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SMS Relies on FAA HF Research and Development Products

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INSIDE THIS ISSUE:

Introduction

When I joined the FAA, in 2004, the senior leadership that interviewed me insisted that FAA research must create and support products that can be used in government and industry. Of course, they expected FAA Technical Reports and Newsletter articles like this one. They also respected that selected basic scientific research helped to validate the ultimate applied products. Much of this short article, also appeared in the May, 2016 AMT Magazine but this version has more elaboration.

A key component, or guiding principle, of today's continuing aviation safety is the concept of Safety Management Systems. SMS has significantly raised the awareness towards the human factors hazards in maintenance. Increasingly, industry is capitalizing on the last decades of products/practices generated from FAA's Maintenance Human Factors Program. A few examples are described below.

SMS Implementation Requires Tools for Thinking and for Acting

The regulations currently require that Part 121 operators have a Safety Management System in place. That is clearly happening. The industry is embracing SMS for more reasons than mere regulatory compliance. I have observed that the word "required" is hardly used when industry personnel talk about SMS. I see enthusiasm for the recognized value in a structured approach to spot trends and to recognize and address hazards before they cost money, injure a worker, or threaten the continuing safety of flight for airline operators. The good news is that there is a large "trickle down" approach where Part 121 operators are asking their suppliers to establish and capitalize on a SMS. Of course, a supplier is not likely to have the same requirement for a large SMS that a 7/24/365 airline has. Each SMS is different and matched to organization needs. These organization-

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SMS RELIES ON FAA HF RESEARCH AND DEVELOPMENT PRODUCTS (CONT…)

specific needs, in my opinion, have triggered a revised interest in maintenance human factors. I offer four examples here, to include 1) How to categorize hazards, 2) Methods to collect event data and predictive data 3) How to estimate return on investment, and 4) The best fatigue risk management methods and training. All of these topics are worth revisiting.

Categorizing Human Factors

Increased attention to safety management, data collection, voluntary reporting, and hazard management begs for an organized categorization of hazards and errors. Over the years maintenance personnel have used the Swiss Cheese, SHELL, Bow Tie, and PEAR. Of course, I am partial to PEAR being the co-inventor and chief promoter the concept for 20 plus years. PEAR, for review, stands for People, the Environment in which they work, the Actions workers perform, and the Resources necessary to perform the work. PEAR is the main human factors training paradigm for FAA and Civil Aviation Authority of Australia inspector training. It is a key part of FAA's web product, The Maintenance Human Factors Presentation System, which has been an international training application for a very long time. Training support resources are available at www.humanfactorsinfo.com as well as at the CASA website. PEAR is significant because the categories can represent the holes of error in the cheese or the human resilience represented by solid part of the cheese. PEAR overlaps with SHELL but is a bit easier to remember and utilize. On the Bow Tie, PEAR is an ideal way to offer the proactive barriers that prevent the event of focus.

The purpose here is not to make you a PEAR expert but instead, to insist that the concept is alive and well. If you want more detail then Google "Johnson PEAR Model."

Tools to Collect Data

SMS requires data collection methods must go well beyond standard post-event investigations. Data collection must include not only audit of daily operations but also a way to look ahead and predict possible risk. FAA worked with Airlines for America to develop the Maintenance and Ramp Line Operations Safety Assessment (LOSA) system (see Article by M. Ma in this Newsletter). The system uses a formal checklist-like method to permit peer-to-peer observation of normal procedures. LOSA is a positive method to support SMS because it recognizes daily hazards and strengths. All LOSA forms and training materials are on the FAA Maintenance Human factors website at www.humanfactorsinfo.com.

In a "perfect world" government conducts the initial research and development to create a product, then industry applies the product to meet company-specific needs. LOSA worked out that way. Thanks to some early industry adopters, like United Airlines (along with Continental's LOSA legacy) and JetBlue , LOSA found early success. Boeing has provided extensive industry support for LOSA in the US and worldwide. The high value of LOSA, for SMS, continues to evolve from industry, rather than government, action.

Justifying your Human Factors Interventions

Engineering/Maintenance managers know where the most significant hazards are. Fostering the positive safety culture, using the technical publications, and ensuring fitness for duty are a few most common opportunities to address hazards. However, organizational-specific information, discovered by voluntary reports or SMS data will identify specific hazards, like aircraft ground movement, availably of specific tools/ equipment, scheduling challenges, shift turnover communications and more. Unlimited resources would permit organizations to address all hazards, but that's not the real world. For that reason organizations must apply risk assessment to look at the likelihood that the hazard may cause

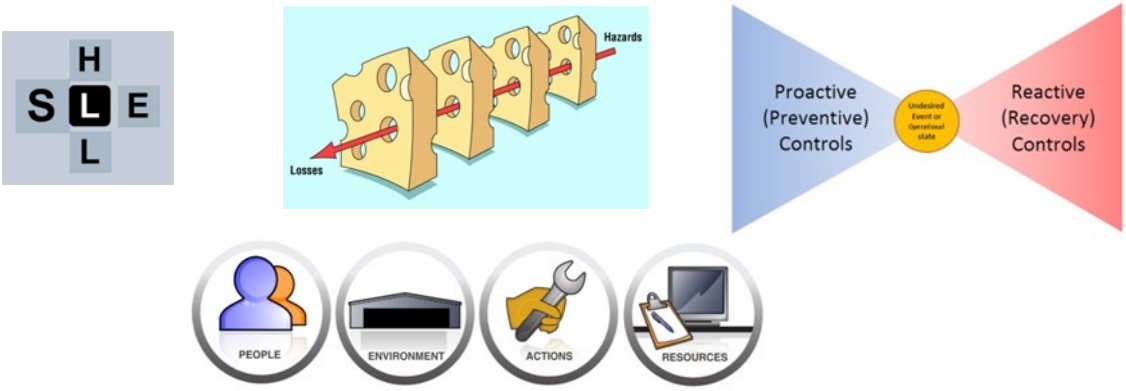

Figure 1. Categorizing Human Factors using the SHELL, "Swiss Cheese," Bow Tie and PEAR methods.

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SMS RELIES ON FAA HF RESEARCH AND DEVELOPMENT PRODUCTS (CONT…)

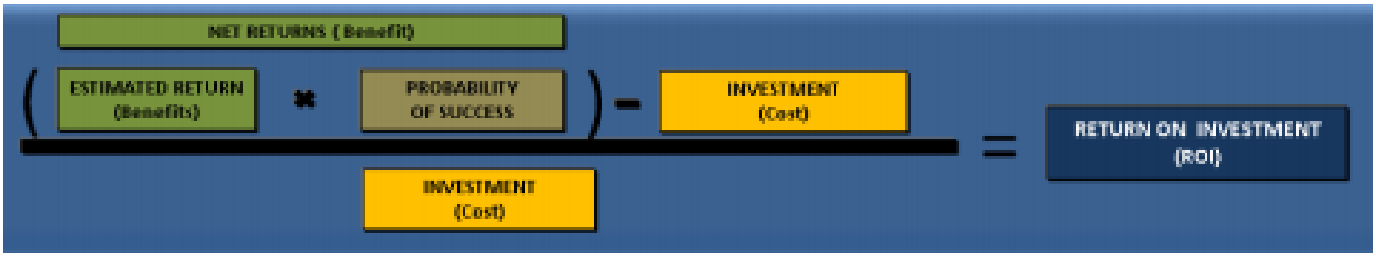

Figure 2. The FAA ROI Model

an error and what is the severity of such an outcome. But organizations must also determine the financial and safety impact of a hazard in order to prioritize which hazard reductions have the highest payoff. That's where the FAA Maintenance Human Factors Return on Investment tools can come in handy.

Figure 2 shows that one does not have to be an economic expert to calculate return on investment. In fact, it is more about understanding your hazards and the associated number of events (or potential events) that will result in an unmanaged hazard. SMS data can help assign costs if you are motivated to assign costs. The aviation maintenance expert will assign cost to the hazard intervention and predict the level of confidence in the estimation. The rest is multiplication and division. The tools and detailed directions are available in the tools section at www.humanfactorsinfo.com.

Many have seen me write or speak that SMS, regulated or not, is the best approach to fatigue management regulations in maintenance. Most authorities do not have strict rules for fatigue risk management. Even when there are national industrial fatigue rules they are usually trumped by a variety of stipulations that permit aviation maintenance personnel to work more consecutive days and longer hours than they should. Proper SMS will quickly discover if there is a maintenance fatigue issue in an organization. By design, an SMS must identify such hazards, determine the corrective action, promote the action, and assess the impact.

My recent experience suggests that industry is becoming increasingly aware of the hazards associated with worker fatigue. I believe that SMS programs have an impact on the awareness of worker fatigue hazards. The numbers of users on the 2-hour web-based training continues to grow (estimated at over 200k users in the past 5 years. (Course # ALC-258 available at www.faasafety.gov). The multiple award winning video, entitled "Grounded," is available as part of that training or accessible on YouTube.

Demand Remains High for Maintenance Human Factors Support

Industry has stepped up to address the hazards associated with human factors challenges in maintenance. For the most part, they have done that without extensive regulations. The safety and business case speak louder than regulation. FAA intends to continue to support the maintenance human factors website and is open to all suggestions for additions to our website and associated resources.

Comments – Send comments to Dr. Bill Johnson at Bill-dr.johnson@faa.gov

Everything old is new again; revisiting "The Dirty Dozen"

Guest Author: Jeff Grenier

About the Author: Jeff Grenier is currently the Manager of Regulatory Programs & Compliance for Southwest Airlines and is an Adjunct Instructor for the Transportation Safety Institute's (TSI) Aviation Division. He has directed aircraft accident investigations and Human Factors and safety initiatives for over 20 years. He has a Master's in Aeronautical Science from Embry-Riddle University, is an Airframe & Powerplant Mechanic, a Certified HFACS Professional, and a Registered Safety Professional. All of the comments and opinions expressed in this article are solely his own and not representative of the views of Southwest Airlines, TSI or any entity therein.

"This new human factors stuff is great!"

A student in a recent maintenance human factors course was really excited about the training and remarked multiple times about the "new" concepts. He asked how long this type of course has been going on, and, as tactfully as I could, I let him know that maintenance human factors training has been evolving for over 25 years. He laughed and said it reminded him of the TV advertising campaign "If you haven't seen it, it's new to you." Human factors and safety in aviation continue to evolve and have more attention and energy directed towards them than ever before. But are these concepts really all that new? Take the following example:

"The term "accident," although we use it for want of a better one, is only one degree less unfortunate than the unhappy expression "act of God." Literally speaking, there is no such thing as an accident. There is always a predisposing cause. It is a common statement that somewhere between eighty and ninety per cent of the misadventures which commonly go by the name of accident are due to the "human factor."

This is from an article titled "Safety…. It Can Be Done" which was published in September 1930 in Aviation magazine (now called Aviation Week & Space Technology).

While the FAA moves forward with the "new" and prepares to release the Advisory Circular on Maintenance Fatigue Risk Management, it has its foundation in the "old." Fatigue is one of the accident precursors documented in the well-known Dirty Dozen, the list of twelve factors recognized to be common contributing influences to maintenance error. Compiled by Transport Canada in the 1990s, the list remains relevant today and is the basis for numerous maintenance human factors training programs.

Too Much:	Not Enough (A Lack of):
Complacency	Communication
Distraction	Knowledge
Fatigue	Teamwork
Pressure	Resources
Stress	Assertiveness
Norms	Awareness

Figure 1. Too much complacency is detrimental to performance. Alternatively, not enough communication is also detrimental to performance.

The Dirty Dozen can be discussed in terms of factors that there are too much of or not enough of (Figure 1). While no single factor is considered more significant than the others, the presence of fatigue, stress, and/or pressure will often amplify the influence of any other existing factors. Each factor has its own specific countermeasures, however, all are impacted by a positive safety culture, a strong Safety Management System (SMS), appropriate training, being properly prepared, and adherence to checklists and procedures. Investigations into aviation accidents involving maintenance error illustrate how these factors can contribute to adverse outcomes. Often, the factors are links in the accident chain of events that lead others (the flight crew, for example) to commit errors. A few examples are listed on pages 5-8 of this newsletter issue.

The Dirty Dozen tends to focus on the maintenance technicians but can also be used to examine the organization in which the action is occurring. Discussions on the Dirty Dozen increase awareness of the factors and the hope is that will translate into a reduction in error and an enhanced safety culture. It's also important to remember that the Dirty Dozen, by themselves, do not make up a human factors program. However, they're a good place to build from and a solid element in a robust SMS.

For a full explanation of the Dirty Dozen, consider participating in a Human Factors in Aviation Maintenance course at TSI. Contact Mr. D Smith at d.smith@dot.gov or learn more about TSI at: www.tsi.dot.gov

"THE DIRTY DOZEN" IN CONTEXT: AVIATION CASE STUDIES

Sundance Helicopters, December 7, 2011

Eurocopter AS350-B2, N37SH
Las Vegas, Nevada
Passengers and Crew: 5
Fatalities: 5
Damage: Destroyed

Potential Dirty Dozen Contributory Factors: Fatigue, Lack of Resources, Lack of Awareness, Pressure, Complacency, Lack of Assertiveness, Lack of Knowledge, Norms

From the NTSB Executive Summary

On December 7, 2011, a Sundance Helicopters aircraft crashed in mountainous terrain.

The accident occurred when the helicopter unexpectedly climbed about 600 feet, turned about 90° to the left, and then descended about 800 feet, entered a left turn, and descended at a rate of at least 2,500 feet per minute to impact. During examination of the wreckage, the main rotor fore/aft servo, one of the three hydraulic servos that provide inputs to the main rotor, was found with its flight control input rod not connected. The bolt, washer, self-locking nut, and split pin (sometimes referred to as a "cotter pin" or "cotter key") that normally secure the input rod to the main rotor fore/aft servo were not found. The investigation revealed that the hardware was improperly secured during maintenance that had been conducted the day before the accident. The nut became loose (likely because it was degraded)[1] and, without the split pin, the nut separated from the bolt, the bolt disconnected, and the input rod separated from the linkage while the helicopter was in flight, at which point the helicopter became uncontrollable and crashed.

Probable Cause

The NTSB determines that the probable cause of this accident was Sundance Helicopters' inadequate maintenance of the helicopter, including (1) the improper reuse of a degraded self-locking nut, (2) the improper or lack of installation of a split pin, and (3) inadequate post-maintenance inspections, which resulted in the in-flight separation of the servo control input rod from the fore/aft servo and rendered the helicopter uncontrollable. Contributing to the improper or lack of installation of the split pin was the mechanic's fatigue and the lack of clearly delineated maintenance task steps to follow. Contributing to the inadequate post-maintenance inspection was the inspector's fatigue and the lack of clearly delineated inspection steps to follow.

American Airlines Flight 1400, September 28, 2007

McDonnell Douglas DC-9-82, N454AA
St. Louis, Missouri
Passengers and Crew: 143
Fatalities: 0
Damage: Substantial

Potential Dirty Dozen Contributory Factors: Distraction, Complacency, Pressure, Norms, Lack of Resources, Lack of Awareness

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"THE DIRTY DOZEN" IN CONTEXT: AVIATION CASE STUDIES (CONT...)

From the NTSB Executive Summary

On September 28, 2007, the American Airlines aircraft experienced an in-flight engine fire during departure climb. During the return to STL, the nose landing gear failed to extend, and the flight crew executed a go-around, during which the crew extended the nose gear using the emergency procedure.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was American Airlines' maintenance personnel's use of an inappropriate manual engine-start procedure, which led to the uncommanded opening of the left engine air turbine starter valve, and a subsequent left engine fire, which was prolonged by the flight crew's interruption of an emergency checklist to perform nonessential tasks. Contributing to the accident were deficiencies in American Airlines' Continuing Analysis and Surveillance System (CASS) program.

Note: A flawed internal Safety Management System, which could have identified the maintenance issues that led to the accident, was cited as a contributing factor.

Chalk's Ocean Airways Flight 101, December 19, 2005

Grumman Turbo Mallard G-73T, N2969
Miami, Florida
Passengers and Crew: 20
Fatalities: 20
Damage: Destroyed

Potential Dirty Dozen Contributory Factors: Complacency, Norms, Lack of Awareness, Lack of Assertiveness, Lack of Knowledge, Lack of Resources

From the NTSB Executive Summary

On December 19, 2005, the Chalk's Ocean Airways aircraft crashed into a shipping channel adjacent to the Port of Miami, Florida, shortly after takeoff from the Miami Seaplane Base. The airplane's right wing separated during flight.

The safety issues discussed in this report focus on air carrier maintenance programs and practices and FAA oversight procedures for air carrier maintenance programs.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the in-flight failure and separation of the right wing during normal flight, which resulted from (1) the failure of the Chalk's Ocean Airways maintenance program to identify and properly repair fatigue cracks in the right wing and (2) the failure of the Federal Aviation Administration (FAA) to detect and correct deficiencies in the company's maintenance program.

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"THE DIRTY DOZEN" IN CONTEXT: AVIATION CASE STUDIES (CONT...)

Air Sunshine Flight 527, July 13, 2003

Cessna 402C, N314AB
About 7.35 Nautical Miles West-Northwest of Treasure Cay Airport
Passengers and Crew: 10
Fatalities: 2
Damage: Substantial

Potential Dirty Dozen Contributory Factors: Lack of Communication, Norms, Lack of Resources, Lack of Knowledge, Complacency

From the NTSB Executive Summary

On July 13, 2003, the Air Sunshine aircraft was ditched in the Atlantic Ocean following the in-flight failure of the right engine.

The safety issues discussed in this report include maintenance record-keeping and practices, pilot proficiency, Federal Aviation Administration (FAA) oversight, and emergency briefings.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the in-flight failure of the right engine and the pilot's failure to adequately manage the airplane's performance after the engine failed. The right engine failure resulted from inadequate maintenance that was performed by Air Sunshine's maintenance personnel during undocumented maintenance. Contributing to the passenger fatalities was the pilot's failure to provide an emergency briefing after the right engine failed.

Air Midwest Flight 5481, January 8, 2003

Raytheon (Beechcraft) 1900D, N233YV
Charlotte, North Carolina
Passengers and Crew: 21
Fatalities: 21
Damage: Destroyed

Potential Dirty Dozen Contributory Factors: Complacency, Fatigue, Norms, Lack of Knowledge, Lack of Awareness, Lack of Resources, Pressure

From the NTSB Executive Summary

On January 8, 2003, the Air Midwest aircraft crashed shortly after takeoff from runway 18R at Charlotte -Douglas International Airport, Charlotte, North Carolina.

The safety issues in this report focus on maintenance work practices, oversight, and quality assurance; aircraft weight and balance programs; maintenance training; FAA oversight; and Beech 1900 cockpit voice recorder problems.

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"THE DIRTY DOZEN" IN CONTEXT: AVIATION CASE STUDIES (CONT...)

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the airplane's loss of pitch control during takeoff. The loss of pitch control resulted from the incorrect rigging of the elevator control system compounded by the airplane's aft center of gravity, which was substantially aft of the certified aft limit.

Contributing to the cause of the accident were (1) Air Midwest's lack of oversight of the work being performed at the Huntington, West Virginia, maintenance station; (2) Air Midwest's maintenance procedures and documentation; (3) Air Midwest's weight and balance program at the time of the accident; (4) the Raytheon Aerospace quality assurance inspector's failure to detect the incorrect rigging of the elevator control system; (5) the Federal Aviation Administration's (FAA) average weight assumptions in its weight and balance program guidance at the time of the accident; and (6) the FAA's lack of oversight of Air Midwest's maintenance program and its weight and balance program.

Additional information on the factors in the Dirty Dozen can be found in the following:

Aviation Maintenance Technician Handbook – General
http://www.faa.gov/regulations_policies/handbooks_manuals/aircraft/media/AMT_Handbook_Addendum_Human_Factors.pdf

Avoid the Dirty Dozen
https://www.faasafety.gov/files/gslac/library/documents/2012/Nov/71574/DirtyDozenWeb3.pdf

NASA's Aviation Safety Reporting System (ASRS) Maintenance Reporting Callback September 2008
http://asrs.arc.nasa.gov/publications/callback/cb_345.htm

Safety Behaviours: Human Factors Resource Guide for Engineers
https://www.casa.gov.au/safety-management/standard-page/safety-behaviours-human-factors-engineers-resource-kit?WCMS%3ASTANDARD%3A%3Apc=PC_100999

Operator's Manual: Human Factors in Aviation Maintenance
http://www.faa.gov/about/initiatives/maintenance_hf/library/documents/media/human_factors_maintenance/hf_ops_manual_2014.pdf

Welcome FAA Schools of Excellence PEGASUS Fellows!

It's a busy time around the Civil Aerospace Medial Center in Oklahoma City, OK. To help us out with that , we have some highly skilled graduate students who have joined us for 10 weeks from the FAA Schools of Excellence Partnership to Enhance General Aviation Safety, Accessibility, and Sustainability (PEGASUS) program. Taken from the PEGASUS website:

PEGASAS is comprised of world-renowned universities and institutes with top-tier aviation programs as well as highly respected schools of engineering, science and policy… PEGASAS strives to expand general aviation's sustainability in a way that allows general aviation to serve the needs of future stakeholders, encompassing environmental, economic, and educational concerns.

We were fortunate to be able to collaborate with PEGASUS to award Audrey Reinert, from Purdue University, and Indira Maharaj , from Florida Institute of Technology a prestigious Fellowship to live and work here in Oklahoma City on Maintenance Human Factors projects. Welcome to you both!

Learn more about PEGASUS at: www.pegasas.aero

Audrey Reinert is a 1st year Ph.D. student in Industrial Engineering at Purdue University. Her work with the PEGASUS Fellows program focuses on identifying trends in ASRS reports to design effective interventions which reduce human factors maintenance errors. Prior to working with the FAA, Audrey has interned with NASA and United Technologies Research Center.

Indira Maharaj is an avid aviation enthusiast who has pursued an academic path dedicated to understanding and advancing the relationship between the human user and automation in aviation. She is a 2nd year Ph.D. student in the Aviation Sciences, Human Factors track at Florida Institute of Technology. Her interests in aviation include, the cognitive influences of human performance in "glass cockpits", bringing a new perspective to the old problem of how to maximize the benefits of aviation technological advancements such that a highly effective and efficient human-in-the-loop system can occur. She has over 8 years of research experience and managing projects which includes membership in the Human Factors and Ergonomics Society. In addition, she is an active member of Women in Aviation and is working on her PPL, with a goal of obtaining instrument rating prior to graduation. When she is not involved in research or aviation, she enjoys volunteering at the Second Harvest Food Bank, advocating for world peace, cuddling with puppies, smelling the rain, and listening to thunderstorms (especially at night).

Maintenance Human Factors Lab Update

As many of you might know from seeing Dr. Michelle Bryant out and about, we are in the midst of collecting data from over 300 maintenance technicians across the nation. The current study is a follow up from a fatigue study published by Dr. Bill Johnson, Dr. Steven Hall, and Jean Watson in 2001. You can find that report by clicking here. The primary recommendation from that study indicated that there was a need for a Sleep Culture among maintenance organizations. As a result, the Flight Deck Lab produced a flurry of documents and training focused on the importance of sleep and the impact of fatigue. You can find these resources by clicking here. Now, we are interested to see if there have been any changes across the industry. We have currently collected data from about 220 maintenance personnel across the industry and expect to complete all 300 by July of this year. Once we have completed data collection, we'll update you on what our participants do in the study, and the anticipated date when results will be available. Thank you to the maintenance community for welcoming our researchers into your hangars. We couldn't do our work without you.

Maintenance Human Factors Recent and Upcoming Events

CHC Safety Summit: Co-Key Note Speaker and ROI Workshops Dr. Bill Johnson	April 5-7 2016 Vancouver, BC
AMFA Conference: Attention to Maintenance Human Factors Dr. Bill Johnson	May 2, 2016 New Orleans, LA
Regional Airlines Convention: Not Your Grandfather's SDRS Dr. Bill Johnson	May 11, 2016 Charlotte, NC
Transportation Safety Institute: Maintenance Human Factors Course Dr. Bill Johnson	May 25, 2016 Mike Monroney Aeronautical Center, OK
Navy Squadron Safety Stand-down: A Focus on Fatigue Dr. Michelle Bryant	June 18th, 2016 Tinker Airforce Base, OK
Transportation Safety Institute: Maintenance Human Factors Course Dr. Bill Johnson	June 19th, 2016 Mike Monroney Aeronautical Center, OK
CSTA Workshop: Train the Trainer Dr. Bill Johnson, D Smith, and Dr. Michelle Bryant	August 2-4th, 2-16 Mike Monroney Aeronautical Center, OK

See something missing?

Are you a regular reader of our Mx HF Newsletter? Do you see something we're missing? As always, please let us know! If you have ideas for future articles or would like to contribute, please contact our newsletter staff at:

crystal.rowley@faa.gov.