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*Written by maintenance human factors professionals dedicated to identifying and optimizing the factors that affect human performance in maintenance and inspection.
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Maintenance Human Factors Training: Time for Curricula Renewal

BY
DR. BILL JOHNSON

About the Author: Dr. William Johnson is the FAA Chief Scientific and Technical Advisor for Human Factors in Aircraft Maintenance Systems. He comments based on nearly 50 years combined experience as pilot/mechanic; professor; engineering consulting, airline/MRO, and FAA scientific executive.



Sometimes it is good to report “work in progress.” It forces one to tidy up the notes and transition into the next phase of the work. It also elicits new ideas from readers of early publications like this one. That is the case with this report. Regulated HF training is evolving worldwide. Most US aviation maintenance entities, without regulation, choose to deliver HF training because of the known safety and financial return. Our current work is looking at a variety of HF curricula regulatory guidance material in an effort to help organizations to “notch up” their HF courses to current operational realities. This review is an initial step in that project. Expect another report later in FY '14. If you have ideas on additional new curricula topics please advise the author.

HF Training Background

Maintenance training organizations have been delivering human factors training for nearly twenty five years. It all started, in 1991, at Continental Airlines. US Airways started their HF programs about that same time. Additional programs emerged quickly. International companies established HF training by the mid-nineties with companies like British Airways and Lufthansa German Airlines in UK/Europe and, Singapore Airlines, Singapore Technologies, and HAECO in Asia. Continental Airlines started by offering a crew resource management (CRM) class to the engineering department. The course contained selected portions of the flight crew training materials that focused on valuable topics like communication and teamwork. About the same time US Airways also initiated a class. Within a short time KLM, British Airways, Lufthansa, and others initiated selected human factors training in engineering. By the mid-nineties, topics like Swiss Cheese (Reason), Dirty Dozen (Dupont), and PEAR (Johnson and Maddox) became standard fare for engineering HF courses. By that time ICAO and the Joint Aviation Authorities (now EASA) had formal guidance and

recommendations for the content of such training. By 2000, various regulations emerged and were especially significant when the EASA regulations were issued in 2002. FAA, in lieu of regulations, relies on the guidance from a very robust HF research program starting in 1988. End of history lesson.

Traditional Curricula

There are numerous guidelines regarding the content for engineering human factors classes. The most widely used is the EASA Module 9, which affects Parts 66, 145, 147 and others. See Table 1 for current Module 9, general topics. These are important topics because engineering personnel must understand and appreciate their own human strengths and weaknesses in order to apply human factors principles to the work environment. The subcategories of topics are not included here.

Table 1. Traditional EASA Module 9 Topics

- 9.1 General
- 9.2 Human Performance and Limitations
- 9.3 Social Psychology
- 9.4 Factors Affecting Performance
- 9.5 Physical Environment
- 9.6 Tasks
- 9.7 Communication
- 9.8 Human Error
- 9.9 Hazards in the Workplace

EASA has proposed (NPA 2013-19) to enhance the Module 9 by adding to the list above to include the subtopic of “Organization Errors” to topic 9.8. EASA also proposes to enhance Section 9, to align with SMS, and include: risk management, occurrence reporting, safety culture, and just culture. It is likely that many of these topics have already been voluntarily added into many initial and

Maintenance Human Factors Training: Time for Curricula Renewal Con't.

recurrent human factors course.

New Topics for Consideration

Human factors issues, over the past two decades, have become a familiar topic and vocabulary for engineers/mechanics worldwide. Today's workers have received the Module 9 topics in school, in general employee training, and in selected recurrent training. Now they would likely benefit from new topics or from a more advanced version of the familiar Module 9 topics. To prepare for this article I created a possible listing of new topics for engineering HF training. I sent the list to a selected international group comprised of regulators, airlines, MROs, manufacturers, and notable consultants. The response was fast and included topics shown in

Table 2: Expanded and New Topics/Subtopics for HF Training

Expanded Topics/Subtopics:

1. Safety culture and motivation
2. The power of the individual in safety culture
3. Safety culture leadership
4. Review of fundamentals like PEAR, Dirty Dozen, Swiss Cheese
5. Personal responsibility for: Fitness for duty, especially fatigue self-reporting
6. Using technical publications, job cards. Etc.
7. Professional ethics and pride in workmanship
8. Additional Physiology
9. Crew resource management (team working between mechanics, between mechanics and flight crew and between mechanics and flight operations & maintenance control).

New Topics/Subtopics:

1. SMS intro to include risk assessment and fundamentals of Threat and Error Management
2. Voluntary Reporting of error, including what to report (WIIFM?)
3. Emphasis that workers may know the hazards better than management
4. Peer to peer assessments and coaching like Maintenance and Ramp LOSA
5. Showing how safety data are used
6. Showing the safety and cost return on safety interventions (from employee data)
7. Generation Thinking/Communication
8. Social Media and Work

Table 2. It is divided into two sections to include: Expanded Treatment of Current Topics and New Topics.

HF Training Evolution

The topics of Module 9 remain relevant. The same holds true for the twelve most common contributing factors to human error, still required by Transport Canada regulations. That does not mean that it is fine to use the same slides, movies, and other media/war stories that were created in the early nineties. In fact, such media and training methods could render relevant topics irrelevant. When the slides and media are older than some of the students it is likely overdue for new methods. As an example, Lufthansa Technical Training redesigned and launched some of their HF training as an Apple Application. FAA stepped up with a modern web-based fatigue awareness training program and new video (Grounded) www.hfskyway.faa.gov.

Perhaps the best example of new Engineering HF training is the multimedia package developed by the Civil Aviation Safety



Authority of Australia. It is titled Safety Behaviours – Human Factors for Engineers. It is available at www.casa.gov.au/hf. Table 3 shows that CASA has incorporated items from Tables 1 and 2. That program is described in the Aviation MX Human Factors Newsletter (www.hfskyway.faa.gov/fatigue/documents/AMHF_Vol1_Issue2.pdf). Finally, there

Table 3. The CASA Human Behaviours Topics

1. Introduction using PEAR
2. Error Management
3. Human Performance and Limitations
4. Decision Making
5. Fatigue
6. Stress, Workload, and Time Pressure
7. Alcohol and Other Drugs
8. Communication
9. Teamwork
10. Leadership
11. Professionalism
12. Applying HF – Safety Culture

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are many excellent third parties offering HF training. Be sure to ask about the age of their materials and media before signing a contract.

Bottom Line and Next Steps?

If there is a bottom line, it is that the value and importance of human factors training is no longer debated. The only debate now is how to ensure that the training and application remains relevant and high value in modern aviation maintenance work environments.

The current plan is to revise The 2006 Operator's Manual for Human Factors in Maintenance. That revision will have expanded curricula guidance for new human factors topics. Stay tuned.

Acknowledgement

The author acknowledges the many industry professionals that contributed to the list of expanded and new topics/subtopics. Portions of this work are reported in the International Federation of Airworthiness News (Winter 2013).



Library

Videos

Fatigue

LOSA

Training Tools

Contacts

www.humanfactorsinfo.com

The FAA maintenance human factors site was launched in the late nineties. Its popularity grew tremendously over the years. Google hits reached in the hundreds of thousands yearly by 2010. Being over a decade since launched, the website was overdue for a "Heavy Check" to improve its search engine and public accessibility. Fortunately, the "Heavy Check" was not an "out with the old and in with the new." It continues to serve as an important dynamic repository of reports, conference proceedings, and other important MX HF materials. The new HF in Aviation MX website can be found at the original address hfskyway.faa.gov or under a number of alias addresses like humanfactorsinfo.com, and mxfatigue.com. Take a look today and please pass this information to your colleagues.

Confessions of a potential Lack-of-SLEEPAHOLIC



by JoyBanks

About the Author: Joy Banks, M.A., works for the FAA in the Human Factors research lab with emphasis in fatigue and Human Factors in aviation maintenance. She is a Licensed Professional Counselor in the state of Oklahoma.

Have you become so accustomed to getting less than 7-9 hours of sleep per night/day that you actually believe you can function optimally on less sleep? Are you so obsessed with getting the job done that you regularly neglect your sleep to do so? If you answered “yes” to one or both questions, you may be a Lack-of-Sleep-aholic (someone who habitually gets less than the recommended 7-9 hours of sleep per night/day). Granted, I coined the term to illustrate a recent experience which validates scientific evidence that working while extremely fatigued can result in performance comparable to someone who is working drunk, figure 1.

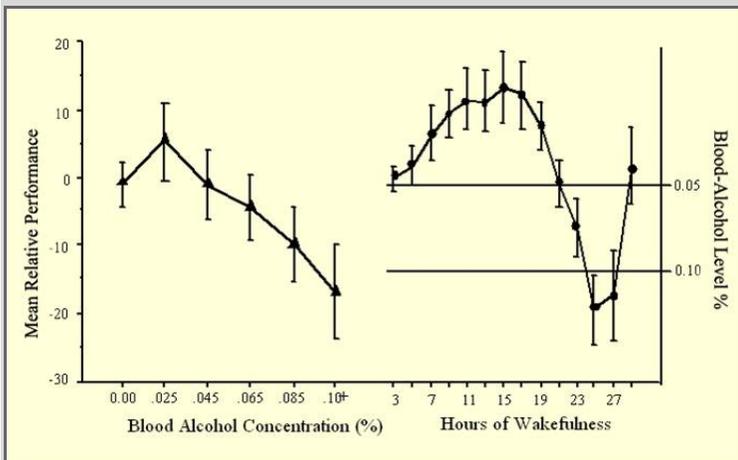


Figure 1. Performance Comparison B.A.C. with Fatigue

Unlike the stigma attached to the term alcoholic, our American culture fosters the concept of the lack-of-sleep-aholic. We may understand the benefits of sleep, but instead of taking a nap to re-energize, we reach for an energy drink or candy bar. We do all of this despite research that links healthy sleep habits with better-behaved kids, better brain functioning, enhanced beauty, weight control, and sickness prevention. Unfortunately, sleep is the first thing, we as a culture, neglect when racing toward a deadline.

I recently experienced how easy it is to cross the line from conscientious fatigue researcher to potential lack-of-sleep-aholic. Knowing the mental, physical, and emotional problems that arise from lack of sleep did not stop me from taking the risk. Here’s my confession.

In addition to having a full time job in human factors research and a part time music gig at my church, I recently became a small business owner. Anyone can tell you that starting a business can be a 24/7 job. I acknowledged that my plate was already full, but that didn’t stop me from agreeing to be a vendor at a tri-state trade show. I assumed that my passion for my new business would keep me energized through all the middle-of-the-night product design, manufacturing, labeling, packaging and video production sessions. I was wrong! On the morning of the trade show, I was tired and cranky. I was somehow functioning on about eight hours of sleep in the past 72 hours. I apologized to my business partner in advance because I knew by the end of the day I was going to bite her head off about something. I gulped down some coffee, which I rarely do, and began to set up our exhibit.

When the doors opened to the public, the caffeine I drank earlier kicked in. I felt ready with our products displayed, professional signage, flyers, business cards, and pricing information. I began to think that sacrificing my sleep was worth the risk. I had completed an amazing amount of work in a short span of time to establish the infrastructure of the business in preparation for the trade show. But before I could finish my thoughts of grandeur, my business partner pointed out that I had made a typo on the pricing information and I had the wrong date on the informational flyers. Rats! Here I am: a human factors professional making dumb errors. I

(Confessions...con't).

knew better. Instead of taking responsibility, as predicted, I snapped at my business partner for not finding the mistakes beforehand. We hurriedly corrected the date on the flyers and pricing. Additionally, I also forgot to do major things like collect email addresses and record my partner's session presentation. Overall, my trade show experience turned out to be positive, despite my mistakes. However, it could have resulted in real tragedy. For example, due to my lack of sleep, I could have had a car accident to or from the trade show, or seriously injured myself when I decided to balance on a chair to hang our tradeshow sign.

After the trade show, I got some much needed sleep. Later, when I reviewed the work completed during my lack of sleep-aholic state, I discovered more mistakes. I was lucky because they were minor errors. Whew! Neglecting my sleep seemed like the most logical choice at the time. This leads me back to why I made that choice in the first place. Passion. Unfortunately, my passion for my new business became an obsession and impaired my decision making. When I made the decision to severely neglect my sleep, I put myself in harm's way. If you can relate to my experience on some level and can recognize that you too could potentially be a lack-of-sleep-aholic, that's the first step to recovery. Let's stop and take inventory. Use the 12 steps to recovery for lack-of-sleep-aholics (adapted from the 12 Steps for Alcoholics Anonymous) to break the habits that drive you to neglect your sleep.

We all need a friendly reminder of how important sleep is to physical, mental and emotional health, and relationships. Carry this message to others, and practice these steps at work and home to avoid working while drunk due to fatigue.



Twelve Steps for Lack-of-SLEEPAHOLICS

1. **Admit that your life has become less manageable due to a lack of sleep.**
2. **Believe that you can get better sleep.**
3. **Make the decision to improve your sleep habits.**
4. **Put your decision to action by changing your behavior to get better sleep.**
5. **Acknowledge the amount of sleep you actually get.**
6. **Share with others your need for sleep.**
7. **Humbly look at your shortcomings when you are sleep deprived.**
8. **Be ready to work on any shortfalls resulting from your lack of sleep.**
9. **Be ready to make direct amends due to your lack of sleep.**
10. **Continue to take personal inventory of your sleep, and when neglected, promptly correct it.**
11. **Improve your relationship with the people around you without neglecting your sleep.**
12. **Become more aware of your actions, people, and your environment.**

How Good is YOUR hearing?

Part 2 of a 3 part series by **James Allen M.D.**

About the author: Dr. Allen is a retired navy physician specializing in preventing health effects due to workplace exposure. He is the author of "Working Healthy" and offers the training course ALC-117 on WING to prevent occupational illnesses and injuries. He resides in Wilmington, DE and can be reached either as a FAASTeam representative or through his web site www.workinghealthyalways.com.



In 1903 a mechanic invented aviation noise. It has been with aviation maintenance ever since. We should continue to emphasize its effect on hearing and fatigue.

In the first part of this series we learned that the initial effects of hearing loss are not readily noticeable. The analogy is with tire pressure or engine compression. The initial loss of pressure may not be noticeable by observing the tire sidewalls or during a static engine run-up. Detecting changes is a large part of the AMT's job. Using pressure gauges the mechanic can determine the exact pressure in a tire or the compression in a cylinder. By comparing the pressure with a standard, the mechanic determines whether a tire needs to be inflated or a cylinder needs more attention. This same sequence of detecting small changes applies to determining the status of your hearing.

The instrument used to detect hearing changes is the audio booth. Most mechanics are familiar with the audio booth, figure 1, either from their health screening before entering the military or participation in a hearing conservation program sponsored by their airline. The booth is lined with lead and contains a chair(s) where the mechanic(s) sits. While seated, the mechanic wears a head set and holds a trigger with a finger activated red button. Through the glass window, the hearing conservation technician observes the mechanic. Instructions to the mechanic are to press the red button when hearing a sound.

Mechanics know how pressure gauges work, so how does the audio booth work? In part 1 of this series we noted that decibels (dB(A)) reflect loudness while frequency measured as hertz (Hz) reflects pitch. Based on a defined program



Figure 1: Hearing booth: Through the window of the booth, the technician views the mechanic wearing the head set.

monitored by the technician, the audio booth produces a pure tone of a specific pitch. This pure tone applies first to one side of the headset, then to the other. In addition to its application to different

sides of the headset, the audio booth also varies the loudness. By pressing the red button on the trigger, the mechanic signals the threshold for hearing of the tone at a specific frequency and loudness. The electronics in the audio booth record the thresholds of dB(A) and Hz for each ear as indicated by the mechanic pressing the red button. The record is called the audiogram. Initials by the technician on the audiogram result in the document becoming part of the mechanic's medical records.

Like pressure readings that reflect the inflation of the tire or the integrity of a cylinder, the audiogram provides an insight into the function of the cochlea, the organ of hearing. Recall from Part 1 that this organ converts the pressure wave of sound into the electrochemical impulses that the brain interprets. The audiogram provides a graphic representation of the hearing limits for the mechanic's left and right ears, figure 2.

An audiogram represents the loudness of sound heard by the mechanic for each pure tone. Most audio booths generate pure tones at 1,000, 2000, 4,000 and 6,000 Hz. These frequencies cover those in the speech range, from 200 to 3,000 Hz, as well as the higher frequencies of 4,000 and

How Good is Your Hearing? Con't.

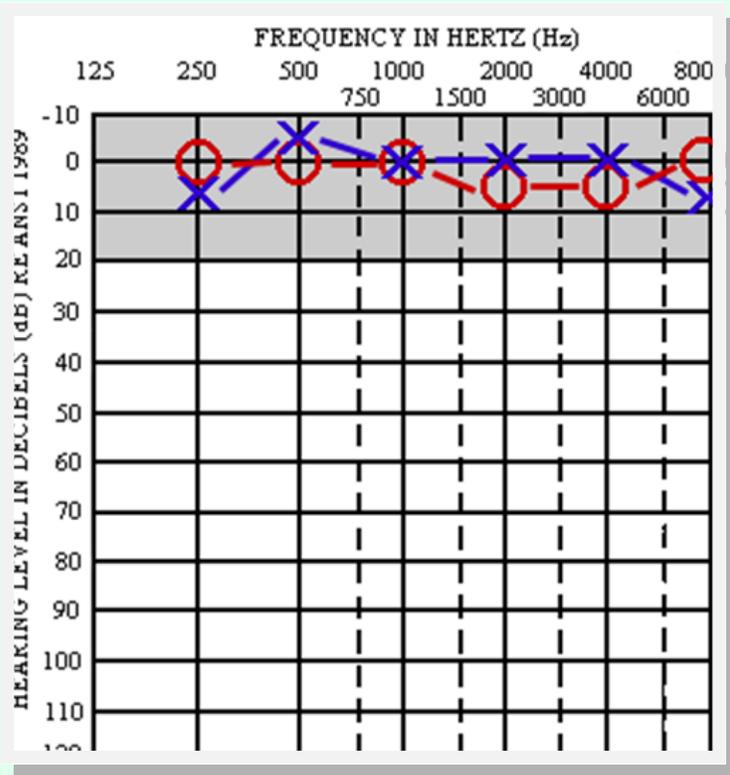


Figure 2: Normal Audiograms: Frequency and hearing level for the left (X) and right (O) ears. Hearing levels for all frequencies are in the normal, shaded, range for loudness.

6,000 Hz. An early sign of hearing loss is at 4,000 Hz so inclusion of this frequency is always included as pure tones. These frequencies also correspond to regulatory requirements that state and federal safety administrations require for certification of hearing conservation programs required from employers.

An important application of the audiogram is its comparison with standards. For example, 35psi may be the target tire pressure and 60psi may be the minimum required in a compression test of a cylinder. For the audiogram the standard is 25 db. Any tones that show more than 25 db are outside the normal range. Using this standard, audiologists can rate the mechanic's hearing loss as mild, moderate, and severe. Note that hearing loss is never in just one tone. As hearing loss progresses beyond the initial loss at 4,000 Hz, more tones become involved. Severe hearing loss has a significant hearing loss at all frequencies, figure 3.

How often should the mechanics have their hearing testing? The answer depends on the level of noise

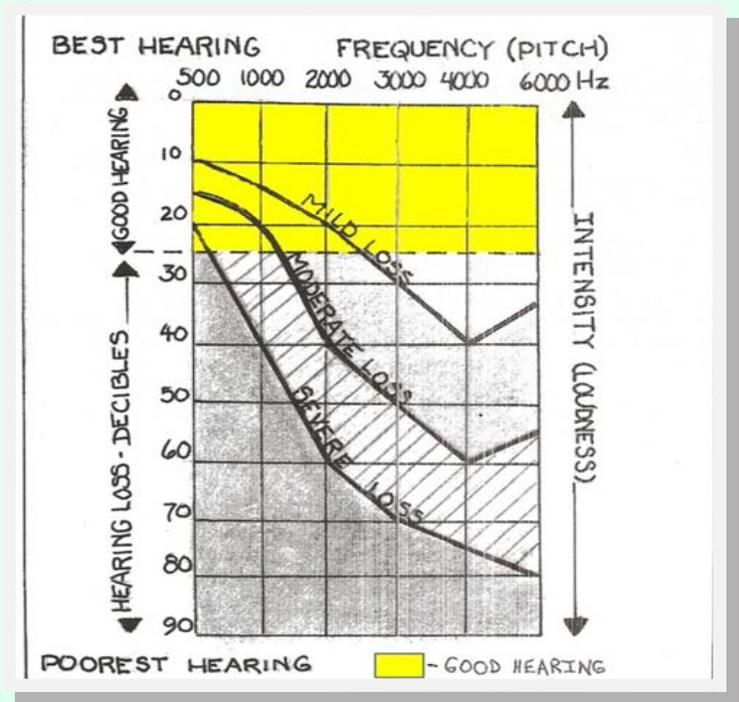


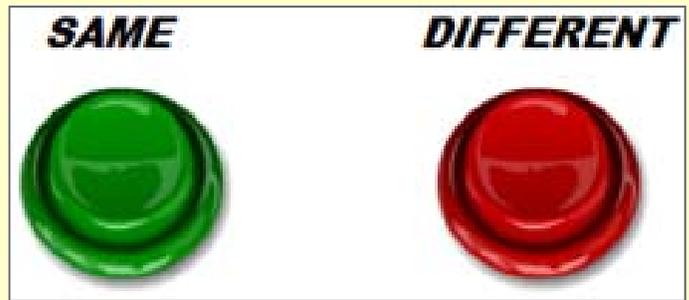
Figure 3: Composite Audiograms: The three lines show mild, moderate and severe hearing loss at the frequency indicated. Normal hearing range is indicated by the yellow block. (Taken from figure 24-2 in Working Health, used with permission from the author).

exposure. Line mechanics, who work around arriving and departing aircraft should have their hearing tested yearly. Mechanics working in less noisy work places, such as inspection or training departments, have less noise exposure so audiograms every three years are adequate. All mechanics should watch for development of the notch at 4,000 Hz. This is the first warning that workplace noise is starting the process of Noise Induced Hearing Loss (NIHL).

The audiogram provides a graphic representation of the initial effect of noise. The initial effect of Noise Induced Hearing Loss (NIHL) is at 4,000 Hz. It appears as a "notch" in the audiogram at 4,000 Hz. A history of working in a noise industry, such as aviation, and a 4,000 Hz notch in the audiogram is characteristic of NIHL. To protect their hearing, mechanics with the "notched" audiogram must implement some hearing protections. In the third and final part of this series, mechanics will learn protections they can use to prevent the notch from expanding to other frequencies.

MAINTENANCE HUMAN FACTORS: DOES IT ALL SOUND THE SAME TO YOU?

BY BILL JOHNSON



About the author: Dr. William Johnson is the FAA Chief Scientific and Technical Advisor for Human Factors in Aircraft Maintenance Systems. He comments based on nearly 50 years combined experience as pilot/mechanic; professor; engineering consulting, airline/MRO, and FAA scientific executive.

I wrote this short article mostly because someone, who should have known better, told me that all human factors sounds the same. It is published on the Cygnus AMT Magazine website (under the title *Music Appreciation and Maintenance Human Factors*). It will likely appear in the AMT magazine in early 2014. I am republishing it here, merely to appeal to additional readers.

When you don't understand and appreciate certain music it "all sounds the same." Let me explain. You may not like classical, opera, folk, rap, or hip hop music. When you hear those genres of music you can't differentiate among the artists; you can't identify the era of the recording because you just don't care. When you like a certain genre of music, say rock or country, you know if the tune is old or new, the name of the artist, and you maybe even went to the concert. You like the new stuff and even the old tunes. You appreciate the subtleties of "your kind of music."

The analogy to music genre appreciation can apply to maintenance human factors. It helps explain why someone would conclude that all Human Factors initiatives are the same and have gone unchanged. They throw around comments like "HF is more than the Dirty Dozen, PEAR, or the Swiss Cheese." They know just enough buzz words to be dangerous. They don't appreciate the artists, can't identify the subtleties of interventions, and generally are not fans of "human factors." But, they are the target fans that must be convinced of the value of HF programs.

Is There a Solution?

It may be difficult for an opera star to convince the county/rock fan to change their listening/appreciation and buying patterns. Each can exist without the other, so that is OK. That is not the same situation

with regards to human factors in maintenance. The industry needs everyone on board. Success is not based on record sales but on the success of evolved safety cultures. That includes such programs as:

- voluntary reporting systems,
- detailed root cause analyses to determine HF contributing factors,
- continued initial and recurrent HF training for all employees including HF trainers,
- implementation of fatigue risk management programs,
- addressing the issues associated with failure to follow procedures,
- continuing participation in government/industry HF forums,
- human factors for all maintenance staff, including managers, executives, and more.

The fact that HF contributes to 80% of events is testimony that on-going HF initiatives are absolutely necessary and must involve everyone.

Catering to the Fan Base

Music stars cater to their fan base. They are also always trying to attract new listeners. They do that by establishing websites, twitter accounts, newsletters, and other media. They get out on the concert tours to meet the loyalists. They release new albums to ensure continued fan loyalty. They may record a duo with an artist from another musical genre. For example, recently Lionel Richie created a hit album by teaming with a variety of country music stars. These activities help grow the fan base. Let's compare that to the promotion of human factors activities.

Maintenance Human Factors: Does it all sound the same to you? Con't.

First, there must be an on-going flow of fresh information. The FAA maintenance HF website has been around since 1995. It has been in a continuous state of update. It contains over 1,700 human factors specific reports dating back to the initial series of maintenance human factors conferences, starting in 1988. In fact, it serves as the sole online source of a hand-picked (by Hon. John Goglia, NTSB Ret.) collection of human factors related aircraft accidents dating back to the fifties. The site contains a variety of HF training media, and even fatigue assessment software that is updated almost monthly. The site is currently undergoing complete interface revision, likely launched by the time you read this article (www.hfskyway.faa.gov or www.mxfatigue.com).

There are many other sources for current material. The Civil Aerospace Medical Institute, with Flight Standards, publishes a quarterly maintenance human factors newsletter. It is one click away from the FAA HF home page. Other examples of timely digital media are the Aviation Human Factors Industry News (Roger Hughes) and the Cygnus AMT Weekly News (Ron Donner, AMT Society). Roger Hughes concentrates on HF while Ron Donner adds HF as it relates to weekly events.

The Chief Scientist/Technical Advisor program, working with CAMI, conducts an annual small workshop to identify challenges and solutions related to maintenance human factors. That multi-disciplinary group, including HF naysayers, has consistently said that the industry needs help with HF issues surrounding like:

- technical documentation,
- worker fatigue,
- proving the payoff of HF interventions,
- effective local use of data from voluntary reporting,
- communicating HF issues,
- fostering a just culture, and more.

On-going FAA HF activity is based on the recommendations from that workshop.

If there were HF concerts then the FAA

Maintenance Human Factors Symposium would be the maintenance HF Woodstock. Those meetings (co-sponsored by FAA, A4A, UKCAA and Transport Canada) had a positive impact over a 20+ year period, starting in 1988. There has been a reduction in these over past few years.

However, the FAA Aviation Safety Action Program (ASAP) InfoShare meeting has provided an excellent replacement forum for human factors information. In addition, there are occasional high value commercial international maintenance human factors conferences. In order to win over new advocates and to reinforce the fan base, a maintenance HF symposium is overdue.



When Lionel Richie joined with the country singers for an album of duets he created an extremely successful product. In the same way, human factors activities must



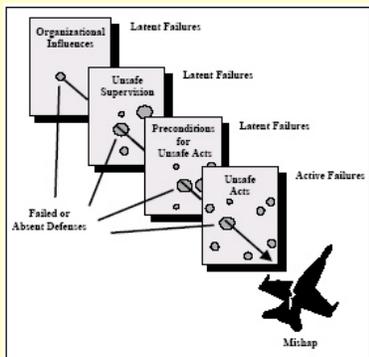
harmonize with other programs. This should include voluntary reporting programs and the total Safety Management System, among others.

Finally, maintenance human factors must prove its value. The money/time spent must have a financial and/or safety return (see July '12 AMT Magazine). EASA recently cited FAA's Return on Investment Process (See hfskyway.faa.gov) as a way to show the financial and safety payback on proposed SMS/Fatigue regulations. When you can demonstrate the impact of HF interventions it helps to win over supporters.

Keeping it Fresh

The new hits must continue to emerge. New songs keep the fans and also ensure that "oldies but goodies" are revisited. Maintenance HF programs have been around since the late eighties. The old

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list of favorites includes the Dirty Dozen, the Swiss Cheese, and PEAR. But those old concepts/hits must be reinforced with new information and new media. The new training materials from CASA (see September '13 AMT Magazine) are an excellent example that can result from an investment in content, graphics, and multi-media. The FAA fatigue training materials and the movie, "Grounded," also exemplify the new materials. Human Factors trainers have relied on certain accidents for group work and discussions. If the aircraft was built before the students were born then you should consider new examples. The

best stories seem to come from local voluntary reports and from the NASA Aviation Safety Reporting System (ASRS). Of course, the occasional NTSB reports provide great factual data.

No Grammy Nominations

Maintenance human factors programs and interventions don't have an annual awards show. Those awards are reduced worker injury, decreased aircraft damage, rework, or delay; and continuing flight safety. There is no annual Grammy Awards night. Instead, the payback and awards occur daily as the industry continues to deliver safe and cost effective transportation to the world.



If you have a story to tell that will help enhance aviation safety, please email katrina.avers@faa.gov or bill-dr.johnson@faa.gov. The editorial staff will help writers with layout and graphics.

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