



Operator's Manual

Human Factors in Aviation Maintenance

<http://www.hf.faa.gov/opsmanual>

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INTRODUCTION

This manual is in response to the industry's requests for a simple and manageable list of actions to implement a Maintenance Human Factors (MHF) program. A panel of experts selected the following six topics for such a program to be successful:

1. Event Investigation
2. Documentation
3. Human Factors Training
4. Shift/Task Turnover
5. Fatigue Management
6. Sustaining & Justifying an HF Program

For each of the six topics that contribute to the success of any MHF program, this manual offers the following:

- Why is the topic important?
- How do you implement it?
- How do you know it is working?
- Key references

Like any good operator's manual, this document tells you what to do without excessive description of why you should do it. This manual recognizes you already know the importance of Human Factors. For detailed information, see the "Key References" at the end of each topic.

The selected six topics are critical because they are based on operational data and practical experience from the US and other countries. Transport Canada (TC), United Kingdom Civil Aviation Authority (UK CAA), and the European Aviation Safety Agency (EASA) regulations contributed to this manual. The steps are derived from a panel of ten industry and government contributors who have worked in aviation maintenance for an average of twenty-five years and in MHF for fifteen years. The contributors characterized these six topics and related steps as "information they wish they had known 15 years ago."

These straightforward suggestions provide the key components for implementing a successful MHF program that will benefit your company, business partners, external customers, and the entire industry. Information is presented in summary bullets as follows:

- These are six topics, from many, that a MHF program may consider.
- Topics are not necessarily in order of importance, except that the data obtained from Event Investigation (Section 1) provide the foundation for many Human Factors activities.
- You may implement any or all of the topics, however, they should be coordinated.
- Your MHF activity should be based on the identified requirements and resources of your organization.
- You are encouraged to supplement this Operator's Manual with additional references.
- This document satisfies the industry request for a short and straightforward list of important actions.

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EVENT INVESTIGATION

Chapter 1



"Jackscrew assembly failure caused by excessive wear resulting from insufficient lubrication... contributing factors included extended lubrication and end-play check intervals, lack of available parts, organizational norms, regulatory oversight issues, etc."

NTSB AAR-02/01 FINAL REPORT

EVENT INVESTIGATION

Chapter 1

The purpose of an event investigation process is to manage the risks from events caused by human actions that may affect flight safety, personal injury, and equipment damage. An error is a human action that unintentionally deviates from the required, intended, and expected action. A violation is a human action that intentionally deviates from company or regulatory policies or procedures.

Event investigations help organizations identify and understand multiple contributing factors to errors and violations. Examples include hard-to-understand procedures, time pressure, task interruption, poor communication, and a variety of additional workplace and life conditions. The identification of these contributing factors provides an organization with a specific focus to prevent future events. Often event investigation systems are part of a company's overall safety management system.

1.1 Why Event Investigation is important

- A. Maintenance was the primary cause of 8.3% of the US accidents in the 1990s for 100+ passenger jets.
- B. A maintenance event started the accident chain in 26% of the worldwide accidents in 2003 for Western- and Eastern-built jets and turboprops.
- C. Worldwide ramp incidents cost \$5 billion in 2004.
- D. Event investigation programs help to identify contributing factors to errors and violations and to create corrective actions to prevent future events.
- E. Event investigation is a method for sharing human performance issues within the organization.
- F. Event investigation is a key part of a Safety Management System, required by many National Aviation Authorities (NAAs).

1.2 How to implement an Event Investigation process

- A. Select a manager/department to be responsible for the process.
- B. From the very beginning, ensure that the program is a cooperative endeavor of labor, management and, if appropriate, the regulator.
- C. Select an investigation process that systematically determines the contributing factors of events and on the basis of these findings develop and monitor a comprehensive fix.
- D. Write the policies and procedures needed to implement the event investigation process.
- E. Consult applicable guidance on voluntary reporting systems, such as FAA's Aviation Safety Action Program (ASAP).
- F. Develop and implement a reasonable, consistently applied, company disciplinary policy.
- G. Identify screening criteria to determine which events will be investigated.
- H. Select and train all investigators—company as well as labor—in a consistent manner to minimize interpretation differences later. Invite/encourage regulatory inspectors to attend such training sessions.
- I. Communicate with management and workforce about the event investigation process to obtain their input and buy-in.
- J. Establish a team to review the investigation findings and to select areas for improvement.

EVENT INVESTIGATION

Chapter 1

- K. Follow up to ensure that needed improvements are being made.
- L. Inform all personnel on the status of improvements in progress. Use newsletters, company/labor websites, crew meetings, and posters to demonstrate and remind everyone that the process is working and somebody is actually tracking the progress.
- M. Create a database for documenting investigation information and measures of change. Events and contributing factors should be classified according to a standardized system so that data can be analyzed, summarized and trended. Examples of existing classification tools include Maintenance Error Decision Aid (MEDA) and Human Factors Analysis and Classification System—Maintenance Extension (HFACS-ME).
- N. Use risk assessment techniques to quantify specific event likelihood and severity.
- O. Evolve the system to include reporting of potential events that are also called threats.

1.3 How to know is working

- A. Events are investigated to understand the contributing factors, and corrective actions are developed to reduce the likelihood of future occurrences.
- B. Deviations from existing procedures are uncovered during the investigations, and they are corrected.
- C. The number of events caused by human performance decreases.
- D. The operator saves time and money by decreasing interruptions to revenue flights, rework, personal injuries, and equipment damage.
- E. Throughout the maintenance organization, personnel are discussing events, contributing factors, and corrective actions.
- F. Positive results from an internal audit or adherence to regulatory guidelines.
- G. All parties increasingly accept voluntary reporting systems.

1.4 Key References

- A. Aviation Safety Action Program AC 120-66B (http://www.faa.gov/safety/programs_initiatives/aircraft_aviation/asap/policy/).
- B. HFACS-ME (www.hf.faa.gov/docs/508/docs/maint_product638b.pdf).
- C. Maintenance Error Decision Aid (MEDA) User's Guide and Results Form and Ramp Error Decision Aid (REDA) User's Guide and Results Form (MaintenanceEngineering@boeing.com and 206-544-7608).
 - MEDA User Guide (www.hf.faa.gov/opsmanual/assets/pdfs/MEDA_guide.pdf)
 - MEDA form (www.hf.faa.gov/opsmanual/assets/pdfs/MEDA_form.pdf)
 - REDA form (www.hf.faa.gov/opsmanual/assets/pdfs/REDA_form.pdf)

DOCUMENTATION

Chapter 2



"Mechanics would benefit from using Airliner Maintenance Manuals with more specific instructions for critical flight system procedures."

NTSB/AAR-04/01

DOCUMENTATION

Chapter 2

Documentation ranges from manufacturers' technical manuals to an organization's job cards to publications from your regulator. Numerous post-event investigations have clearly demonstrated that failure to use documentation appropriately was a major contributing factor. Issues associated with maintenance documentation are related to the way the information is written, to where and how it is accessed in an organization, and to the motivation of aviation maintenance personnel. There are often numerous and diverse reasons that documentation is not used properly. A good MHF program must address and correct documentation challenges.

2.1 Why Documentation is important

- A. A 2004 UK Flight Safety Committee determined that the top three causes of maintenance mishaps were:
 - 1. Failure to follow published technical data or local instructions.
 - 2. Using an unauthorized procedure not referenced in the technical data.
 - 3. Supervisory personnel accepting non-use of technical data or failure to follow maintenance instructions.
- B. A 2001 FAA study found that documentation is the leading contributing factor to maintenance events. In most cases organizational issues resulted in failure to use documentation that was available.
- C. A 2002 study of procedural issues from NASA Aviation Safety Reporting System incident reports showed that the following factors contributed to documentation-related errors: procedural design flaws, user errors, currency and accessibility of documents, and organizational practices.
- D. Aviation maintenance personnel spend from 25-40% of their time searching for, using and completing maintenance documentation.

2.2 How to implement a Documentation program

- A. Ensure that your event reporting system is capturing events where documentation is a contributing factor; code these events so that focused interventions are developed and tracked.
- B. When implementing technology upgrades or changes to the document system, preserve standardization and best practices; take the opportunity to address current problems.
- C. When addressing standardization issues across mixed fleets, use industry working group to achieve standardization (e.g., structure, terminology, logic) within and across manufacturers.
- D. For technical documentation that is developed by the maintenance organization, develop guidelines and standards for the documentation development. The guidelines/standards should include the following:
 - 1. Use a standard format and page layout.
 - 2. Use one action per statement.
 - 3. Write DANGER, WARNING and CAUTION statements using current international (American National Standards Institute/International Standards Organization) standards.

DOCUMENTATION

Chapter 2

4. Avoid using acronyms and abbreviations.
 5. Ensure that where an arrow is pointing to a figure or graphic it is immediately obvious.
 6. Use A Guide for the Preparation of Aircraft Maintenance Documentation in the International Aerospace Maintenance Language (Simplified English).
 7. Verify the documentation by having a second person check for technical accuracy.
 8. Validate the documentation by having a sample of users check for usability.
- E. Provide a process for immediate and longer-term improvements to technical documents based on user feedback.
 - F. Ensure prompt acknowledgement to submissions for document change.
 - G. Respond to the document improvement suggestion in a timely manner.
 - H. Develop measures to track specific documentation problems and corrective actions.
 - I. Be sure the document delivery system is functional and well maintained.
 - J. Use advice from documentation research and industry best practices.

2.3 How to know it is working

- A. Event investigations and audits indicate a reduction in the number of documentation-related incidents and findings.
- B. There is an increased employee use of documentation, which could require additional access, room, and equipment.
- C. Users report inaccurate, ambiguous, or incomplete documentation.
- D. Recommended changes to documentation are being acknowledged and addressed in a timely manner.
- E. Immediate and longer-term change requests may increase following program modifications and spike under certain conditions (e.g., new fleet), but should decrease over time.
- F. There are decreased documentation complaints from users.
- G. Authoring groups adopt a higher standard of quality, including verification and validation.

2.4 Key References

- A. SD Simplified Technical English (2005). AeroSpace and Defense Industries Association of Europe Specification ASD-STE100(tm) (http://www.simplifiedenglish-aecma.org/Simplified_English.htm#se_guide).
- B. Inaba, K., Parsons, S.O., and Smillie, R. Guidelines for Developing Instructions. Boca Raton, FL; CRC Press (ISBN 0-415-32209) (Amazon.com).
- C. United Kingdom Civil Aviation Publication (CAP) 716: Aviation Maintenance Human Factors (EASA Part-145), Chapter 6 and Appendices N and O. (<http://www.caa.co.uk/docs/33/CAP716.PDF>).

HUMAN FACTORS TRAINING

Chapter 3



"The Safety issues raised in this report include:...The Human Factors aspects of air carrier maintenance and inspection for the continuing airworthiness of transport category airplanes, to include repair procedures and the training, certification and qualification of mechanics and inspectors."

NTSB AAR-89/03 FINAL REPORT

HUMAN FACTORS TRAINING

Chapter 3

Research and experience have shown that Human Factors training can address many of the issues that contribute to events. Training can reduce costs associated with human performance issues.

3.1 Why Human Factors Training is important

- A. Human Factors training is instrumental in fostering a positive safety culture.
- B. Human Factors training for the workforce, including for the leadership, is a critical and cost-effective first step in identifying methods to recognize, understand, and manage human performance issues.
- C. Effective Human Factors training not only improves work performance, but also promotes workforce physical and psychological health.
- D. Initial and recurrent training on new regulations, procedures, and equipment are opportunities to reinforce awareness of the Human Factors issues that affect job performance.
- E. ICAO and many NAAs mandate or recommend Maintenance Human Factors training, recognizing its impact on safety and quality.

3.2 How to implement a Human Factors Training program

- A. Maintenance Human Factors experts have identified the following key topics to be included in a training program:
 - 1. General/introduction to Human Factors.
 - 2. Safety culture/organizational factors.
 - 3. Human error principles, event investigation and case studies.
 - 4. Human performance and limitations.
 - 5. Environment.
 - 6. Procedures, information, tools and task sign-off practices.
 - 7. Planning of tasks, equipment, and spares.
 - 8. Communication.
 - 9. Teamwork.
 - 10. Professionalism and integrity.
 - 11. Shift and task turnover.
 - 12. Undocumented maintenance.
 - 13. Fatigue management/fitness for duty.
- B. Determine training requirements and company priorities to map to the key topics listed above.
- C. Work to ensure cooperative development between workforce and management.
- D. Integrate training with a system wide Human Factors plan.

HUMAN FACTORS TRAINING

Chapter 3

- E. Decide on content and delivery technique matched to audience requirements.
- F. Decide on internal/external provider.
- G. Deliver initial training and begin planning for recurrent training.
- H. Measure the effects of training, provide feedback to the instructors and the management, improve training, and measure the effects again.

3.3 How to know it is working

- A. Regulatory program acceptance/approval.
- B. Management/Workforce acceptance/approval.
- C. Pre- and post-training evaluations and workplace discussions from trainees show positive trends.
- D. Event investigations indicate a reduction in the number of human-factors-related contributing factors. Expect increase in reported events at first because of improved awareness.
- E. Work performance is improved in targeted areas.
- F. Demonstrated employee behavior change towards safety awareness.
- G. Increased requests for more/recurrent training.

3.4 Key References

- A. Air Transport Association (2001). ATA Specification 104 Guidelines for Aircraft Maintenance Training. Washington, DC: Air Transport Association.
(http://66.153.70.186/ATA_eBiz/Default.aspx?tabid=44&action=ShowProductDetails&args=128).
- B. Federal Aviation Administration (2000). Maintenance Resource Management Training Advisory Circular AC 120-72. Washington, DC: Federal Aviation Administration
(<http://www.hf.faa.gov/docs/508/docs/AC120-72.pdf>).
- C. ICAO (1998). Human Factors Training Manual Doc 9683-AN/950. Montreal, Canada: International Civil Aviation Organization.
(<http://www.icao.int/anb/humanfactors/Documents.html>).

SHIFT/TASK TURNOVER

Chapter 4



"Departures from approved procedures included failures to solicit and give proper shift-change turnover reports, failures to use maintenance work cards as approved, failures to complete required maintenance/inspection shift turnover forms, and a breach in the integrity of the quality control."

NTSB AAR-92/04 FINAL REPORT

SHIFT/TASK TURNOVER

Chapter 4

Shift and task turnover are critical periods in aircraft maintenance activities because workers relay crucial information for ending a shift and starting another. This can also apply to an exchange of task information within a shift. Efficient and effective turnovers require adherence to policies, procedures, planning guidelines, teamwork, and effective communication practices.

The classic challenges associated with fatigue, distraction, false assumptions, personnel conflicts, cultural prejudices, and failure to properly document can negatively affect the quality of shift turnover as well as task turnovers within shifts. Events have shown us that inadequate information exchange during shift and task turnovers can have serious consequences.

4.1 Why is Shift/Task Turnover Important?

- A. Data show that poor shift/task turnover is a common contributing factor to events.
- B. Challenges related to shift turnover include:
 - 1. High demand for teamwork and interpersonal communication skills.
 - 2. Need for structured and standardized policies and procedures.
 - 3. Using a location that is conducive for discussion and planning.
 - 4. Ineffective verbal and written communication.
 - 5. Finishing workers are tired and want to depart facility.
 - 6. Lack of adequate shift overlap to provide time to give one-on-one briefings between the team leaving and the team coming on.
 - 7. Absence of a process to ensure departing personnel have documented all tasks accomplished or started.
 - 8. Minimal training on procedures for shift/task turnover.
- C. High-quality shift/task turnover procedures enable improvement in practice and improve safety and accountability to all involved in the work.
- D. Most NAAs have regulations that require a formal process for shift turnover.

4.2 How do you implement the Shift/Task Turnover process?

- A. Create and instill standard policies, procedures, and protocol.
 - 1. Formalize policy and procedures that make the turnover as important as the work.
 - 2. Develop, improve, and implement policies and procedures.
 - 3. Communicate policy and procedures to all personnel.
 - 4. Consider technology enhancements that improve the transfer of visual information (e.g., photos, graphics, movies).
 - 5. Consider best practices documents for shift/task turnover.

SHIFT/TASK TURNOVER

Chapter 4

- B. Provide a time and place for formal shift/task turnover.
 - 1. Dedicate a location for shift turnover meetings that is clean, comfortable, and relatively free of distractions. Access to computers and data sources should be provided, if appropriate.
 - 2. Include a dedicated time for a proper shift turnover within the regular work hours.
 - 3. Carry out the task turnover at the aircraft where the task is being accomplished.
- C. Ensure the quality of shift/task turnover Information.
 - 1. Standardize written communications.
 - 2. Ensure consistent level of detail in turnover documentation.
- D. Deliver initial and recurrent training on how to conduct a good shift/task turnover.
 - 1. Emphasize the criticality of shift/task turnover and impact on continuing safety.
 - 2. Emphasize use of checklists, shift status reports, and applicable shift/task turnover documents.
 - 3. Define acceptable communication practices.
 - 4. Describe how to conduct and participate in turnover meetings.

4.3 How to know it is working

- A. Decrease in regulatory findings/concerns related to shift/task turnover.
- B. Audit findings show reduced errors.
- C. Less task rework.
- D. Improved quality of the documentation for describing both the shift and task turnover processes.
- E. Noticeable improvement in communication and cooperation between/among shifts. Less "blaming the other shift."

4.4 Key References

- A. Maddox, M. (1998) Shift work and Scheduling in Maddox (Ed, 1998) The Human Factors Guide for Aviation maintenance and Inspection, Washington, DC. Federal Aviation Administration (<http://www.hf.faa.gov/docs/508/docs/shiftwork.pdf>).
- B. Jiang, X., Master, R., Kelkar, K. and Gramopadhye, A. K. (2002). Task Analysis of Shift Change Activity in Aviation Maintenance Environment: Methods and Findings, Human Factors and Aerospace Safety, 2(1), 45-69. (http://www.hf.faa.gov/opsmanual/assets/pdfs/Analysis_of_Shift_Change.pdf)
- C. Offshore Technology Report - OTO 96 003. Effective Shift Handover - A Literature Review. Health and Safety Executive. Author - Ronny Lardner. (<http://www.hf.faa.gov/opsmanual/assets/pdfs/CAP716.pdf>)

FATIGUE MANAGEMENT

Chapter 5



"A combination of 16 hours of straight work compounded by influenza contributed to fatigue and falling asleep at the wheel..."

AIRPORT INTERNAL REPORT

FATIGUE MANAGEMENT

Chapter 5

Fatigue can be caused by many factors, including physical and mental exertion and lack of proper sleep. Fatigue issues can also be called “Alertness” issues because alertness includes a broader range of factors associated with human fitness for duty.

Most aviation maintenance personnel, who have worked extended hours to repair an aircraft away from base, remember that they were fatigued more than they remember the complexity of the technical repair. The entire workforce is susceptible to errors induced by fatigue. FAA research found that the maintenance workforce does not achieve proper sleep. Further, the workforce does not recognize their fatigue and compensate accordingly.

Fatigue/Alertness Management programs are generally voluntary. Nevertheless, Fatigue/Alertness Management is an important component of a Human Factors program.

5.1 Why Fatigue/Alertness Management is important

- A. Longer commutes and extended shifts, double and triple shifts, shift swapping, and extra jobs impose greater demands on the workforce and reduce the time to sleep.
- B. Reduced numbers of maintenance personnel result in increased workload on remaining workers.
- C. Fatigue affects emotional, physical, and mental capabilities.
- D. Fatigue causes performance decrements similar to those caused by alcohol.
- E. Few regulations adequately address the issue of alertness.

5.2 How to implement a Fatigue/Alertness Management program

- A. Seek expertise to develop, implement, and measure the effectiveness of the program.
- B. Fatigue/Alertness Management programs must adjust to shift rotation patterns, worker schedules, and local circumstances.
- C. Encourage workforce participation and input.
- D. Ensure that fatigue issues are considered during event investigations.
- E. Implement Fatigue/Alertness Management awareness training.
- F. Ensure compliance with applicable regulations from your National Aviation Authority.

5.3 How to know it is working

- A. Less absenteeism/sickness/injuries.
- B. Less rework.
- C. Increased self-awareness of fatigue.
- D. Reduced events related to fatigue/alertness.

FATIGUE MANAGEMENT

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5.4 Key References

- A. ICAO (2003) Human Factors Guidelines for Aircraft Maintenance. Doc. 9824 Appendix H, of Chapter 3, 'Possible fatigue management interventions' (<http://www.hf.faa.gov/opsmanual/assets/pdfs/ICAOHF.pdf>).
- B. Johnson, W.B., Mason, F., Hall, S., and Watson, J (2001). Evaluation of Aviation Maintenance Working Environments, Fatigue, and Human Performance. Washington, DC: Federal Aviation Administration Office of Aviation Medicine. (<http://www.hf.faa.gov/docs/508/docs/WorkingEnvironments.pdf>).
- C. Dawson, D., Fletcher, A., and Hussey, F. (2001). Beyond the midnight oil. Proceedings of the 15 th Annual FAA Symposium on Human Factors in Aviation Maintenance and Inspection. (<http://www.hf.faa.gov/docs/508/docs/MidnightOil.pdf>).

SUSTAINING & JUSTIFYING AN HF PROGRAM

Chapter 6



"...various initiatives come and go sometimes based on corporate whims... a sustainable maintenance human factors program must have shared support from senior management and all levels of company personnel... the program must show value in continuing safety, worker job satisfaction, and cost control..."

W.B. JOHNSON, FAA

SUSTAINING & JUSTIFYING AN HF PROGRAM

Chapter 6

The first five topic areas of this document recommend specific actions. The topics of Program Sustainability and Cost Justification are general and apply to all aspects of a MHF program. MHF programs often get off to a good start but then struggle over time. Challenges to program sustainability include changes in policies and projects when management changes, a lack of cost justification, and limited program integration. The ideas presented here help sustain multiple MHF initiatives and provide a straightforward consideration of cost justification.

6.1 Why Program Sustainability is important

- A. Benefits of a MHF program are seldom immediate. A long-term commitment to the program is needed.
- B. A long-term sustained program is necessary to create and maintain culture change.
- C. Motivation and enthusiasm for programs will subside if programs are constantly changing like a “flavor of the month.”
- D. Programs must be sustained long enough to collect measurement data and demonstrate a Return on Investment (ROI).

6.2 How to sustain a MHF program

- A. Establish a Steering Committee to develop and monitor planning and implementation of MHF programs.
- B. Start with a program plan with sufficient detail to secure a policy-level commitment from leadership with workforce buy in.
- C. Ensure that each MHF-related initiative can stand-alone without depending on other MHF initiatives.
- D. Ensure that the program plan is consistent with corporate policies and procedures and that it is designed to achieve specific goals that are consistent with the corporate mission and values.
- E. Ensure that all parties within the company can share the success of various components of the program. Communicate these successes.
- F. Build an individual-level and team-level recognition system that acknowledges everyone's efforts to improve the system and celebrates successes.
- G. Prepare for occasional setbacks. Examine each setback seriously and develop timely recovery strategies so that it does not jeopardize the entire program.
- H. Conduct regular meetings (not one-way briefings) with leadership and workforce to share goals, successes, and lessons learned.

6.3 How to know it is working

- A. Heightened employee attitude towards safety, months after initial training.
- B. Consistent follow-up by leadership to support system-wide improvements.
- C. Employees are not disciplined for reporting their errors.
- D. Increased trust between workforce and leadership.

SUSTAINING & JUSTIFYING AN HF PROGRAM

Chapter 6

- E. Increased involvement of the workforce sharing their ideas for improvement.
- F. Increased voluntary workforce error disclosure (NOTE: Increased reporting may appear to be increased "errors." Be sure these two are not equated).
- G. Decreased repetitive errors/rework.
- H. High interest in event investigation results and MHF initiatives.
- I. Increased positive feedback on the MHF initiatives from all levels of the organization.
- J. Increased positive responses on annual employee surveys.

6.4 Why Cost Justification is Important

- A. Maintenance Human Factors interventions compete for resources. Senior managers ask for measures to show how Human Factors interventions can affect the "bottom line." They want to know the return on investment for Maintenance Human Factors.
- B. When Maintenance Human Factors programs are voluntary, not regulatory, they are likely justified either on the grounds of safety or cost.

6.5 How to implement measures to quantify Maintenance Human Factors investments for cost justification

- A. Useful cost justifications must be straightforward and easy to understand. They need not be computed by economists.
- B. The imprecise measurement of Human Factors interventions may complicate cost justification calculations.
- C. Try to use existing maintenance event examples for cost justifications. Use data from the event investigation system described in Section 1.
- D. How to calculate a Return on Investment (ROI) of a specific maintenance-related event.
 - 1. The basic equation for ROI is simple: merely divide benefit by cost.
 - 2. Estimate the annual cost of a particular type of maintenance error. Call this "Cost."
 - 3. Determine the contributing factors to the event, and estimate the cost to mitigate these factors. Keep it simple and call this "Cost to Fix."
 - 4. Estimate a reasonable "Probability of Success" that the interventions will be successful. Say, for example, that you estimate an 80% success rate.
 - 5. Multiply "Cost" by "Probability of Success." Call this "Return."
 - 6. Divide ("Return" – "Cost to Fix") by "Cost to Fix." Call this "Return on Investment" (ROI).
 - 7. A positive ROI (> 1.0) may not be achieved in one year.

SUSTAINING & JUSTIFYING AN HF PROGRAM

Chapter 6

6.6 Key References

- A. Stelly, J. and Poehlman, K. 2000. Investing in Human Factors Training: Assessing the Bottom Line. Presented at the 14 th Annual Human Factors in Aviation Symposium. Vancouver, Canada. (<http://www.hf.faa.gov/508/docs/508/JSTELLY.PDF>).
- B. Patankar, M.S., and Taylor, J.C. (2004). Risk management and error reduction in aviation maintenance. Aldershot , U.K.: Ashgate Publishing. (Amazon.com)
- C. Johnson W.B., Sian, I.B., and Watson, J. (2000). Measuring the impact of human factors interventions. SAE Meeting on Advances in Aviation Safety. Daytona Beach, Florida, April 11-13, 2000. SAE paper. (http://www.hf.faa.gov/docs/508/docs/Johnson_ROI.pdf)

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<http://www.hf.faa.gov/opsmanual>