefore would be addressed by the enforcement-related incentive.

(2) Examples of events involving an apparent violation that is excluded from the ASAP and to which the enforcement-related incentive would not apply:

(a) A pilot submits a report indicating that after takeoff he/she operated an aircraft below an altitude of 1,000 ft. AGL, over a congested area. Investigation of this event revealed that the aircraft was deliberately flown at an altitude of 500 ft. AGL over a city ten miles from the airport. Due to the deliberate nature of the pilot's conduct, it would not be covered under the ASAP. The report would be referred for further action.

(b) A technician submits a report stating that he/she had used a lubricant other than what was stated in the maintenance manual for an engine valve installation. No authorized substitute lubricants were available. The investigation revealed that the technician intentionally used a substitute non-approved lubricant. These actions were not in accordance with the maintenance manual or company procedures. Because these actions were a substantial deviation from required conduct, and intentional, the technician's conduct would not be covered under the ASAP. The report would be referred for further action.

(3) Examples of events where no action would be taken for an alleged violation disclosed through a safety-related report.

(a) A pilot reports an altitude deviation where the aircraft was assigned by ATC to climb to an altitude of 10,000 ft. MSL, but actually levels off at 11,000 ft. MSL. The investigation of this event reveals that the apparent violation is covered under the program. However, the only evidence of the deviation is the pilot's safety-related report filed under the ASAP. Since the pilot's safety-related report will not be used as evidence to support taking punitive legal enforcement action or administrative action against the pilot, there is insufficient evidence to support a violation of the Regulations. Therefore, the case would be closed with no action.

(b) A technician reports that during a preflight inspection, he/she did not replace a brake pad that was worn past allowable wear limits. The report indicated at the time of the inspection, the technician unknowingly used the wrong gauge for that aircraft to measure brake pad wear for that aircraft. The aircraft departed and later returned to the station where the brake pad was replaced. The investigation of this event reveals that the apparent violation is covered under the program. However, the only evidence of the aircraft operating with an out-of-limit brake pad was the technician's safety-related report filed under the ASAP. Since the technician's safety-related report will not be used as evidence to support taking punitive legal enforcement action or administrative action against the technician, there would be insufficient evidence to support a violation of the Regulations. Therefore the case would be closed with no action.

8. CORRECTIVE ACTION. The FAA will work with a certificate holder to develop acceptable corrective action that should be taken based on information obtained under an ASAP.

9. MOU. The provisions of an ASAP, that is acceptable to the FAA, should be set forth in an MOU signed by each party. A program will be implemented in accordance with the provisions of its MOU. A sample MOU is provided in Appendix 1. Each MOU will be based on the parties' different needs and purposes for an ASAP.

a. The MOU should set forth the elements of the ASAP, including at least the following:

(1) A statement of the essential safety information that is reasonably expected to be obtained through the program and the safety concern(s) that is/are reasonably expected to be addressed through the program.

(2) The benefits to be gained by the program.

(3) The duration of the program, which should be limited to the period of time needed, to achieve the desired goals and benefits articulated in the program. Programs initially should have a duration of no longer than one (1) year and should be reviewed prior to renewal.

(4) A process for timely reporting to the FAA, all events disclosed under the program, procedures for the resolution of those events that are safety-related, and procedures for continuous tracking and analysis of safety-related events.

(5) Any enforcement-related incentive that is needed to achieve the desired goal and results of the program.

(6) The frequency of periodic reviews by the parties to determine whether the program is achieving the desired results. These reviews are in addition to any other review conducted by the FAA.

(7) A point of contact within each party who is responsible for oversight of the program.

(8) A process for training and distributing information about the program to certificate holder employees and procedures for providing feedback to individuals who make safety-related reports under the program.

b. The MOU should also address the following elements that will pertain to any ASAP:

(1) The program can be terminated at any time, by any party.

(2) Failure, of any party, to follow the terms of the agreement ordinarily will result in termination of the program.

(3) Failure of a certificate holder, to follow through with corrective action acceptable to the FAA, to resolve any safety deficiencies, ordinarily will result in termination of the program.

(4) Modifications of the MOU must be approved by all parties.

(5) Termination or modification of a program will not adversely affect anyone who acted in reliance on the terms of a program in effect at the time of that action, i.e., when a program is terminated all reports and investigations that were in progress will be handled under the provisions of the program until they are completed.

(6) Any enforcement-related incentive will not apply to alleged violations involving deliberate misconduct; substantial disregard for safety or security, as defined in the key terms; criminal conduct; or conduct that demonstrates or raises a question of a lack of qualification.

c. The MOU must be signed by an authorized representative of each party. The MOU will be signed by the CHDO manager on behalf of the FAA after coordination with the Director, Flight Standards Service, AFS-1 and the Associate Administrator for Regulation and Certification, AVR-1.

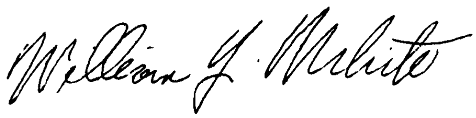
10. ACCEPTANCE/RENEWAL PROCEDURES.

a. The certificate holder should initially develop and present a program to the CHDO for review. The CHDO and the certificate holder will review it to ensure that it is satisfactory to the guidance in, FAA Order 2150.3A, and FAA Orders 8300.10, Airworthiness Operations Inspector's Handbook, and 8400.10, Air Transportation Operations Inspector's Handbook, for establishing an ASAP. Prior to acceptance, a program will be reviewed to ensure that FAA resources are available to administer the program effectively. When the FAA determines that a program proposal requires excessive agency resources, a matter within the sole discretion of the FAA, modifications will either be suggested to the program proposal, or the proposal will be disapproved.

b. When the CHDO is satisfied that a program is satisfactory to the guidance provided in FAA Order 2150.3A, and FAA Orders 8300.10 and 8400.10, the CHDO manager will forward two copies of the MOU through the Flight Standards division regional office to the appropriate headquarters program office(s); i.e., AFS-200 for operations programs and AFS-300 for airworthiness and repair station programs. When the MOU encompasses both operations and airworthiness programs it goes to AFS-200 and AFS-300. The program offices will review and forward the MOU to the Office of the Chief Counsel for appropriate legal review. All programs must receive final approval of the Director, Flight Standards Service, AFS-1, and Associate Administrator for Regulation and Certification, AVR-1. AFS-1 will indicate approval of the MOU by FAA memorandum to the CHDO manager. Following approval by AFS-1 and AVR-1, the CHDO manager will sign the MOU on behalf of the FAA.

c. Program renewal will be handled in accordance with the guidance for the review and renewal of programs, provided in FAA Order 2150.3A. The CHDO will forward its recommendation whether a program should be renewed, along with supporting information, in accordance with the procedures outlined in FAA Orders 8300.10 and 8400.10.

11. RECORDKEEPING. The parties should maintain those records necessary for a program's administration and evaluation. Records submitted to the FAA, for review pursuant to the ASAP, are protected to the extent allowed by law, under applicable exemptions of the Freedom of Information Act.



William J. White,
Deputy Director, Flight Standards Service

APPENDIX 1. SAMPLE MEMORANDUM OF UNDERSTANDING

This is a sample of a memorandum of understanding (MOU) for an air transportation Aviation Safety Action Program (ASAP). It is for illustrative purposes; an actual MOU developed by a certificate holder may be different from this sample. An MOU should address the elements of an ASAP that are set forth in FAA guidance material.

MEMORANDUM OF UNDERSTANDING

1. GENERAL. ABC Airlines, Inc. is a Title 14 of the Code of Federal Regulations part 121 domestic air carrier engaged in scheduled passenger operations within the United States, Mexico, and Canada. It also conducts passenger charter and cargo operations. ABC Airlines operates 100 turbojet aircraft and has over 3,500 employees including 1,100 flight crewmembers (pilots and flight engineers) represented by ABC pilot union.

2. PURPOSE. Over the past six months ABC Airlines has experienced an increase in certain types of incidents that have resulted in problems relating to safety of flight, including violations of the Regulations by the company and its flight crewmembers. Such incidents have occurred during all phases of flight and have involved the following: non-compliance with air traffic control (ATC) clearances; (e.g., routing, heading, and altitude deviations), runway and taxiway incursions, and departure without a proper flight plan fuel onboard. To obtain valuable safety information that may lead to correcting these and other safety of flight problems, ABC Airlines is entering into an ASAP with its flight crewmembers, represented by ABC pilot union, and the FAA. This MOU describes the provisions of the program. The objective of the program will be to gather safety information from the flight crewmembers that will focus on the incidents described above and to obtain information concerning any additional safety of flight item that a flight crewmember believes should be reported. The information will be analyzed in order to develop and implement solutions to safety problems identified under the program.

3. BENEFITS. The program will provide a voluntary, cooperative, non-punitive environment for the open reporting of safety of flight concerns. Through such reporting, all parties will have access to valuable information that may not otherwise be obtainable. This information will be analyzed in order to develop corrective action to solve safety problems and minimize deviations from the Regulations.

4. APPLICABILITY. The ABC ASAP applies to all flight crewmember employees of ABC Airlines. Apparent violations of the Regulations that, involve deliberate misconduct, substantial disregard for safety or security, criminal conduct, or conduct that demonstrates or raises a question of a lack of qualification, are excluded from the program. Repeated instances involving the same or similar type of misconduct previously addressed by the enforcement-related incentive may be covered under the program. The determination whether a repeated instance will be covered under the program will be made by the FAA on a case-by-case basis.

a. Apparent violations of the Regulations by ABC Airlines, that are discovered under this program, will be handled under the voluntary disclosure policy, provided that ABC Airlines voluntarily reported the alleged violations to the FAA and the other elements of that policy are met. (See AC 120-56, FAA Order 2150.3A, Compliance and Enforcement Program, and Compliance/Enforcement Bulletin No. 90-6).

b. Any modifications of this MOU must be approved by all parties to the agreement.

5. PROGRAM DURATION. The ASAP is designed to identify and correct specific problems related to flight safety at ABC Airlines. The duration of the program will be one (1) year, beginning the date it is implemented by the parties to this MOU. The program may be terminated at any time for any reason by ABC Airlines, the FAA, or any other party. If the program is terminated, all safety-related reports that have been submitted will continue to be processed under the MOU in effect at the time of the program's termination. If necessary, the program may be renewed at the end of one (1) year provided that a final review and analysis supports renewal of the program and all parties agree to renewal of the program. Failure of any party to follow the terms of the program ordinarily will result in termination of the program. Failure of ABC Airlines to follow through with corrective action to resolve any safety deficiencies ordinarily will result in termination of the program.

6. REPORTING PROCEDURES. When a pilot observes a safety problem or experiences an incident during flight, he/she should note the problem or incident and be able to describe it in enough detail so that it can be evaluated by a third party. For example, if the safety incident involves a deviation from an ATC clearance the pilot should note the date, time, place, altitude, flight number, and ATC frequency, along with enough other information describing the incident and any perceived safety problem. After the trip sequence has ended for that day, the pilot should complete ABC Airlines ASAP Form number 123 for each safety problem or incident (hereinafter referred to as "report") and submit it by company mail to the Director of Flight Operations, ATTN: ASAP Manager. In order for the flight crewmember, who submitted the report, to be covered under the ASAP and eligible for any FAA enforcement-related incentive, the report must be mailed within 24 hours after the end of the flight sequence for the day of occurrence, absent extraordinary circumstances. For example, if the incident occurred at 14:00 hrs. (Monday) and the pilot completes his/her flight sequence for that day at 19:00 hrs., the report should be mailed no later than 19:00 hrs. the following day (Tuesday). In order for all flight crewmembers to be covered under the ASAP for any regulatory violations resulting from an incident, they must all sign the same report or submit separate individual reports for the same incident. If the company mail system is not available to the flight crewmember at the time he/she needs to file a report, the crewmember may contact the ASAP manager's office and file a report via fax or telephone.

7. POINT OF CONTACT. The Event Review Committee (ERC) will be comprised of the ASAP manager, representing ABC Airlines Flight Department management; the ASAP coordinator for ABC Pilot Union; and an FAA inspector from the Certificate Holding District Office (CHDO) for ABC Airlines, or designees in their absence.

8. ASAP MANAGER. When the report is received by the ASAP manager, he/she will record the date and time of any incident described in the report and the date and time that the report was submitted through the company mail system. The ASAP manager will enter the report, along with all of the supporting data, on the agenda for the next ERC meeting. Untimely reports may still be considered by the ERC if extraordinary circumstances precluded timely submission of the report (e.g., a flight crewmember became ill requiring hospitalization at the termination of the flight). In those cases, the report should be mailed via company mail as soon as is reasonably possible. The FAA representative to the ERC will determine whether a report is submitted in a timely manner and whether extraordinary circumstances precluded timely submission. To confirm that a report has been received, the ASAP manager will send a written receipt (ABC Airlines ASAP Form number 234) through the company mail system to each flight crewmember who submits a report. The receipt will confirm whether or not the report was determined to be timely. The ASAP manager will serve as the focal point for information about, and inquiries concerning the status of, ASAP reports, and for the coordination and tracking of recommendations.

9. ERC. The ERC will review and analyze reports submitted by flight crewmembers under the program, identify actual or potential safety problems from the information contained in the reports, and propose solutions for those problems. The ERC is responsible for tracking the status of each ASAP report and for providing feedback to the individual who submitted the report. It will also conduct a review of the program six months after its inception. This review is in addition to any other reviews conducted by the FAA. The ERC also will be responsible for preparing a final report on the program at its conclusion. If renewal of the program is anticipated, the ERC will prepare and submit that report to the FAA 60 days in advance of the termination date for the initial program.

10. ERC PROCESS.

a. The ERC will meet as necessary to review and analyze reports that will be listed on an agenda submitted by the ASAP manager. The ERC will determine the time and place of the meeting. The ERC will meet at least twice a month and the frequency of meetings will be determined by the number of reports that have accumulated.

It is anticipated that three types of reports will be submitted to the ERC: safety-related reports that appear to involve a violation(s) of the Regulations; reports that are of a general safety concern, but do not appear to involve a violation(s) of the Regulations; and any other reports (e.g., involving catering and passenger ticketing issues). The ERC will forward non-safety reports to the appropriate ABC Airlines department head for his/her information and if possible, internal (ABC Airlines) resolution. For reports related to flight safety, including reports involving possible violations of the Regulations, the ERC will analyze the report, conduct interviews of reporting crewmembers, and gather additional information concerning the matter described in the report, as necessary.

b. The ERC should also make recommendations to ABC Airlines for appropriate comprehensive fixes. Such comprehensive fixes might include changes to ABC Airlines procedures, aircraft equipment modifications, or additional training for a crewmember. Any recommended changes that affect ABC Airlines will be forwarded through the ASAP manager to the appropriate department head for consideration and comment, and if appropriate, implementation. The FAA will work with ABC Airlines to develop acceptable comprehensive fixes. The ASAP manager will track the implementation of the recommended comprehensive fixes and report on the progress of the fixes to the ERC as part of the regular ERC meetings. Any recommended comprehensive fix that is not implemented should be recorded along with the reason it was not implemented.

11. FAA ENFORCEMENT. All reports submitted under the ASAP that involve potential violations of the Regulations will be referred to the FAA representative of the ERC for evaluation, and to the extent appropriate, investigation. The FAA representative will review the report and determine whether the alleged violation is supported by sufficient evidence, other than the individual's safety-related report. Sufficient evidence means evidence gathered by an investigation not caused by, or otherwise predicated on, the individual's safety-related report. Apparent violations supported by such evidence will ordinarily be addressed with administrative action provided the apparent violations do not involve deliberate misconduct, substantial disregard for safety or security, criminal conduct, or conduct that demonstrates, or raises a question of a lack of qualification. Administrative action has been determined to be a necessary enforcement-related incentive to achieve the desired results and goals of the program.

a. Safety-related reports identifying alleged violations that are not covered under this program will be referred to an appropriate office within the FAA for any additional investigation and reexamination and/or legal enforcement action, as appropriate.

b. In order for an alleged violation covered under the ASAP to be addressed with administrative action, the elements of paragraph 205 of FAA Order 2150.3A, should be satisfied, and the individual who committed the apparent violation must agree to accomplish any corrective action determined appropriate by the FAA representative to the ERC. Notwithstanding the guidance in paragraph 205 of FAA Order 2150.3A; however, repeated instances involving the same or similar type of misconduct previously addressed with administrative action under the ASAP may also be covered under the program. The determination whether a repeated instance will be covered under the ASAP will be made on a case-by-case basis by the FAA, upon consideration of the facts and circumstances surrounding the violation.

c. The ERC may review and discuss the evidence available to support an apparent violation reported under the ASAP. The FAA representative to the ERC will determine the enforcement action, if any, that should be initiated for the apparent violation.

d. The FAA will work with a certificate holder to develop acceptable comprehensive fixes for safety problems identified from information obtained under the ASAP. The decision to accept the corrective actions implemented under an ASAP in lieu of legal enforcement action remains solely with the FAA.

12. EMPLOYEE FEEDBACK. The ASAP manager will publish a synopsis of the reports received from the flight crewmembers in the ASAP section of the monthly ABC Airlines Employee Newsletter. The synopsis will include enough information so that reporting flight crewmembers can identify their reports. Employee names, however, will not be included in the synopsis. The outcome of each report will be published. Any employee who submitted a report may also contact the ASAP manager to inquire about the status of his/her report.

13. INFORMATION AND TRAINING. The details of the ASAP will be made available to all flight crewmembers and their supervisors by publication in section 5 of the ABC Airlines flight crew operating manual. Each flight crewmember will receive written guidance outlining the details of the program at least two weeks before the program begins. Each flight crewmember also will receive additional instruction concerning the program during the next regularly scheduled recurrent training class. All new hire pilot employees will receive training on the program during initial training.

14. RECORDKEEPING. All official documents and records regarding this program will be kept by the ASAP manager and made available to the parties of this agreement at their request. The ABC Airlines Pilot Union and FAA will maintain whatever records they deem necessary to meet their needs.

15. SIGNATORIES.

Director of Operations, ABC Airlines	Date
President, ABC Airlines Pilot Union	Date
Manager, FAA CHDO	Date

Appendix G - MEDA Brochure

IMPACT OF MAINTENANCE ERROR

Recent Studies Are Just Beginning to Focus on the Impact of Maintenance Error.

- 1/3 of all equipment failures (U.S. Air Force study)
- 20 percent of all in-flight shutdowns (Boeing)
- 50 percent of engine-related flight delays and cancellations (GE)

Economic Impact On One Airline - 1988 - 1991
(fleet of 300+ aircraft)

- 203 total maintenance mishaps resulting in aircraft damage
- 13,299 total hours out-of-service
- $16.5 million in repairs on parts and labor (excludes lost revenue)
- Approximately 95 percent attributable to procedural error

Most Common Maintenance Errors
(1992 study, United Kingdom)

- Incorrect installation of components
- Using wrong parts
- Electrical wiring discrepancies
- Leaving loose objects in aircraft
- Inadequate lubrication
- Unsecured access panels, fairings and cowlings
- Unsecured fuel/oil caps and fuel panels
- Failure to remove gear pins before departure

Such Errors Can be Reduced or Eliminated with a Better Understanding of Their Causes.

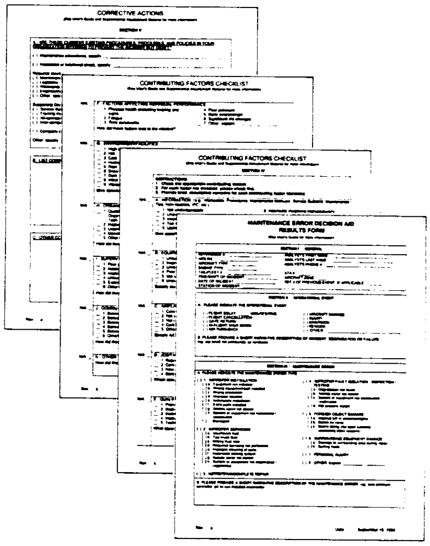
TO ERR IS HUMAN

> *"....our airplane suffered an in-flight shutdown when one of our technicians forgot to reinstall a borescope cover. When we started our investigation, we expected to find an inexperienced or unprofessional technician. When we finally tracked down the error, we found our best engine technician was involved! That's when we decided to reevaluate our thinking toward maintenance error...."*
>
> *An international air carrier*

While experts in the highly technical field of aircraft maintenance are comfortable investigating equipment failure, they are often ill-equipped to address human failures and their contributing factors. The fundamental concept behind MEDA is the belief that human errors are seldom random, and in fact, can be traced to causes and contributing factors which, once isolated, can be eliminated or at least reduced.

MEDA is the systematic tool that provides the information necessary to make improvements in the industry's maintenance processes.

MEDA AS A TOOL



When errors occur, MEDA provides investigation at two levels.

1. Line Investigation:

MEDA begins with a paper-based investigation that gives line level maintenance personnel a standardized way to investigate maintenance errors and their consequences.

MEDA investigations identify system problems that both increase exposure to error and decrease efficiency. MEDA guides the investigator in the selection of corrective actions that will reduce the exposure to error.

An important element of the MEDA approach to error investigation is open communication with the erring technician. Our team's maintenance error research show that current industry practices have placed excessive emphasis on the accountability of the erring technician and inadequate emphasis on the human factors contributing to the error. Realizing this, some participating airlines and regulatory authorities are reassessing their disciplinary practices with the goal of optimizing the balance between deterrence and open communication.

2.Organizational Trend Analysis:

MEDA then provides a means for computerized error trend analysis for the maintenance organization.

MEDA (as a paper-based and computerized tool) gives the maintenance organization a better understanding of how human performance issues contribute to error.

MEDA BRIDGES THE GAP

MEDA bridges the gap between those who must manage maintenance error on a daily basis, those responsible for the administration of maintenance systems and those who design aircraft and their maintenance programs.

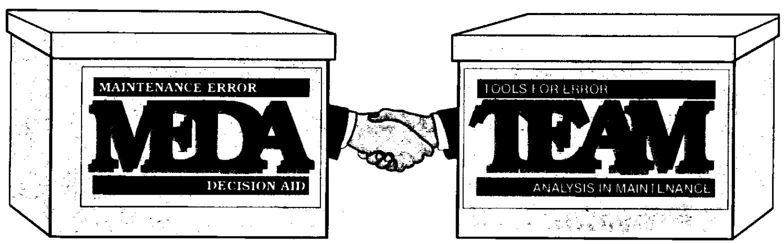
MEDA's computerized trend analysis data may influence cultural and process changes in the airline's maintenance environment and provide manufacturers with useful information for designers and maintenance support personnel — improvements which are less frequently possible with input from a single line investigation.

MEDA serves as a common language to increase communication and cooperation between operators, regulators, manufacturers and the maintenance workforce.

Maintenance error has a tremendous financial impact on airlines. In 1995, Boeing Commercial Airplane Group and a team of airlines designed a process to investigate maintenance error. That process is called **MEDA**, for Maintenance Error Decision Aid.

The **MEDA** system is a paper and pencil process to aid in investigation after an apparent maintenance error. The **MEDA** system is a cost-effective means to standardize data collection. These data are the basis for systems to recognize error - before it occurs.

Knowing that software was the necessary catalyst to convert **MEDA** data to useful information, Boeing selected Galaxy Aviation Corporation to create a software partner for **MEDA**. The software is called Tools for Error Analysis in Maintenance (**TEAM**).

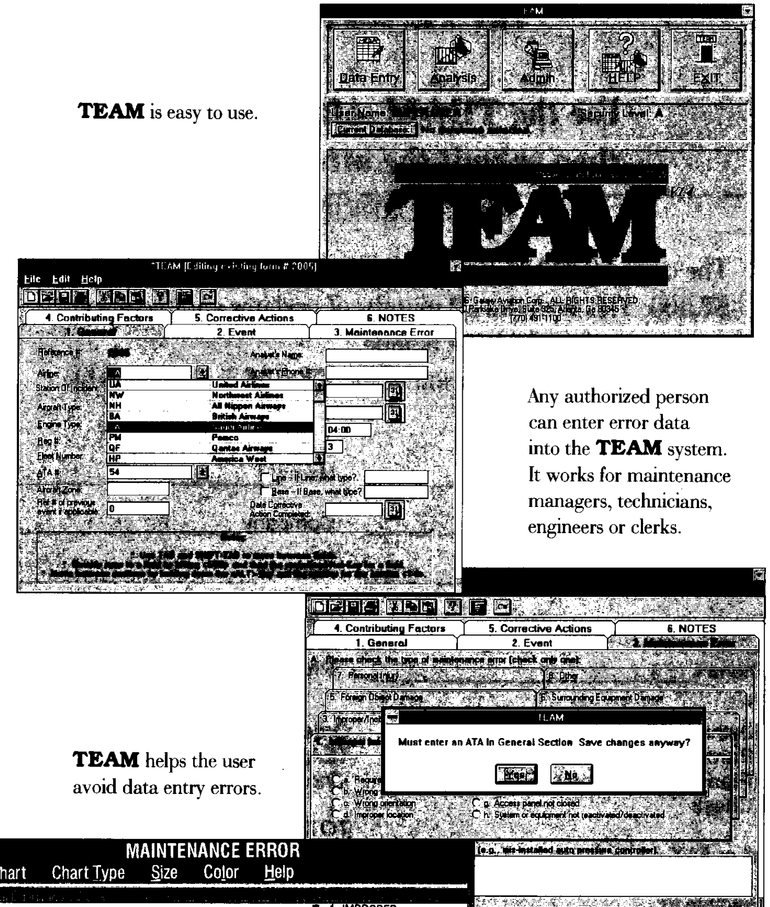


Galaxy Aviation offered the **MEDA** group not only software expertise but also extensive experience in maintenance human factors. Galaxy knew how to create software that was easy to use and designed to answer real-world maintenance questions. The **MEDA-TEAM** combination is a cost-effective tactic to reduce or prevent maintenance error.

MEDA (Process) & TEAM (Tools) =

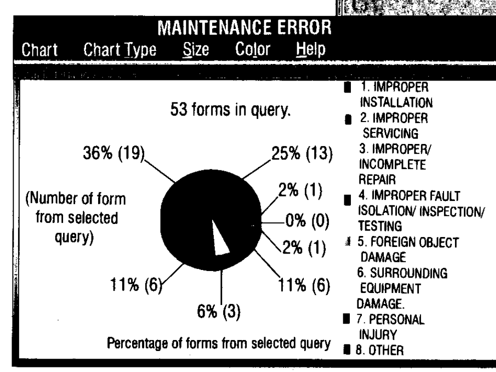
- Error Reduction Potential
- Continuing Safety Enhancement
- Cost Control
- Enhanced Maintenance Performance

TEAM is easy to use.



Any authorized person can enter error data into the **TEAM** system. It works for maintenance managers, technicians, engineers or clerks.

TEAM helps the user avoid data entry errors.



TEAM's Data Analysis tools and graphics provide immediate and easy-to-understand data analysis.

The Aviation Safety Reporting System

The Aviation Safety Reporting System (ASRS) was established in 1975 under a Memorandum of Agreement between the Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA). FAA provides most of the program funding; NASA administers the program and sets its policies in consultation with the FAA and the aviation community. NASA has chosen to operate the program through a contractor selected via competitive bidding. The current contractor is Battelle.

Purposes of the Program

The ASRS collects, analyzes, and responds to voluntarily submitted aviation safety incident reports in order to lessen the likelihood of aviation accidents. ASRS data are used to:

- Identify deficiencies and discrepancies in the National Aviation System (NAS) so that these can be remedied by appropriate authorities.
- Support policy formulation and planning for, and improvements to, the NAS.
- Strengthen the foundation of aviation human factors safety research. This is particularly important since it is generally conceded that over two-thirds of all aviation accidents and incidents have their roots in human performance errors.

Confidentiality and Incentives to Report

Pilots, air traffic controllers, flight attendants, mechanics, ground personnel, and others involved in aviation operations submit reports to the ASRS when they are involved in, or observe, an incident or situation in which aviation safety was compromised. All submissions are voluntary.

Reports sent to the ASRS are held in strict confidence. More than 300,000 reports have been submitted to date and no reporter's identity has ever been breached by the ASRS. ASRS de-identifies reports before entering them into the incident database. All personal and organizational names are removed. Dates, times, and related information, which could be used to infer an identity, are either generalized or eliminated.

The FAA offers ASRS reporters further guarantees and incentives to report. It has committed itself not to use ASRS information against reporters in enforcement actions. It has also chosen to waive fines and penalties, subject to certain limitations, for unintentional violations of federal aviation statutes and regulations which are reported to ASRS. The FAA's initiation, and continued support, of the ASRS program and its willingness to waive penalties in qualifying cases is a measure of the value it places on the safety information gathered, and the products made possible, through incident reporting to the ASRS.

Report Processing

Incident reports are read and analyzed by ASRS's corps of aviation safety analysts. The analyst staff is composed entirely of experienced pilots and air traffic controllers. Their years of experience are uniformly measured in decades, and cover the full spectrum of aviation activity: air carrier, military, and general aviation; Air Traffic Control in Towers, TRACONS, Centers, and Military Facilities.

Each report received by the ASRS is read by a minimum of two analysts. Their first mission is to identify any aviation hazards which are discussed in reports and flag that information for immediate action. When such hazards are identified, an alerting message is issued to the appropriate FAA office or aviation authority. Analysts' second mission is to classify reports and diagnose the causes underlying each reported event. Their observations, and the original de-identified report, are then incorporated into the ASRS's database.

Database

The database provides a foundation for specific products and subsequent research addressing a variety of aviation safety issues. ASRS's database includes the narratives submitted by reporters (after they have been sanitized for identifying details). These narratives provide an exceptionally rich source of information for policy development and human factors research. The database also contains coded information from the original report which is used for data retrieval and statistical analyses.

continued over...

Program Outputs

ASRS uses the information it receives to promote aviation safety in a number of ways:

- **Alerting Messages**. When ASRS receives a report describing a hazardous situation—for example, a defective navigation aid, mischarting, a confusing procedure, or any other circumstance which might compromise safe flight—it issues an alerting message. Alerting messages take a variety of forms, but they have a single purpose: to relay safety information to individuals in a position of authority so that they can investigate the allegation and take needed corrective actions. ASRS has no direct operational authority of its own. It acts through, and with the cooperation of, others.
- **CALLBACK**. ASRS distributes CALLBACK, a monthly safety bulletin, to more than 78,000 pilots, air traffic controllers, and others. Each issue of CALLBACK includes excerpts from ASRS incident reports with supporting commentary. In addition, CALLBACK may contain summaries of ASRS research studies and related aviation safety information. CALLBACK is one of the ASRS's most effective tools for improving the quality of human performance in the NAS at the grass roots level. Editorial use and reproduction of CALLBACK articles, with appropriate attribution, is encouraged.
- **ASRS Directline**. New in 1991, ASRS Directline is published periodically to meet the needs of operators and flight crews of complex aircraft, such as commercial carriers and corporate fleets. Articles contained in Directline are based on ASRS reports that have been identified as significant by ASRS analysts. Distribution is directed to operational managers, safety officers, training organizations, and publications departments. Editorial use and reproduction of Directline articles, with appropriate attribution, is encouraged.
- **Database Search Requests**. Information in the ASRS database is available to interested parties. Individuals and organizations wishing to access ASRS data on a particular aviation safety subject may contact the ASRS with a statement of need. The ASRS will then search its database for pertinent reports and will print, bind, and mail any information applicable to the request. To date more than 3,000 searches have been accomplished in support of government, industry, and academe.
- **Operational Support**. Through frequent communications between the two organizations, the ASRS contributes to the FAA's ongoing safety efforts. The ASRS also supports the FAA and the NTSB during rule-makings, procedure/airspace design efforts, accident investigations, and like circumstances by assembling and digesting relevant information from its database. This is a growing role for the ASRS.
- **Topical Research**. ASRS has conducted and published over 56 research studies. ASRS research has always been designed and conducted with an orientation toward real-life operational applications; most have examined human performance in the NAS. Ways are sought to effect incremental improvements in aviation safety through improved procedures, training, design, etc. Recent subjects of ASRS research include: wake turbulence incidents, digital avionics software and hardware problems, TCAS II incidents, cockpit interactions incidents analysis, airport ramp safety incidents, crew performance during aircraft malfunctions, air carrier return-to-land incidents, use of digital flight data to measure safety and crew performance (APMS), and use of ASRS incident data in the FAA's AQP program.

Summary

The ASRS is a small but important facet of the continuing effort by government, industry, and individuals to maintain and improve aviation safety. The ASRS collects voluntarily submitted aviation safety incident/situation reports from pilots, controllers, and others. The ASRS acts on the information these reports contain. It identifies system deficiencies, and issues alerting messages to persons in a position to correct them. It educates through its newsletter CALLBACK, its journal ASRS Directline and through its research studies. Its database is a public repository which serves the FAA's and NASA's needs and those of other organizations world-wide which are engaged in research and the promotion of safe flight.

Limitations

1. The ASRS assurance of confidentiality and the availability of waivers of disciplinary action do NOT extend to reports of accidents or criminal activity (e.g., hijacking, bomb threats, and drug running). Such reports should not be submitted to ASRS. If such reports are received, they are forwarded identified to cognizant agencies.
2. FAA policies regarding the ASRS are covered by Advisory Circular 00-46C, FAR 91.25, and paragraph 2-38 in the "Facility Operations and Administration" handbook (7210.3K). The waiver of penalties is subject to the following limitations: (A) the alleged violation must be inadvertent and not deliberate, (B) it must not reveal an event subject to section 609 of the federal aviation act, (C) the reporter must not have been found guilty of a violation of the FARs or the Federal Aviation Act during the preceding five years, and (D) the ASRS report must be submitted within 10 days of the event.
3. The ASRS professional staff is composed of retired controllers, as well as both active and retired pilots. To avoid conflicts of interest, ASRS analysts, researchers, and management personnel are not permitted to have ongoing employment relationships with the FAA, air carriers, or similar organizations.
4. ASRS's mailing address is: P.O. Box 189, Moffett Field, California, 94035-0189.

Since its inception in 1990, BASIS, the British Airways Safety Information Service, has become the world standard aviation safety application. It is now in service not only with many major airlines, but with key international safety and regulatory bodies and aircraft manufacturers.

The system was developed by end-users and systems analysts to be **exceptionally easy to operate** and eliminate the majority of paperwork. BASIS provides both new and experienced safety professionals with powerful analysis capability, empowering them to answer both straightforward and highly complex queries with speed and precision without resorting to manuals or specialists.

A fundamental principle supporting BASIS is an **open penalty-free reporting culture.** This encourages staff to contribute high quality safety information without fear of recrimination.

A **risk analysis** assessment is made of all the incoming safety information which takes into account both severity and recurrence elements. Areas of significant risk can be readily identified, analysed and

BASIS. Already managing safety information for over 100 airlines, aviation authorities and aircraft manufacturers worldwide.

preventative efforts targeted accordingly. Analysis by frequency, delay and cost is also possible. Moreover, BASIS now incorporates a powerful Human Factors evaluation matrix.

The whole safety process is managed through a reliable **paper-free system** that will communicate with all sections of an organisation. BASIS entirely supersedes old methods involving literally tonnes of paper data, but very little usable information.

BASIS has been made widely available through Speedwing, a division of British Airways, which has unparalleled experience of the air transport industry.

Its expertise is based on 25 ye of building long-standing relationships with customers, covering the supply of systems, strategic and implementation consultancy, operations and communications - long term proven solutions that work.

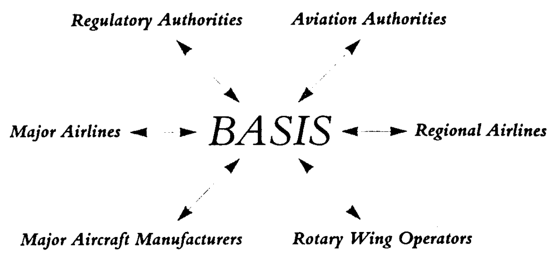
Safety Aware Culture. BASIS encourages a positive attitude to safety, across individual organisations and throughout the world. BASIS, offers effective communication between relevant departments, encourages greater scrutiny of safety management methods. In this sense BASIS is not just a system but a whole positive attitude to safety, both across an individual airline and across the world.

Risk Management. BASIS is primarily concerned with continuously improving the standard of safety performance through the assessment and management of risk. Easy communication of the BASIS assessment to all relevant safety, operational and technical departments promotes validation by the specialists and prioritisation of action to prevent occurrence or recurrence.

Safety Information Exchange. User organisations have the option to participate in the programme of BASIS international safety information exchange.

BASIS information exchange within the UK was pioneered by the UK Flight Safety Committee in 1992, and within

BASIS in action: multiple benefits through an established system.



BASIS has paved the way for the global exchange of safety information between airlines, aircraft manufacturers, and aviation authorities.

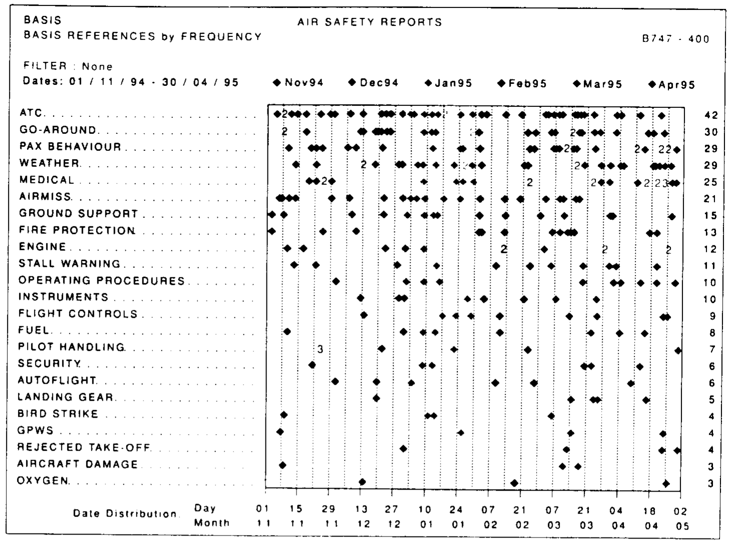
Europe by the European Regional Airlines Association in 1993. Carriers from North America, Africa, Europe and the Middle and Far East have widened the scope for rapid access to comparative data.

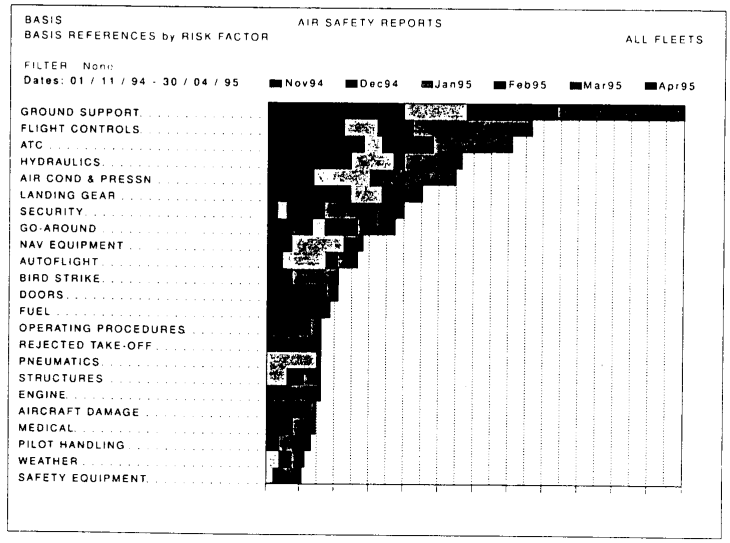
Participants can access the global safety information from BASIS users throughout the world's aviation industry. The same high level of analysis is possible as with in-house data.

This offers organisations the ability to analyse and compare their safety problems with those of others and acquire their solutions

"The aim of the exchange is [illegible] provide, with a single key stroke, the industry's answers to every possible type of problem, in a system which is networked throughout each airline." *Callum MacGregor, Senior Air Safety Investigator, British Airways.*

Whether it's the frequency of incidents...





...or a sophisticated risk analysis task, BASIS provides support for informed safety decisions.

BASIS into the future.

Continuous improvement is key to the overriding concern for aviation safety. BASIS has been designed from the start as a flexible, forward-looking system. Its evident success around the world demonstrates the versatility of the system and the strength of the philosophies which lie behind it.

The future direction of BASIS continues to be driven solely by those who use it. Development proposals and global safety trends are discussed at the BASIS User Group Conference which is attended by representatives from the participating organisations and airlines.

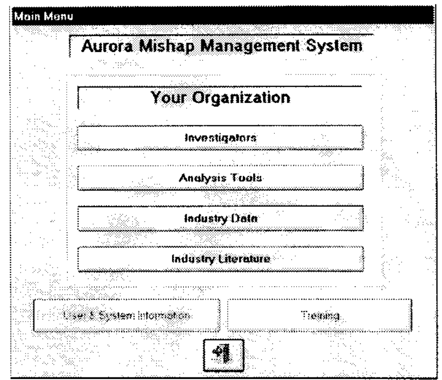
Additional BASIS modules are at an advanced stage of development. These will offer a similar standard of analysis and risk management in the fields of flight data recording, confidential human factors reporting, maintenance defects, quality lapses and ground handling incidents.

" The strength of BASIS lies not in the storing of information, but in using it to ask questions about the operation and to provide some answers ... a practical probing into all the available data with the intention of uncovering the unknown and undesirable." *Captain Mike Holtom, Manager Safety Systems, British Airways.*

BASIS operates on any IBM-compatible PC, running DOS, OS/2 or Windows. The progr can be run either stand-alone or networked. It does not require any other licence or supporting software.

Appendix K - AMMS Brochure

An Overview of the Aurora Mishap Management System (AMMS)



AMMS, developed by Aurora Safety and Information Systems, Inc., is a safety information system, with emphasis on human error management, providing customers with the methods and tools to improve safety and reduce costs. Users of AMMS can perform computer-assisted mishap investigations, conduct analyses, and develop prevention strategies to reduce future errors. AMMS is available as a complete solution, with software, and training- to start you down the road of human error management.

INVESTIGATORS

At the heart of AMMS is a computerized investigative tool for Maintenance, Ground Operations, and Flight Operations mishaps. The interactive investigator prompts the user to respond to questions based on the answers to previous questions. Thus only relevant questions for each investigation are asked, providing maximum detail in minimum time. The investigator module aids in the collection of relevant information and immediately stores this data in a protected data base for analysis. Along with AMMS training, this module provides the human investigator the necessary tools to enhance their ability to uncover the true contributors to error.

ANALYSIS TOOLS

AMMS contains two distinct analysis tools. The *Information Retrieval* module enables the user to quickly examine data in ways only limited by his or her own imagination. Queries are created with point and click functionality and results are displayed as graphs and tables. This module incorporates "drill down" which allows the analyst to access and view the individual mishap records which comprise a bar on a graph. The *Information Retrieval* module provides a substantial data mining capability all within the same user interface and using the same functionality as the other modules within AMMS. Customer owned data bases can be accessed and analyzed using the same point and click functionality used to query the investigator data base. It also enables the results of analysis to be passed to the *Prevention Strategy Analysis* module.

The *Prevention Strategy Analysis* module is designed to provide a structured repeatable process to propose and evaluate prevention strategies to reduce or prevent future mishaps. This module provides the capability for an analyst to justify these strategies by projecting return on investment or net mishap reduction. Other metrics can be added based o the needs of specific users. By saving the query and rationale used to develop a prevention strategy, it also provides the analyst with the ability to perform a post-implementation assessment after a prevention strategy has been implemented in order to evaluate its effectiveness.

INDUSTRY DATA

This optional module can include a wide sample of publicly available data. Use of this type of data can be beneficial for correlation and or comparison to determine whether others are experiencing similar mishaps. Using the same information retrieval tool, the analyst can easily search customer specified data bases such as FAA ASRS reports and Service Difficulty Reports.

INDUSTRY LITERATURE

Currently this section of AMMS contains the International Civil Aviation Organization (ICAO) human factors circulars, valuable reference material now available electronically through AMMS and searchable with the Folio narrative search engine. Users can select the specific human factors circular of interest and view it directly on screen. Or, they can conduct complex searches using plain English text. Additional reference material can be incorporated based upon customer needs.

SUPPLEMENTAL INFORMATION

The optional *Supplemental Information* module provides access to a variety of information unique to each customer such as policies and procedures manuals, emergency response plans, cabin logs, and historical mishap records. This type of information can help support mishap investigations and the collection of information through AMMS. These electronic documents can be quickly and effectively searched using Folio®. As the world's most powerful pc-based free form textual search engine, Folio® gives our users unprecedented capability to find pertinent information in large amounts of narrative data.

SECURITY & CONTROL

Given the extremely sensitive nature of customer data, Aurora employs several measures to ensure security. These measures include encryption of data to make it unintelligible to all but authorized users, password protection which makes the system available only to authorized personnel, and multiple levels of access which ensure that users have access consistent with their level of authorization. Additionally, AMMS software and periodic updates can be distributed on CD-ROM with each CD-ROM disk serially numbered and coded to work only with a designated computer. These and other security features are incorporated in full cooperation with each customer resulting in a customized installation for each customer.

DATA SHARING

Aurora believes that sharing pertinent data on mishaps experienced by our customers is an important step in continuing efforts to reduce costs and improve safety across the industry. But, customers own their data and they determine if or what data will be shared outside of their company. To this end Aurora will work with our in order to facilitate sharing of data.

TRAINING

Aurora offers a three day class for AMMS investigators and analysts. This class covers an introduction to human factors, human error management theory, interviewing techniques, and the use of the AMMS tools. Depending on the needs of the customer, this class can be tailored to provide emphasis on particular unique issues or customer implementation. Additional training, such as the *Prevention Strategies Workshop* are available based upon specific customer needs.

SUMMARY

AMMS is an extremely powerful integrated suite of tools which provides those who are tasked with investigating and reducing mishaps or incidents the requisite tools to investigate, analyze, and develop prevention approaches. With its friendly user interface and readily understood functionality, AMMS represents the application of proven technology for the improvement of safety and reduction of costs. This suite of tools is unmatched and is available now from Aurora Safety and Information Systems, Inc.

Contact us for pricing information. Multiple user license discounts for network installations are available.

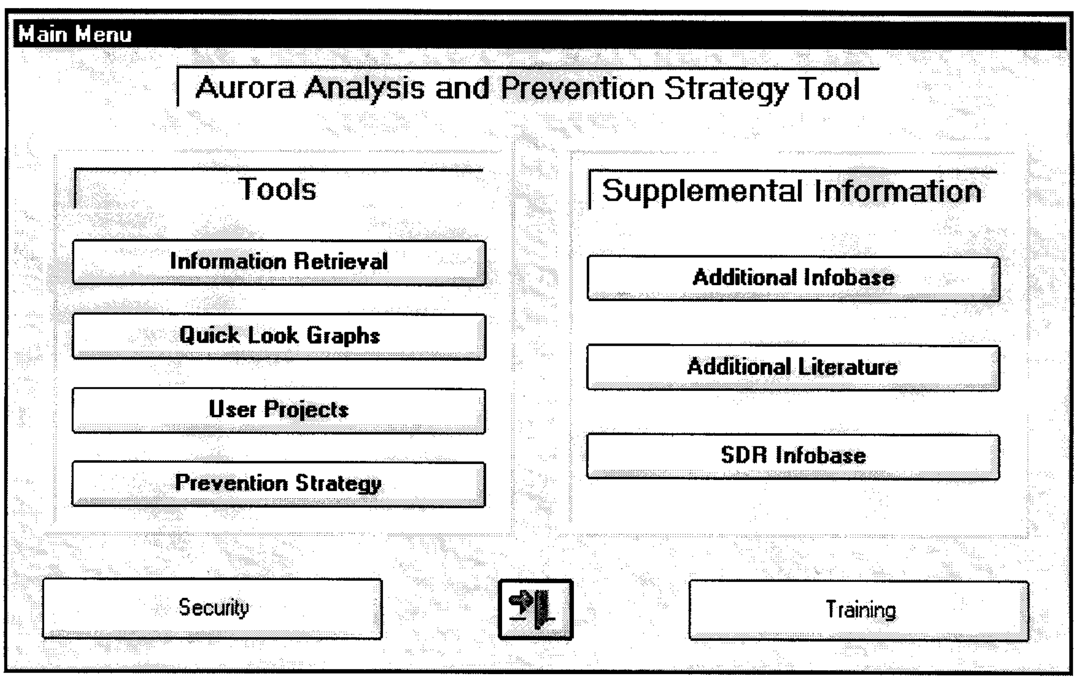
Aurora Analysis and Prevention Strategy Tool (APSAT)

Background

Nearly every company has data stored in numerous databases. The databases may be as diverse as pilot logs, injury claims, and information about delayed departures. This information is typically collected and used only by a single functional area that collects and holds the data. Typically, this data is stored in different types of data base software, with little or no capability to analyze the data. Even if there is some type of analysis capability, it is typically different for each database. Thus if you want to determine if there is a relationship between Service Difficulty Reports (SDRs) and pilot logs, you would have to learn two different systems, and then be able to compare the results.

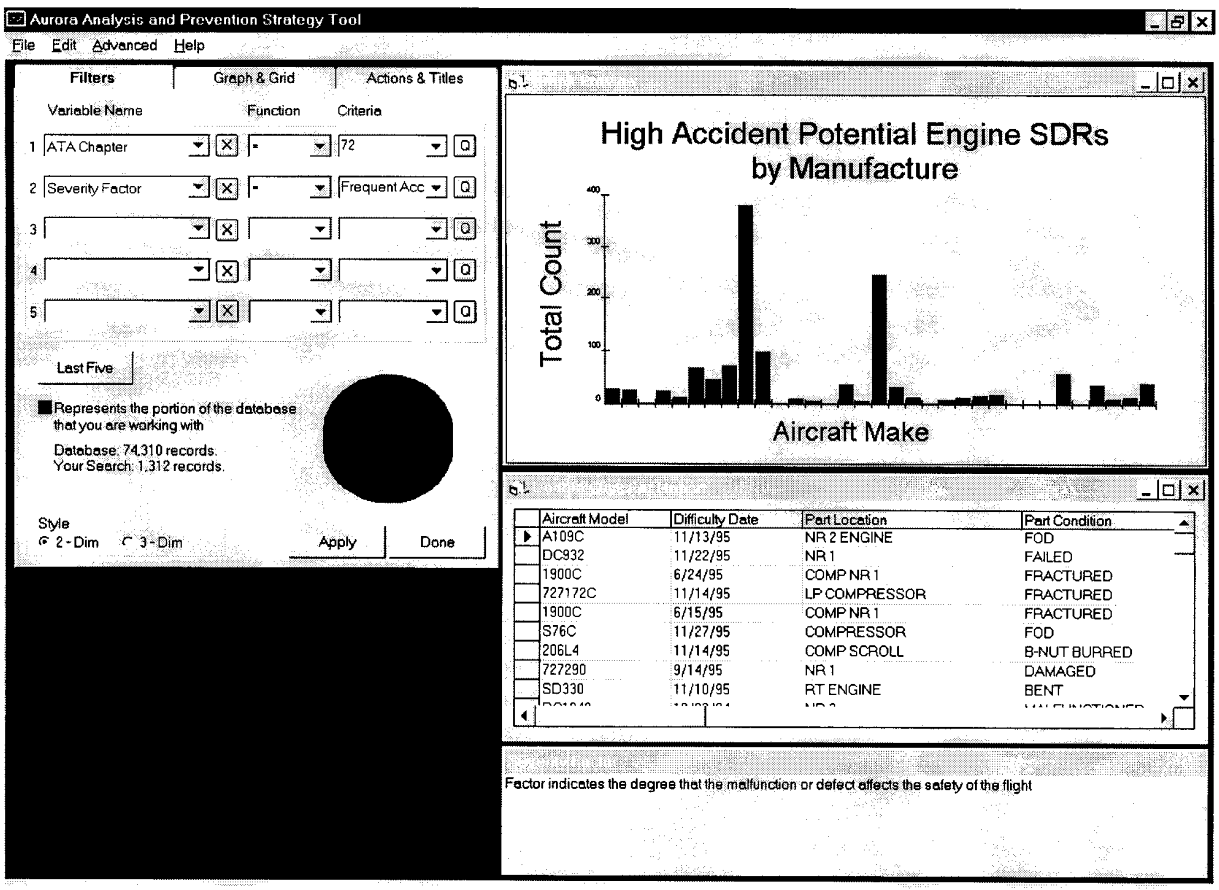
Aurora's Solution

Aurora has developed an integrated suite of tools to analyze data, develop, and assess prevention strategies (corrective actions) using existing customer data bases. This product is APSAT. APSAT can connect directly to a customers data bases using ODBC drivers, or work against an extract of the data, depending on the customer's desires. For each database that the customer wants to analyze, a table within the APSAT tool is built that contains plain English names for each field, as well as a short description of the data field. This enables those who are unfamiliar or who are not data base experts to analyze the data without having to know the database structure or esoteric naming conventions. APSAT has a simple point and click interface that provides both graphical and tabular access to the data.



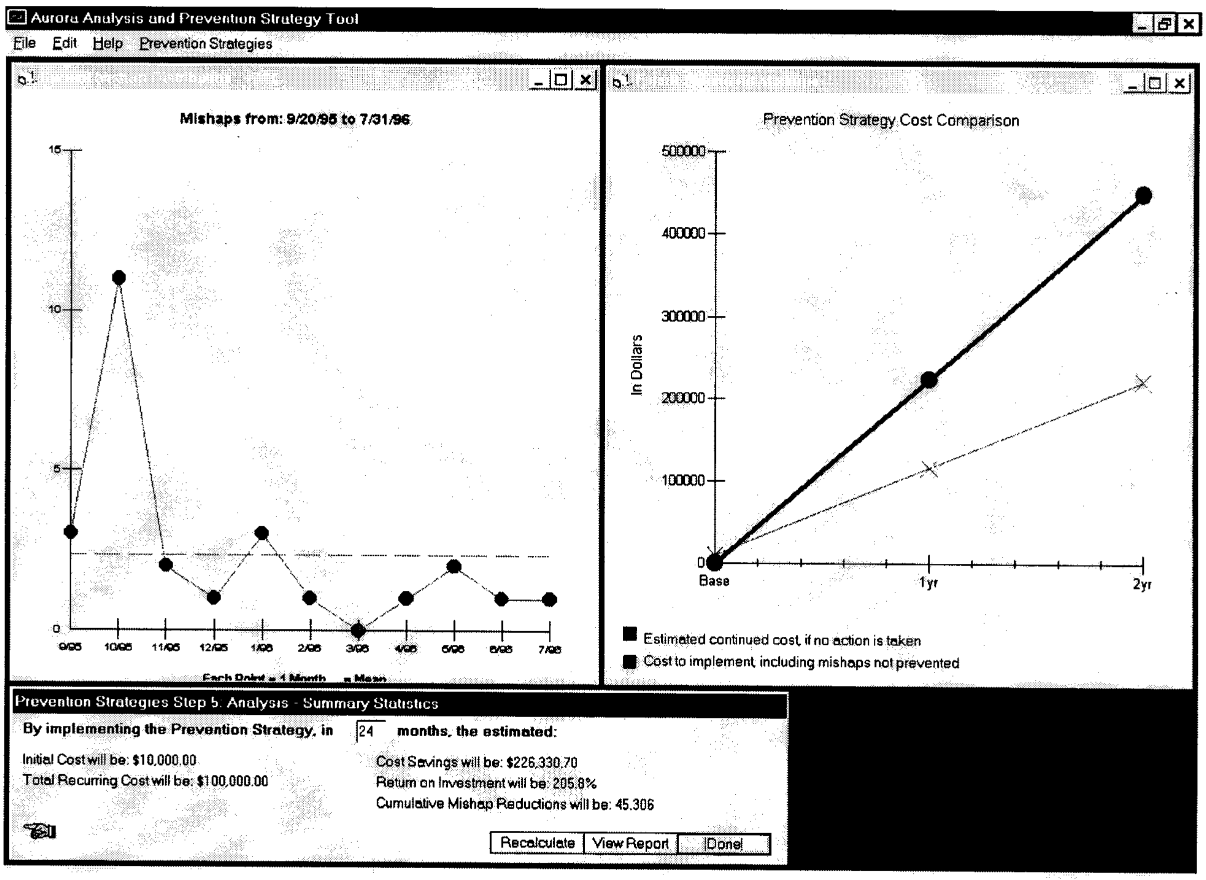
Information Retrieval

The information retrieval portion of APSAT uses pick lists and simple point and click options to filter data and customize the graphs or data elements desired. Graphs, queries, and data can be saved both for external use such as briefings and for later analysis within the tool. Users select the data base and then apply filters to narrow their search to the specific areas of interest. Results are simultaneously displayed graphically and in a tabular listing. Additionally, a pie chart is displayed where the entire pie represents the data base and the highlighted slice represents the portion of the data base that the user is working with after the application of the filters. By placing the mouse cursor on a bar within the graph and clicking the mouse button, the user is able to perform a drill down to the individual events that comprise the selected bar on the graph. A tabular listing of those events is then displayed. Another drill down is available by selecting a single event. The report associated with the selected event is then displayed. Information retrieval is a critical part of the process of understanding the types of events that occur and to being able to develop effective and affordable corrective actions. Our approach provides a powerful search and retrieval capability in an easy to use and easy to understand user interface.



Prevention and Cost Savings Strategies

The prevention strategy module allows appropriate technical, safety, and management personnel to analyze data, identify systemic issues, develop and evaluate prevention strategies, and review effects of previously implemented strategies. This tool uses the same user friendly interface as the information retrieval module to filter the data. Initially, events are identified that meet the user defined profile associated with a particular type of incident or problem, then a step by step procedure is followed to build and evaluate the effects of a proposed strategy. The system supports multiple "what if" analysis, so that upper and lower limits of effectiveness and cost for possible prevention strategies can be evaluated. The results include a forecast of the cost of doing nothing, and the expected cost of implementing the strategy with its impact on the number of future mishaps. These results are displayed in easy to understand graphs and textual summaries.



Narrative Search

This add-on module is designed to allow quick and easy searching of large volumes of narrative information, because in addition to the structured data that a company has about its operations it typically has a large volume of written information. This textual information generally includes operations manuals, policies and procedures manuals, and narrative reports of incidents and accidents. The capability to quickly and accurately search large volumes of textual information has many benefits. It might be as simple as searching a procedure manual for the appropriate section to do a specific job. Another example is searching ground incident reports to determine is a particular vendor or contractor is involved in incidents that negatively impact flight operations at a single site, or at several different airports. If this information is in filing cabinets on paper reports, it will take many hours to find the necessary information. If the information is contained in word processed reports, it will take from minutes to hours to assemble all of the reports and then read through them. But, if these reports are contained in a Folio Infobase, the search will be completed by the time a user finishes typing the search phrase. Through the power of Folio™ Infobase technology large volumes of information could be searched nearly instantly. This capability also includes proximity, synonym, and various wild card searches. Not only can you search large volumes of information quickly and accurately, but the information can be personalized by adding highlighters and notes to the text, just like you would for a paper document. Any electronic document can be converted to a Folio™ Infobase. Scanning and optical character reading services are available to transform hard copy documents into electronic format. Folio Infobase technology and Aurora help you to turn large amounts of data into information that can be used to make important decisions that can improve your operation and save money.

For more information please contact:

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Edgewood, NM 87015

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E-mail: obrientp@aol.com

Justification for the "48,800" Number

Skepticism will undoubtedly meet the assertion that 48,800 aircraft per year in the US are dispatched in a technically unairworthy condition because of maintenance error. Such a high number is intuitively inconsistent with our observations of an extremely reliable aviation system. Thus, I provide the following as justification of this number.

First, what is meant by "technically unairworthy"? Per case law, an aircraft is "unairworthy" when it meets one of two conditions. First, the aircraft is out of conformity with its type design, or second, the aircraft is not in a condition for safe operation. For example, a technician who dispatches an aircraft with a missing O-ring has dispatched an aircraft in an unairworthy condition because the aircraft is out of conformity with the type design that requires an installed O-ring. However, this is not to say that an out-of-conformity aircraft is necessarily unsafe. Even on an aircraft with just two engines, one engine missing an oil system O-ring may not always be an "unsafe" condition. An example of a clearly unsafe aircraft would be an aircraft dispatched with its wing de-icing boot partially installed, as there is no redundancy or tolerance for this particular error. The statistic that 48,800 unairworthy aircraft are dispatched into revenue service each year does not necessarily mean that 48,800 *unsafe* aircraft were dispatched into revenue service. It does mean that 48,800 aircraft were dispatched out of conformity with their type design because of a technician's error. And perhaps most important from a human factors perspective, is the dispatch of 48,800 aircraft in a condition other than what the technician ultimately intended.

For two reasons, I was unable to *exactly* determine how often aircraft are dispatched in an unairworthy condition because of maintenance error. First, no air carrier in the US today has that particular data. Air carriers do not track maintenance error as a class of event. Whether an oil leak was caused by a failed O-ring or a mis-installed O-ring is not generally tracked within an air carrier. Second, it's difficult to determine from today's typical logbook write-up whether an aircraft discrepancy was caused by maintenance error. In fact, "defensive logbook write-ups" have developed in response to the typically punitive response to maintenance error. For example, to protect a colleague, a technician who receives an aircraft with a missing O-ring might write in the log that he has "installed a new O-ring." Evidence of a preventable error is made invisible in this write-up. While industry debates the prevalence of defensive logbook write-ups, my conversations with numerous technicians and engineers indicates that a considerable number of errors fall into this category.

To determine how often aircraft are dispatched out of conformity, I needed a valid data set from which to extrapolate an overall number. Engine in-flight shutdowns (IFSDs) fulfilled this need. The FAA mandates reporting of Engine IFSDs and they are of such a critical nature that inaccurate or misleading causal explanations are minimized. The Boeing 1994 study indicating that of 1443 IFSDs investigated, 276 involved errors by the technician performing an earlier maintenance task, provided the starting point:

19.1% of IFSDs are caused by maintenance error

This number is the percentage of one class of in-flight events that are caused by maintenance error. Next, it is important to extract from this number the IFSD events that were caused by pilot error, thus leaving the percentage of "mechanical IFSDs" caused by maintenance error. Engine manufacturer data reviewed suggested that 6% of IFSDs were caused by pilot error.[1] Thus, the figure was altered as follow:

19.1% ÷ (1-.06) = 22.9% of Mechanical IFSDs caused by maintenance error

This number then tells us what percentage of mechanical IFSDs are caused by maintenance error. The next step was to extrapolate this number to say that an equal percentage of all mechanical in-flight events are caused by maintenance error (that is, errors in previous maintenance). While this is the largest stretch in this analysis, no available data contradicts this assertion. That is, there is no reason to believe that other non-IFSD flight discrepancies are either more or less susceptible to maintenance error. Extrapolating this number gives us:

22. 9% of mechanical discrepancies identified in flight are caused by error in a previous maintenance task.

The next task was to determine how often aircraft experienced in-flight faults. An actual figure for this piece of data was not available because of the required complexity for any carrier to develop an accurate count. In many cases, discrepancies stay with an aircraft for a number of flights. Additionally, many discrepancies are permissible per the Minimum Equipment List (MEL) while others may involve non-critical systems not covered by the MEL. Although one carrier did state that approximately 14% of aircraft experience at least one mechanical discrepancy per flight, to keep these calculations on defensible and steady footing, I used an average mechanical dispatch reliability of 98%.[2] That is, in approximately 2% of flights, the aircraft experiences delay or cancellation to correct a mechanical discrepancy leading to some in-flight manifestation. While this is an extremely conservative figure and ignores all mechanical discrepancies not resulting in a delay or cancellation, it nevertheless provides the following extrapolation:

22.9% X 2% = .458% of flights involve an aircraft dispatched out-of-conformity because of a maintenance error

I next needed a total number flights in the US to determine the number of aircraft dispatched in error. NTSB data shows that there were 8,185,000 Part 121 and 2,474,000 Part 135 flights in the US in 1996.[3] Using this number, the total number of aircraft dispatched out of conformity because of maintenance error is:

.458% X (8,185,000 + 2,474,000) = 48,818 aircraft dispatched into revenue service out-of-conformity in the US each year because of a maintenance error.

Using available data, this final number is a "best estimate" of how often technicians make errors that manifest themselves as mechanical discrepancies on revenue flights.

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[1] Unpublished Boeing Study of Engine In-Flight Shutdown Causes shown in *The Effect of the Maintenance System on the Aviation Accident and Incident Rate*, Boeing Commercial Airplane Group, October 16, 1995. (Results published in *Approaches to Controlling Maintenance Error*, James Reason, Ph.D., Meeting Proceedings, Federal Aviation Administration's Eleventh Meeting on Human Factors Issues in Aviation Maintenance and Inspection, March 12-13, 1997.)

[2] Estimation of average mechanical dispatch reliability confirmed by a number of air carrier representatives. Actual data was not used because aircraft manufacturers, for competitive reasons, each use a different definition of mechanical delay.

[3] www.ntsb.gov, Accidents, Fatalities, and Rates, 1996 Preliminary Statistics, U.S. Aviation.