

# Human Factors and Your Job in Aviation Maintenance

William B. Johnson, Ph.D.  
Chief Scientific and Technical Advisor  
Human Factors in A/C Maintenance Systems  
[bill.johnson-dr@faa.gov](mailto:bill.johnson-dr@faa.gov)  
+1.404.305.6118

PAMA Regional Meeting  
Savannah, GA  
November 2, 2006



Federal Aviation  
Administration



**Maybe we all need  
some “thought  
control?”**

**What is in it for you?**

**Most of our errors are in thinking rather than  
lack of knowledge.**

**Think about your actions that may lead to  
error.**

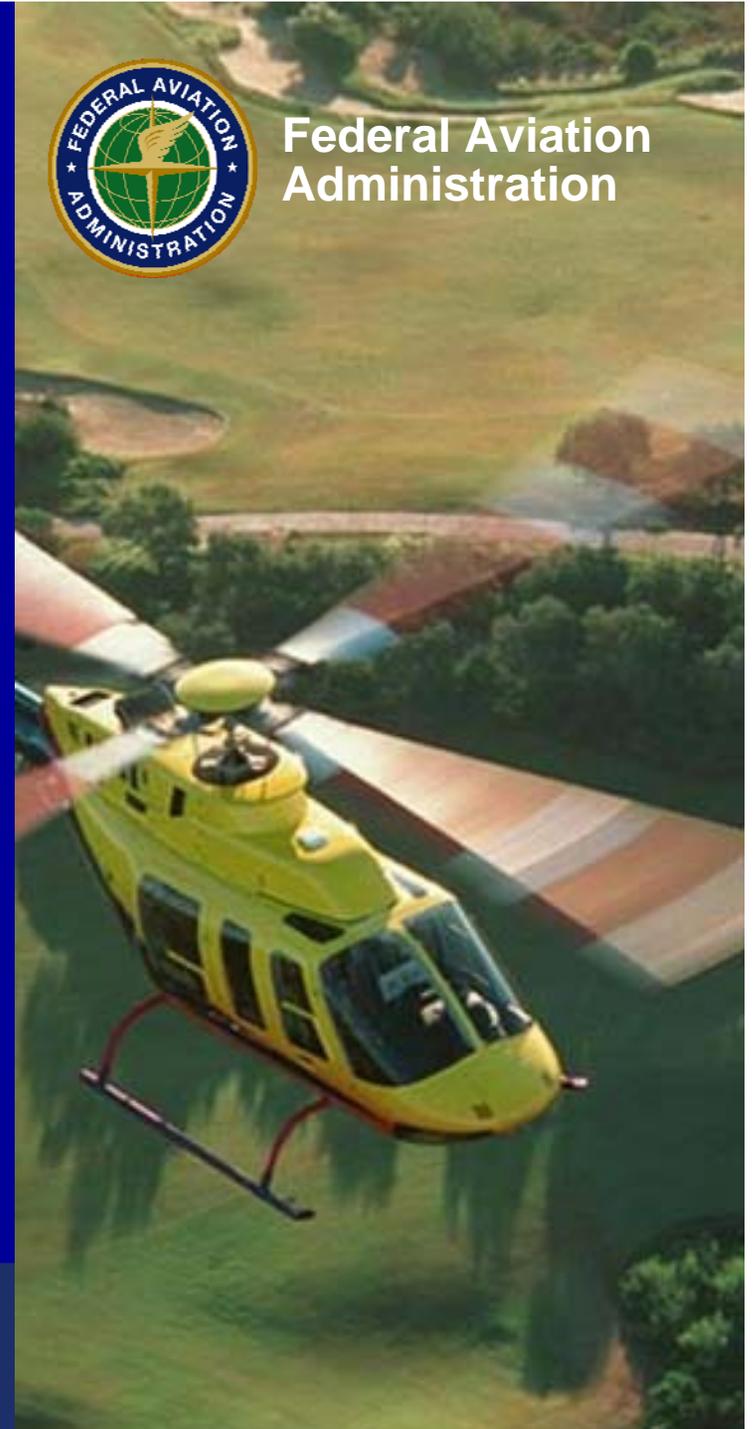
**Save time and money?**

**Apply principles to life.**

PAMA Regional Meeting  
Savannah, GA  
November 2, 2006



Federal Aviation  
Administration



# Human Factors Spectacles



# Presentation Plans

- Speak in straight forward terms
- Reinforce your current knowledge
- Offer new concepts and/or new ways to explain old concepts
- Provide links for more information
- Have a few laughs?



# Agenda

2005 International Safety Data with Human Factors Implications

Human Factors Fundamentals and Review

**Break**

Status of US & International Regulations

Operator's Manual for HF in Aviation Maintenance

2006+ FAA Human Factors Activities



# Agenda

2005 International Safety Data with Human Factors Implications

Human Factors Fundamentals and Review

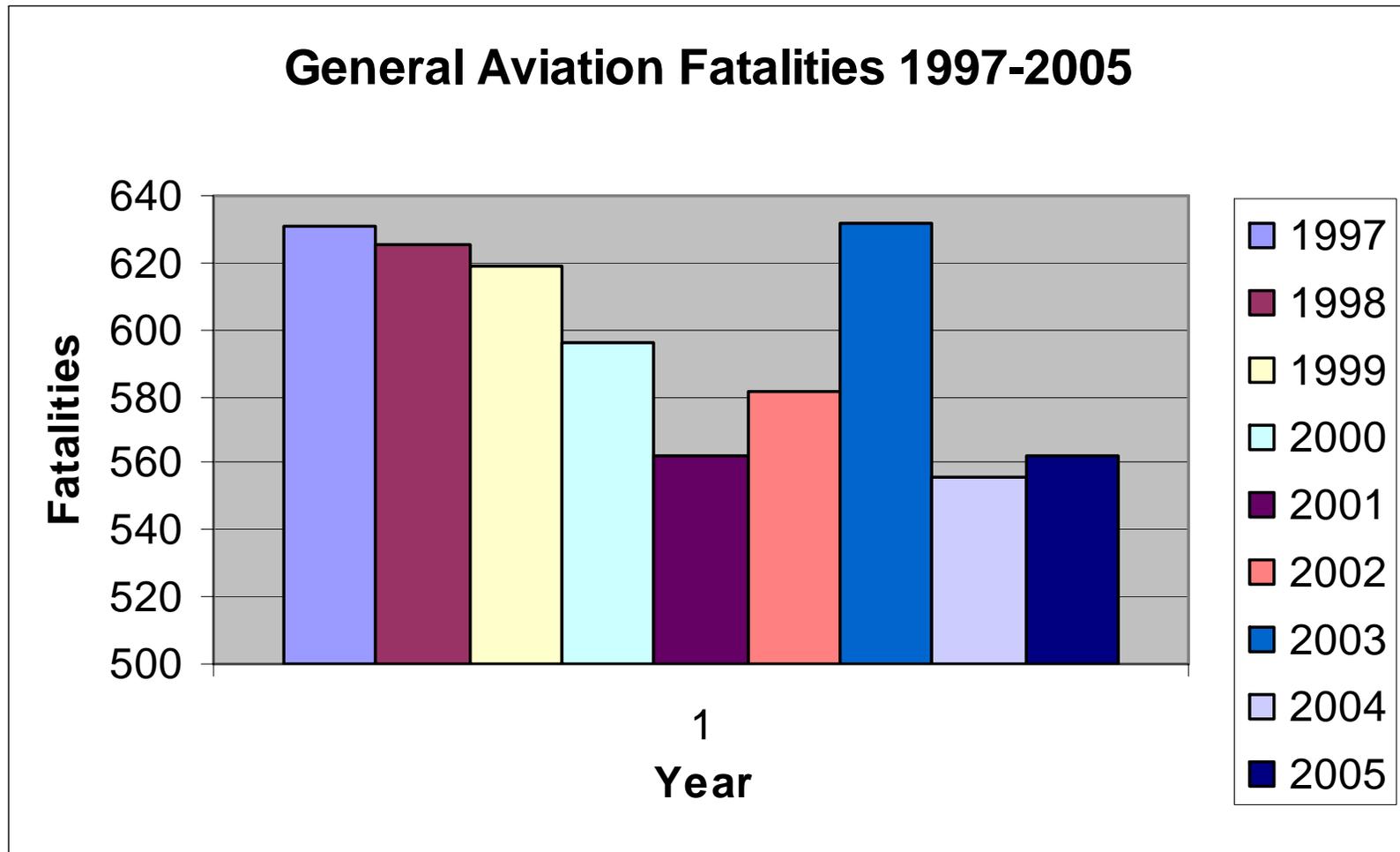
Status of US & International Regulations

Operator's Manual for HF in Aviation Maintenance

2006+ FAA Human Factors Activities



# GA Fatalities Stable 2004-2005



BTS/NTSB Data 2005-2006



## Implications of the 2005 Safety Stats for Mx HF

- **There are “opportunities for improvement”**
- **Maintenance and technical issues are areas of concern**
- **Technical manuals!!**
- **Human factors challenges are ever present**



# Agenda

2005 International Safety Data with Human Factors Implications

Human Factors Fundamentals and Review

Status of US & International Regulations

Operator's Manual for HF in Aviation Maintenance

2006+ FAA Human Factors Activities



# Mx Human Factors has evolved in 20 years!



PAMA Regional Meeting  
Savannah, GA  
November 2, 2006



Federal Aviation  
Administration

# Events where Maintenance was a Factor

The graphic features a grid background with several aircraft silhouettes. A red box labeled 'accident' is positioned near the top left. A table on the right lists the following accidents:

|                         |      |
|-------------------------|------|
| American Airlines DC-10 | 1979 |
| Eastern Airlines L1011  | 1982 |
| Aloha Airlines B737     | 1988 |
| Valu-Jet DC-9           | 1995 |
| Lufthansa A320          | 2001 |

Below the table, a green bar is visible. At the bottom left, the text 'INTRODUCTION TO HUMAN FACTORS' is present, and at the bottom right, the code '01-04-021' is displayed.

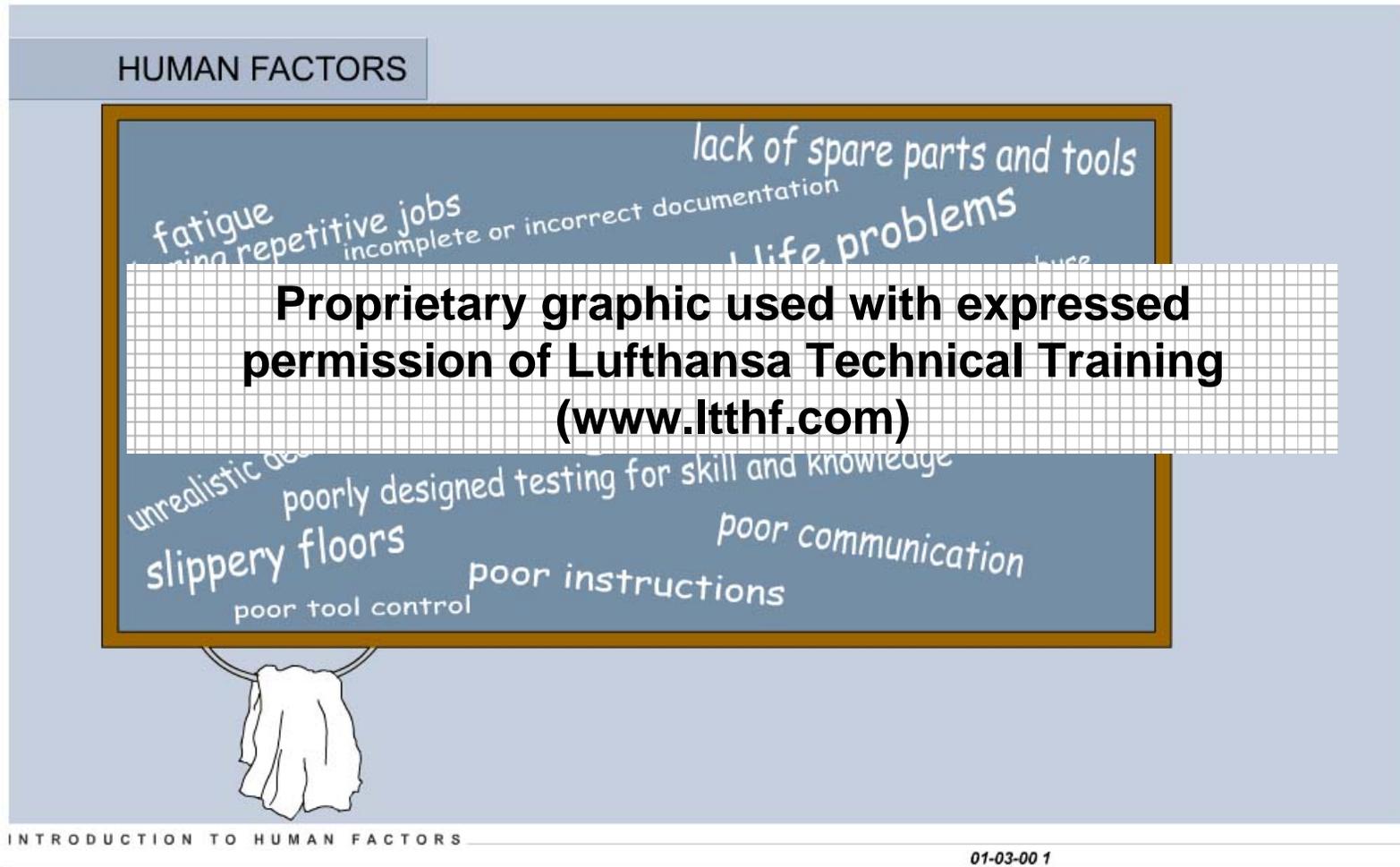
**Proprietary graphic used with expressed permission of Lufthansa Technical Training (www.ltthf.com)**

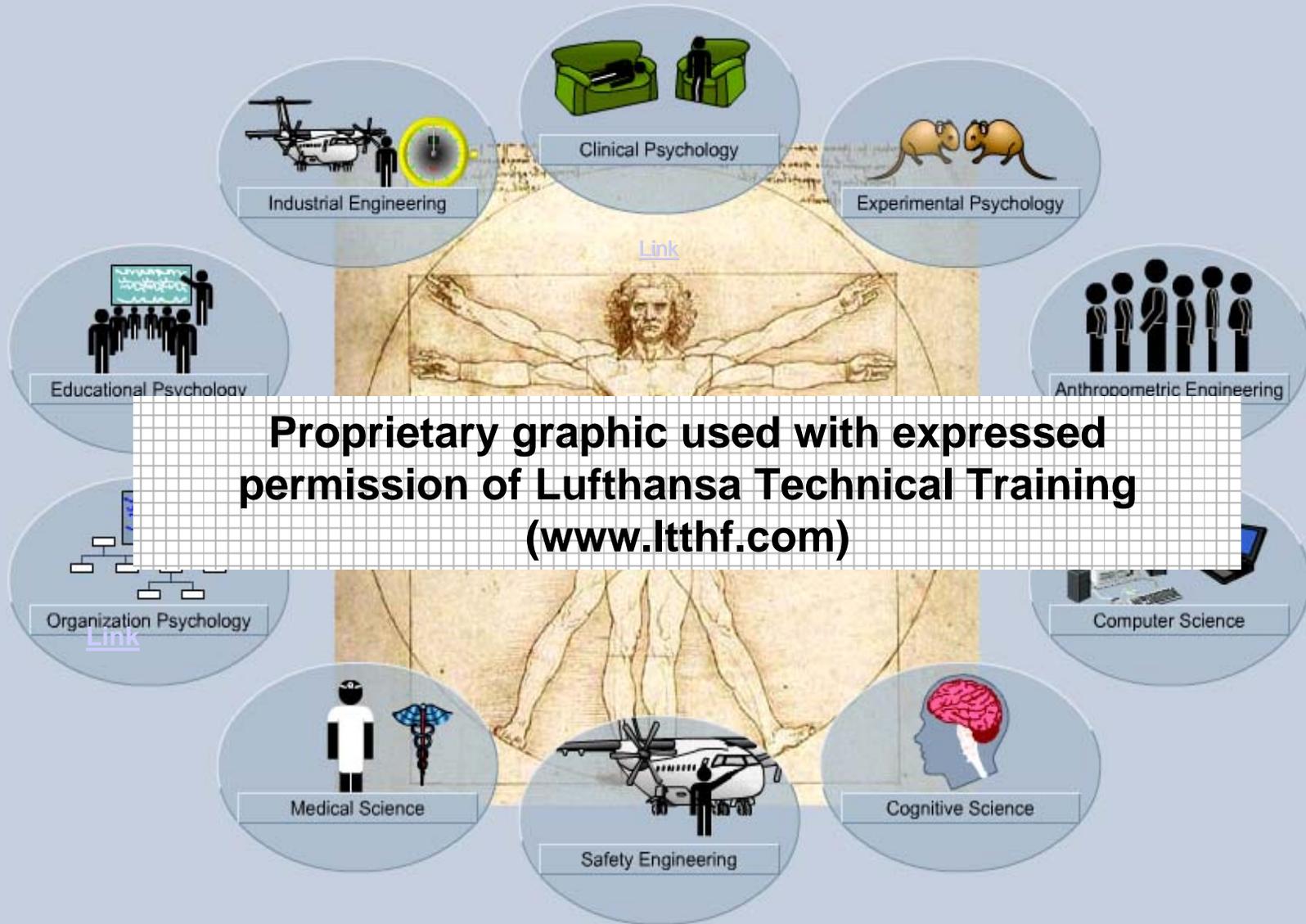
[Link](#)

# Example Maintenance Error

|           |                   |              |                                |
|-----------|-------------------|--------------|--------------------------------|
| Jan 2000  | Alaska Airlines   | Boeing MD-80 | Jackscrew for Elevator Control |
| Mar 2001  | Lufthansa Airbus  | A320         | Mis-wired side stick           |
| Apr 2001  | Emery Worldwide   | DC-8         | Reversed hyd. check-valve      |
| Aug 2001  | Air Transat       | A310         | Fuel exhaustion over Atlantic  |
| May 2002  | China Airlines    | B747-200     | In flight break-up at 35K Ft.  |
| Jan 2003  | Air Midwest       | Beech1900D   | Trim Rigging                   |
| Aug 2003  | Colgan Air        | Beech 1900D  | Trim Rigging                   |
| Jan 2006  | Continental       | B737-500     | Engine Run-up                  |
| July 2006 | Spectrum Aircraft | Spectrum 33  | Mis-Rigging                    |

# List “Human Factors” related to maintenance?





# The PEAR MODEL



**People  
Environment  
Actions  
Resources**

Maddox & Johnson, 1996

[Link](#)

PAMA Regional Meeting  
Savannah, GA  
November 2, 2006

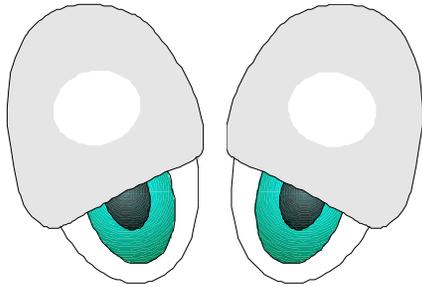


Federal Aviation  
Administration

# Can a machine do this job?

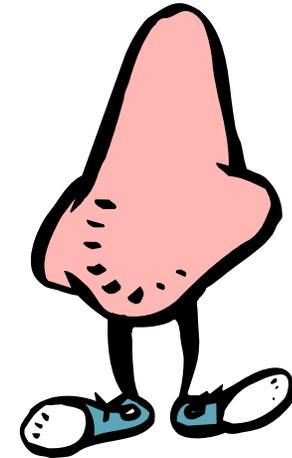


# Sensing and Perception



## Human Senses

Human Factors  
Human Factors  
Human Factors



# How to Remember the 5 Senses



PAMA Regional Meeting  
Savannah, GA  
November 2, 2006



Federal Aviation  
Administration

# A Test / Example of.....(Volunteer Needed)

As quickly as possible, say the color of each word on the screen.



**desk**

**rock**

**cat**

**spoon**

**book**



**dog**

**house**

**table**

**car**

**tree**



red

blue

gray

purple

green



# What is this?

**IB**

# What is this now?

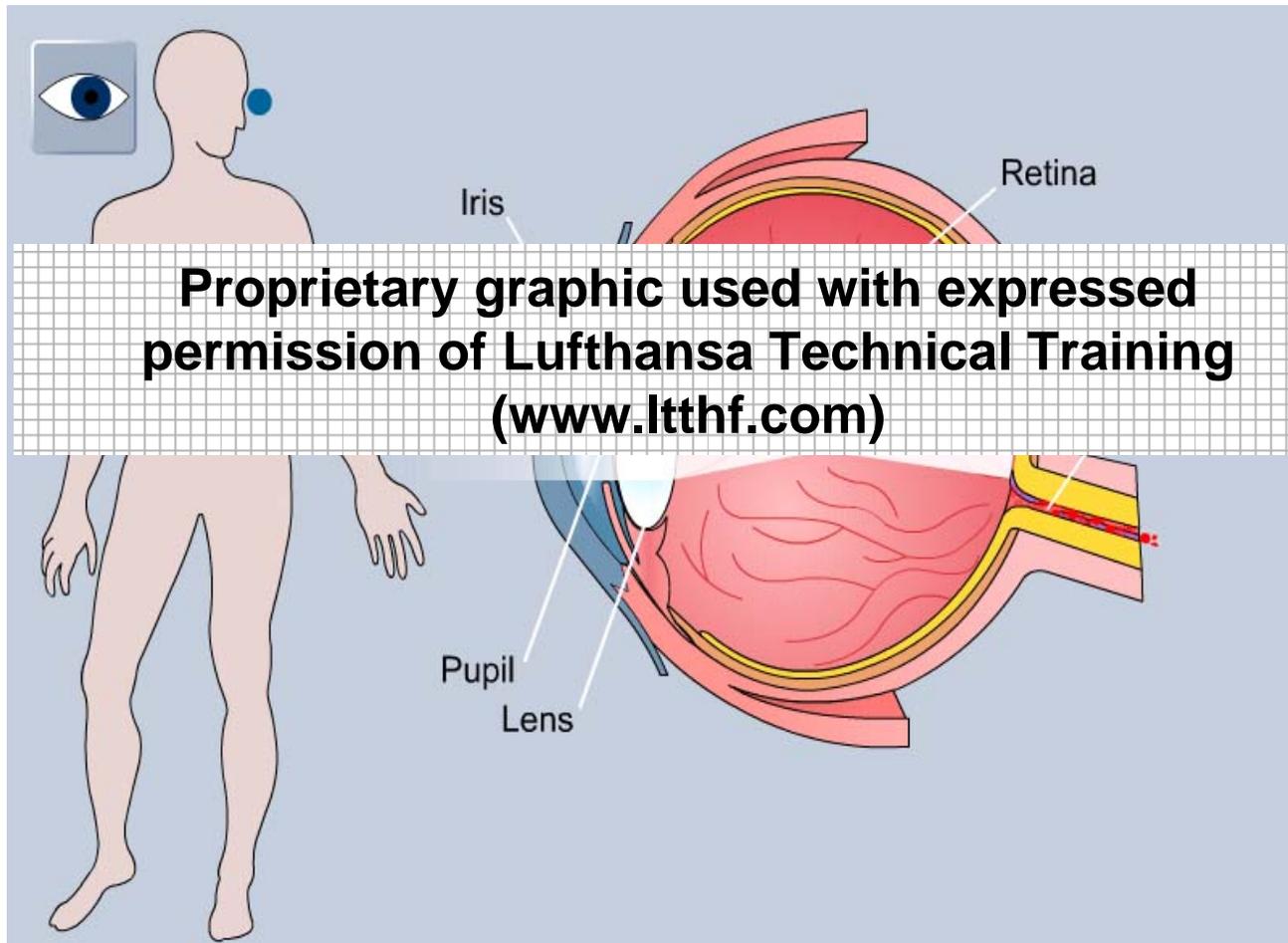
A, B, C, D, E, F  
10, 11, 12, 13, 14

**Both the letter “B” and the number “13” are the same figure. However, the context determines how you perceive them.**

(Coren, et al, (1994), Sensation and Perception, Harcourt Brace College Publishers)

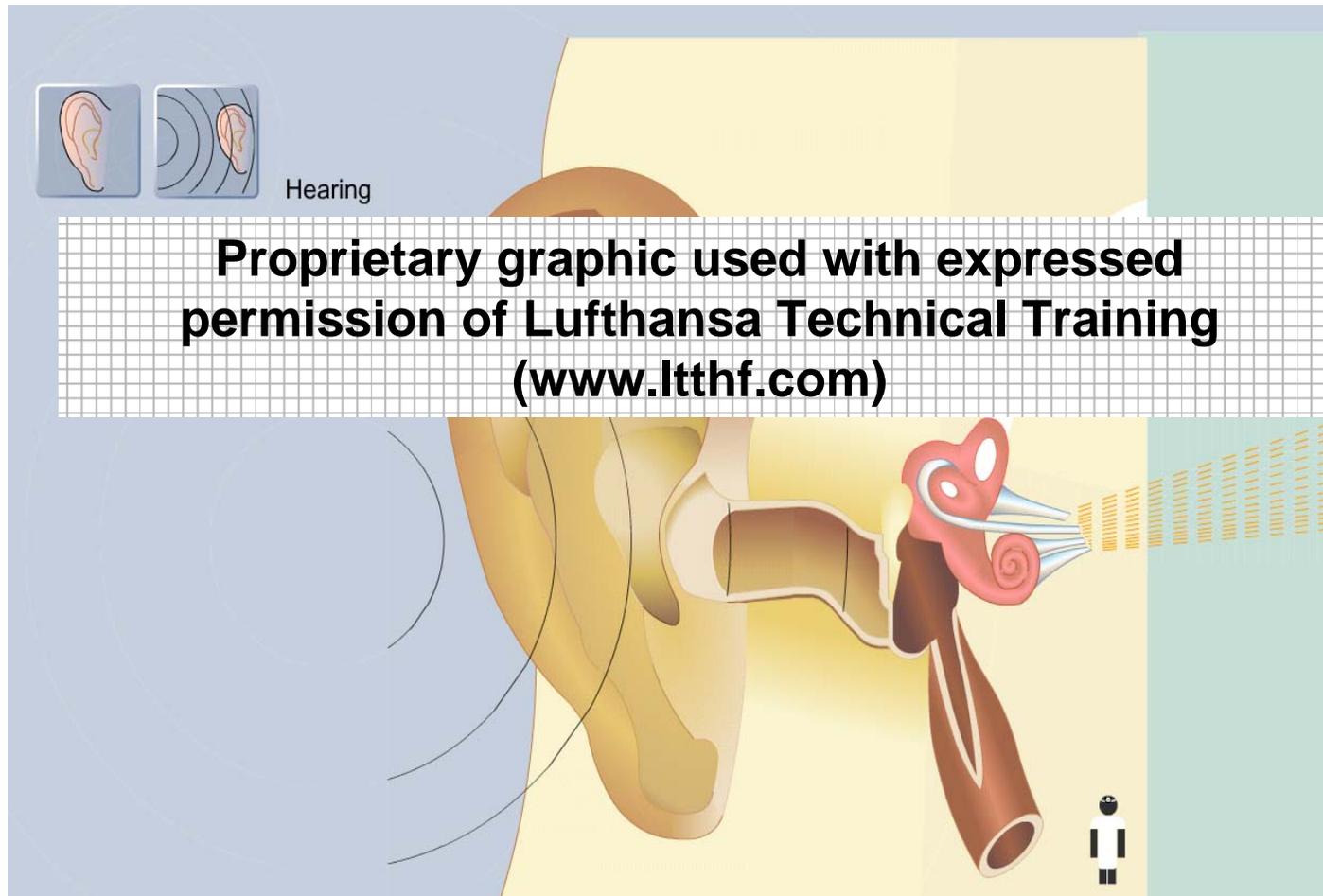


# Seeing

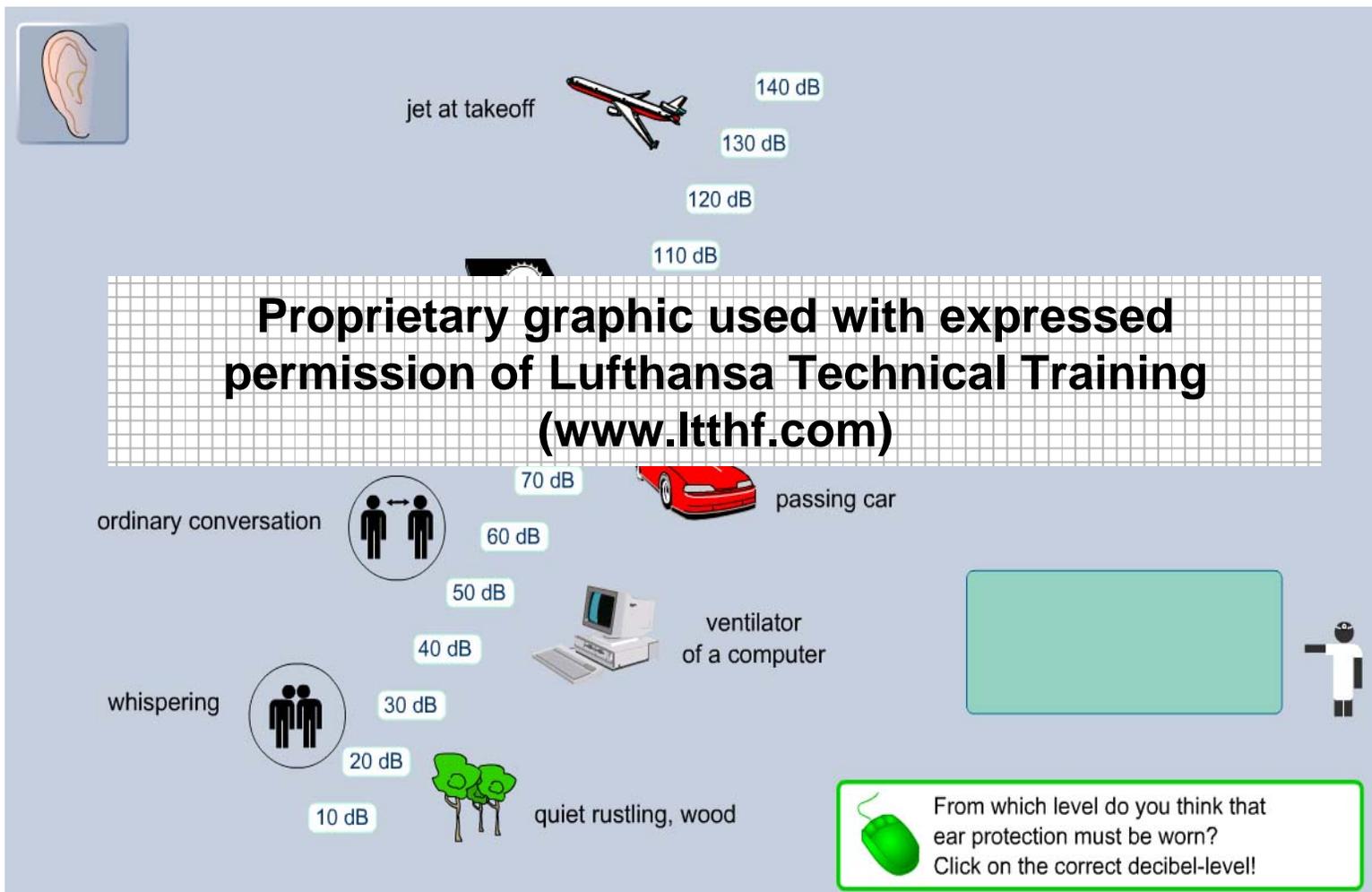


[Link](#)

# Hearing

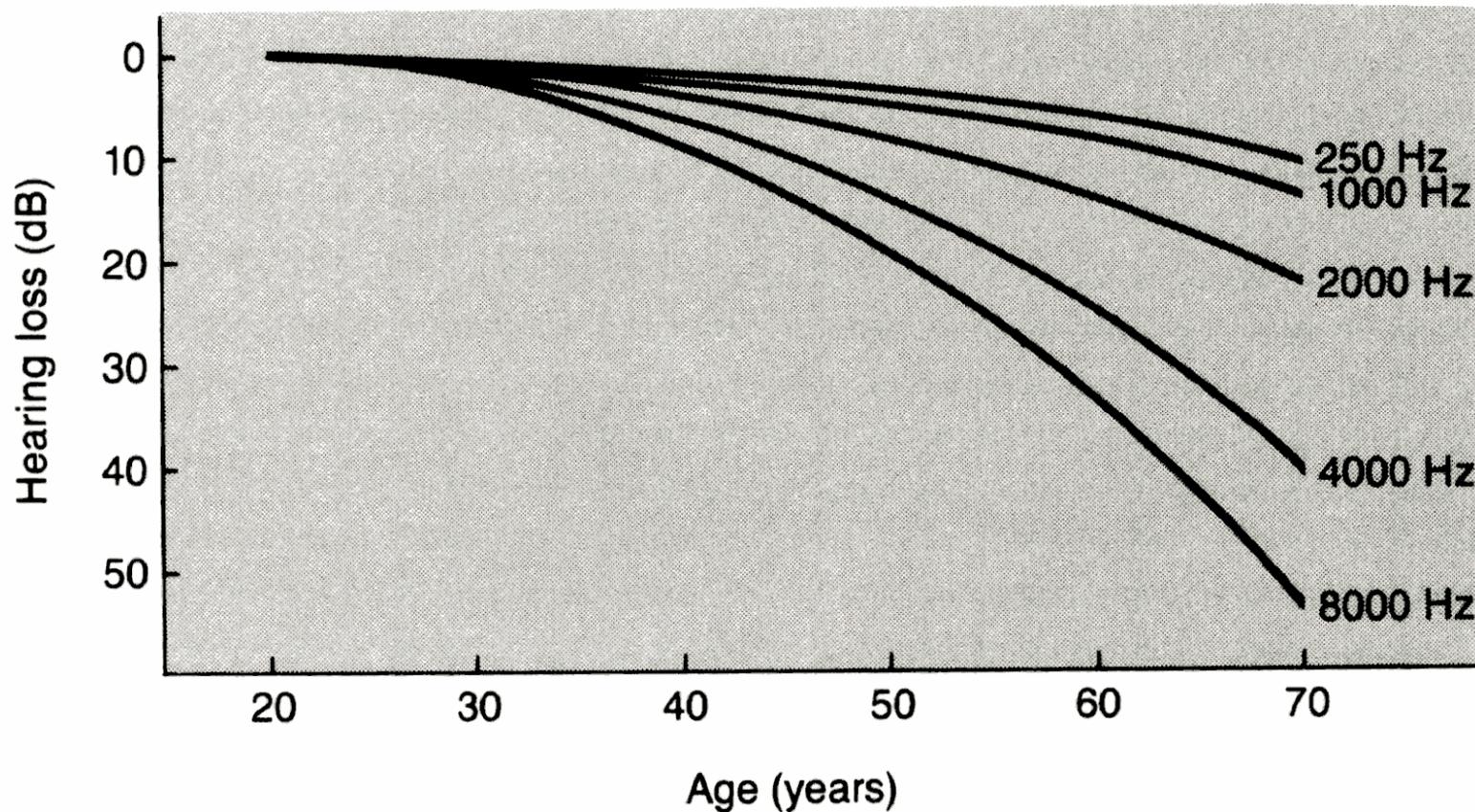


# Safe Sound Levels



[Link](#)

# Mother Nature is Cruel ☹️



Ability to hear stimuli, especially in the high ranges, decreases with age. (McFarland et al. (1960), *Journal of Gerontology*, 15, 149-154)

# A Couple of Slides to Help Understand Error

**Proprietary graphic used with expressed permission of Lufthansa Technical Training ([www.ltthf.com](http://www.ltthf.com))**

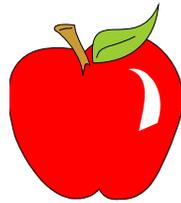
"To minimize error, it is necessary to understand error."



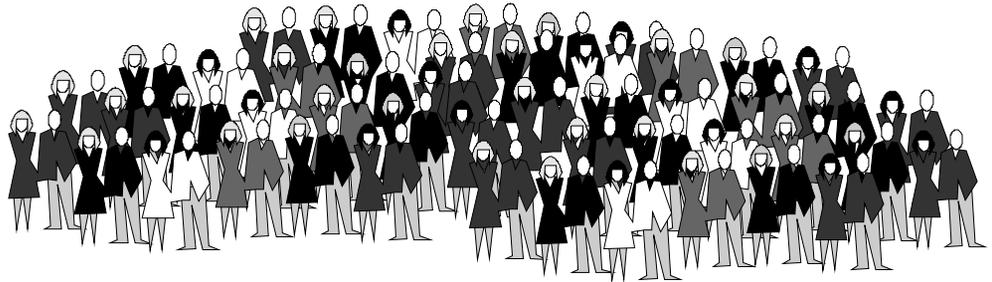
HUMAN ERROR

# The Greatest Hazard to Aircraft is?

**Gravity**

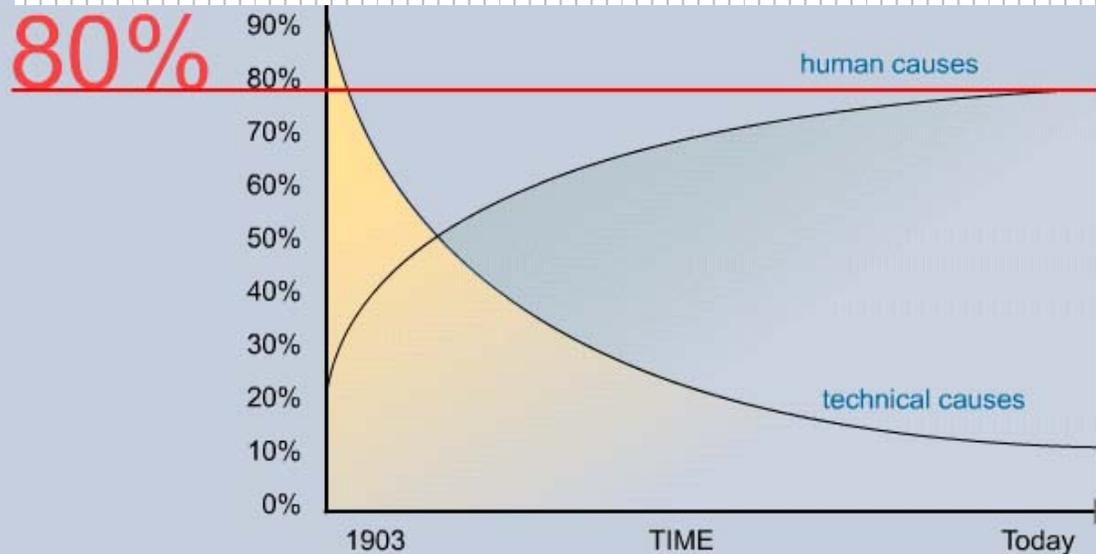


**Humans**

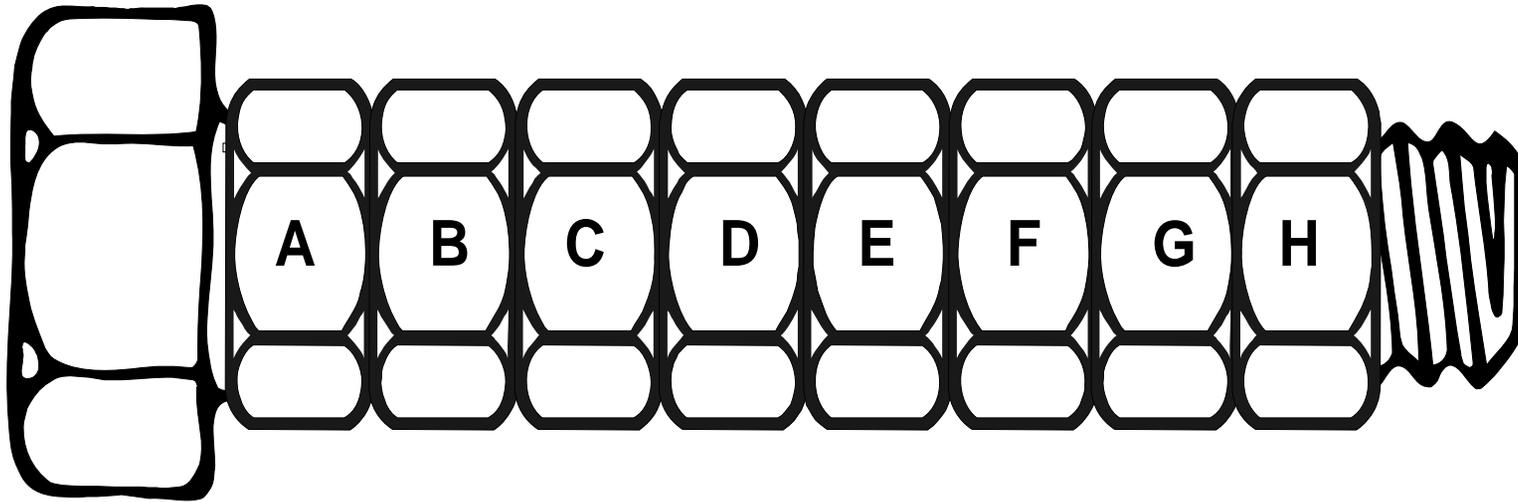


# The 80% Human Error in Events!

Proprietary graphic used with expressed permission of Lufthansa Technical Training ([www.ltthf.com](http://www.ltthf.com))



# High Chance of Error



- **Only One way to disassemble**
- **40,000+ ways to error in reassembly!**

Thanks to Prof. J. Reason

# Error Definitions

## Definitions of Error

unintentionally

intentionally

### SLIP

A slip is merely a good plan poorly executed.

### MISTAKE

A mistake is a "bad plan."

### VIOLATION

A violation is a very serious mistake.

Proprietary graphic used with expressed permission of Lufthansa Technical Training ([www.ltthf.com](http://www.ltthf.com))



# Active and Latent Error: An Important HF Concept

## |Different kinds of ERROR|

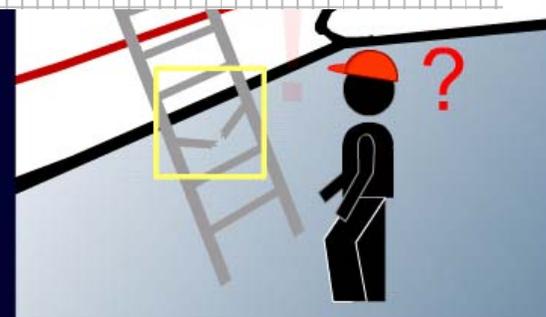
### Active error

specific individual activity  
that is an obvious event

### Latent error

company issues  
that lead up to the event

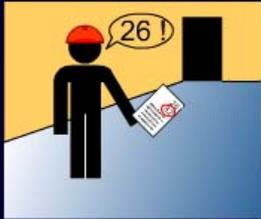
Proprietary graphic used with expressed  
permission of Lufthansa Technical Training  
([www.ltthf.com](http://www.ltthf.com))



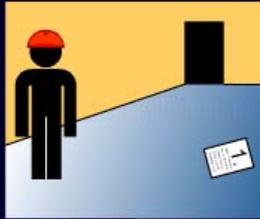
# Define the Errors: For Discussion

## |Different kinds of ERROR|

A) Berndt misreads a torque value. It is 62 and he sees 26.



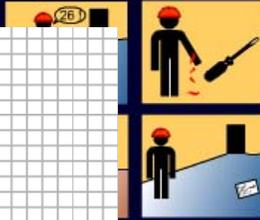
D) Ted does not use the job card because he already knows the job from memory.



B) Klaus cut when he from the



E) (26)



C) Brian does not use a new locking device because the parts room was closed at the time he needed the hardware.



Proprietary graphic used with expressed permission of Lufthansa Technical Training ([www.ltthf.com](http://www.ltthf.com))



Which of these examples is a "latent error"?  
Please click on one of the boxes!

# Boeing's top 7 Errors

276 Inflight shutdowns (1994)

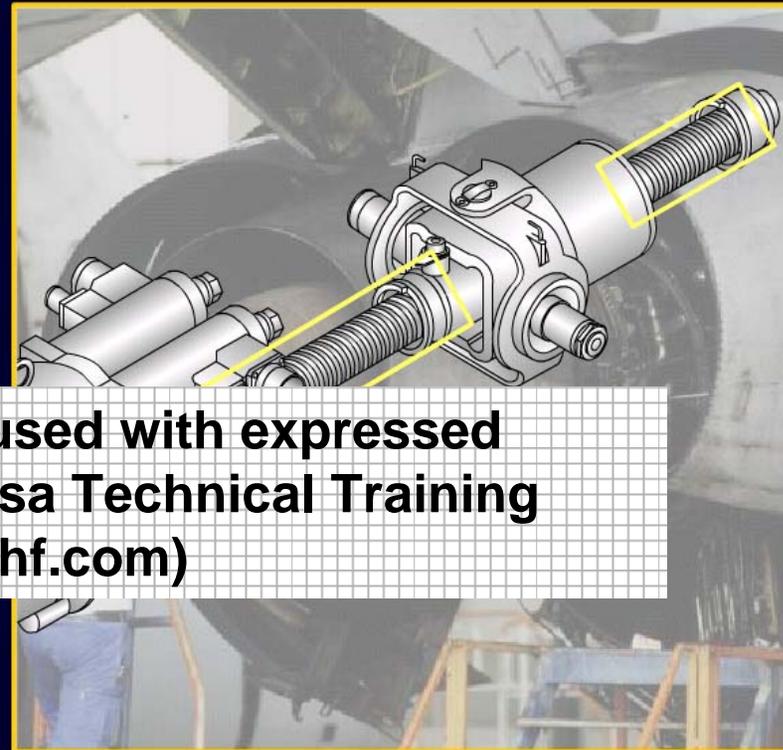
- Incomplete installation (33%)
- Damage on installation (14.5%)
- Improper installation (11%)
- Equipment not installed or missing (11%)
- FOD (6.5%)
- Improper troubleshooting, inspection, test (6%)
- Equipment not activated or deactivated (4%)



# The CAA Error List Shown in LTT WBT

List of maintenance errors over 3 years

- 1.) Incorrect installation
- 2.) Electrical wiring
- 3.) Cross connections
- 4.) Forgotten tools and parts
- 5.) Failure to lubricate



**Proprietary graphic used with expressed permission of Lufthansa Technical Training ([www.ltthf.com](http://www.ltthf.com))**

# The 12 Common Human Errors

**The Dirty Dozen**

- Lack of Communication
- Lack of Teamwork
- Norms
- Pressure
- Lack of Resources
- Distraction
- Assertiveness
- Fatigue
- Stress

**Proprietary graphic used with expressed permission of Lufthansa Technical Training (www.ltthf.com)**

HUMAN ERROR

[Link](#)



# Iceberg Model

The Iceberg Model



Time

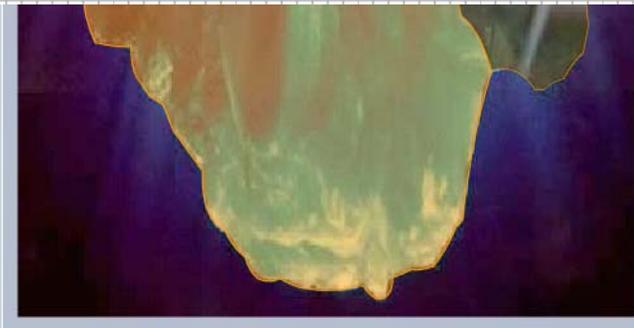


Tools

**Proprietary graphic used with expressed permission of Lufthansa Technical Training ([www.ltthf.com](http://www.ltthf.com))**



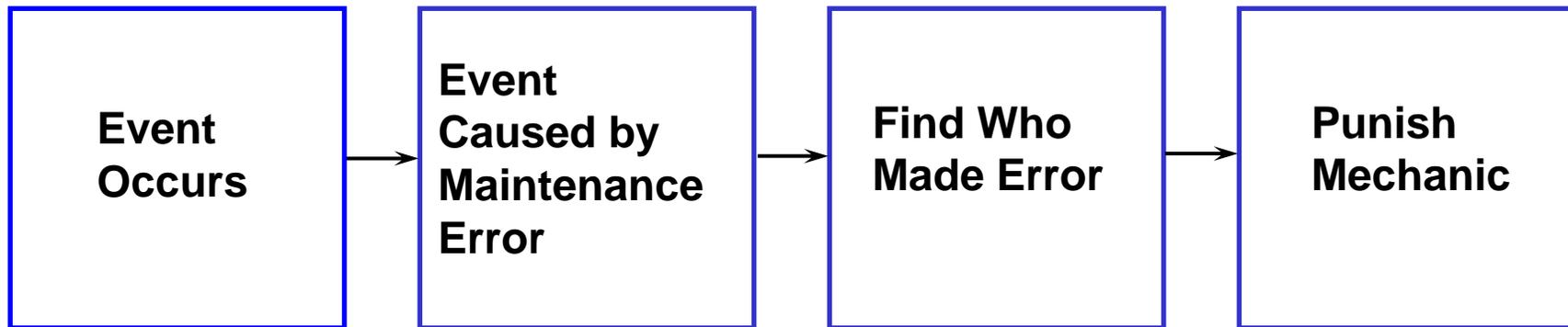
Money



Computer

# Traditional Error Investigation Process

(a.k.a., Your system?)



## Philosophy of Error Reporting (Boeing-MEDA)

- **Staff do not make errors on purpose**
- **Maintenance errors are made because of a series of related contributing factors**
- **Most of the contributing factors are part of maintenance organization processes and can be changed**

Slide provided by Boeing, Dr. Bill Rankin

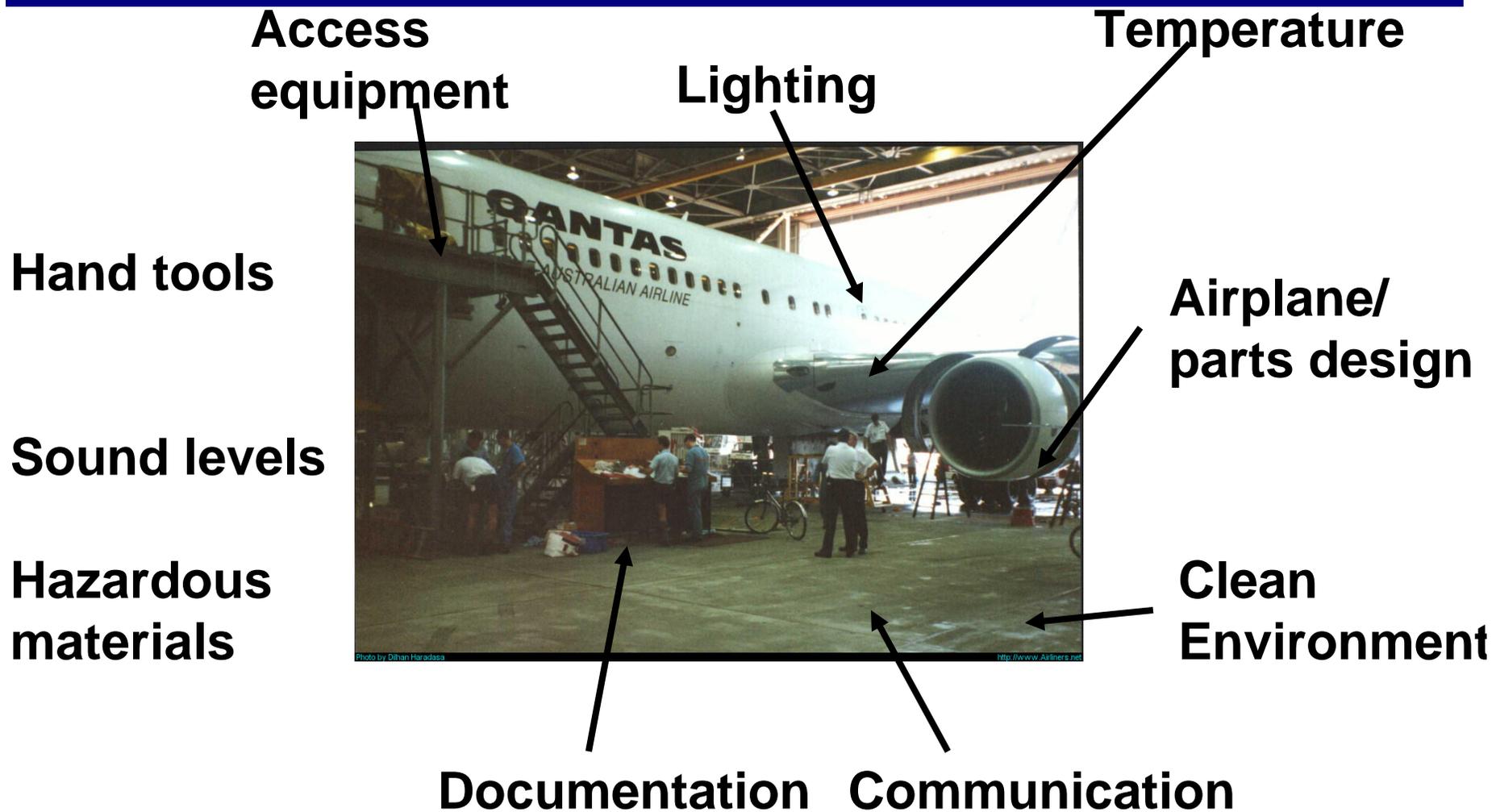


# More MEDA Philosophy

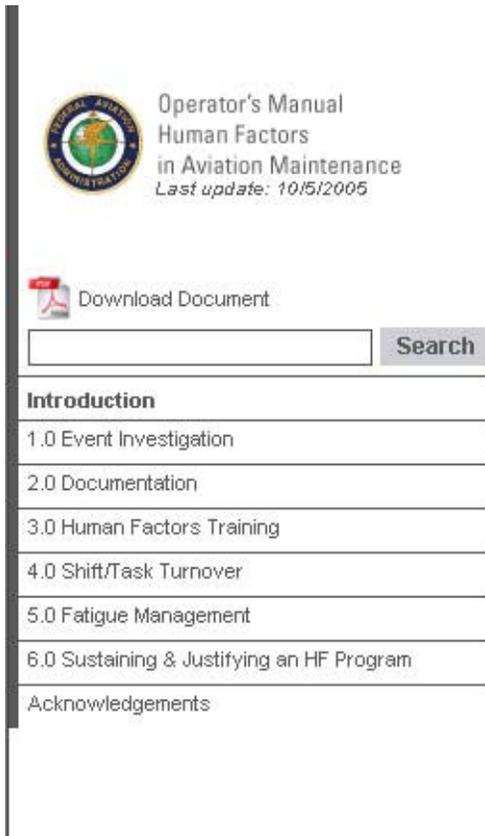
- **Maintenance program must be viewed as a system, where the mechanic is one part of the system**
- **Addressing lower level events helps prevent more serious events**



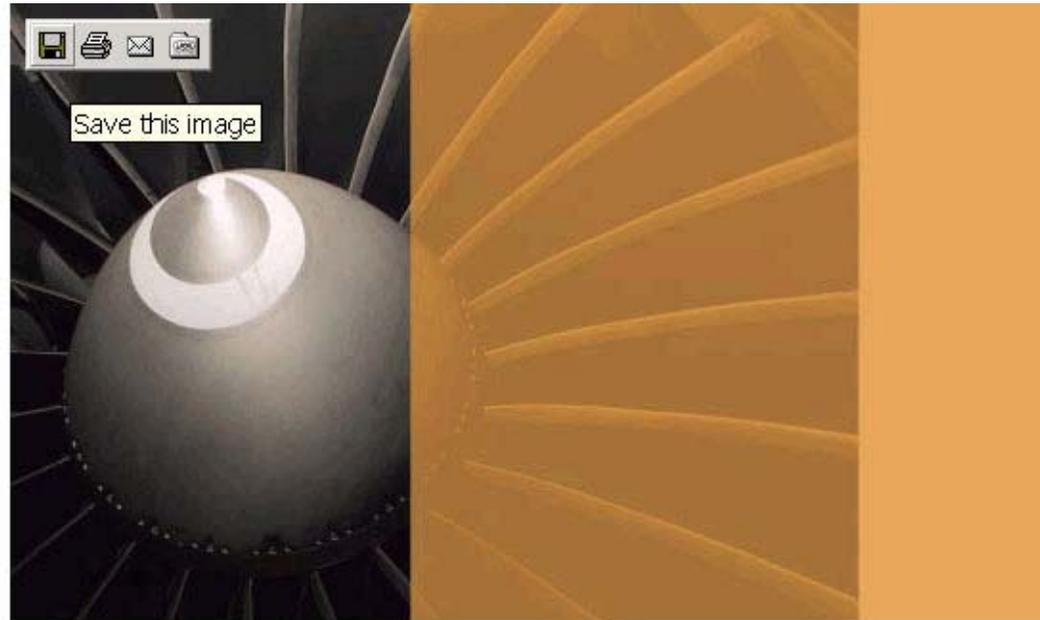
**Contributing Factors: Anything that affects how a mechanic does his/her job.**



# A Reference for Error Reporting



The screenshot shows the top portion of a web page. On the left is the FAA logo. To its right, the text reads: "Operator's Manual Human Factors in Aviation Maintenance Last update: 10/5/2005". Below this is a "Download Document" button with a PDF icon. Further down is a search bar with a "Search" button. A table of contents is visible, listing sections: Introduction, 1.0 Event Investigation, 2.0 Documentation, 3.0 Human Factors Training, 4.0 Shift/Task Turnover, 5.0 Fatigue Management, 6.0 Sustaining & Justifying an HF Program, and Acknowledgements.



## 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:

[www.hf.faa.gov/opsmanual](http://www.hf.faa.gov/opsmanual)

# What does this mean?

**Proprietary graphic used with expressed permission of Lufthansa Technical Training ([www.ltthf.com](http://www.ltthf.com))**

7 days per week X 24 hours per day X 365 days per year

ACTORS AFFECTING PERFORMANCE AND WORK ACTIVITY

Link

PAMA Regional Meeting  
Savannah, GA  
November 2, 2006



Federal Aviation  
Administration

# The Fatigue Issue is not New!

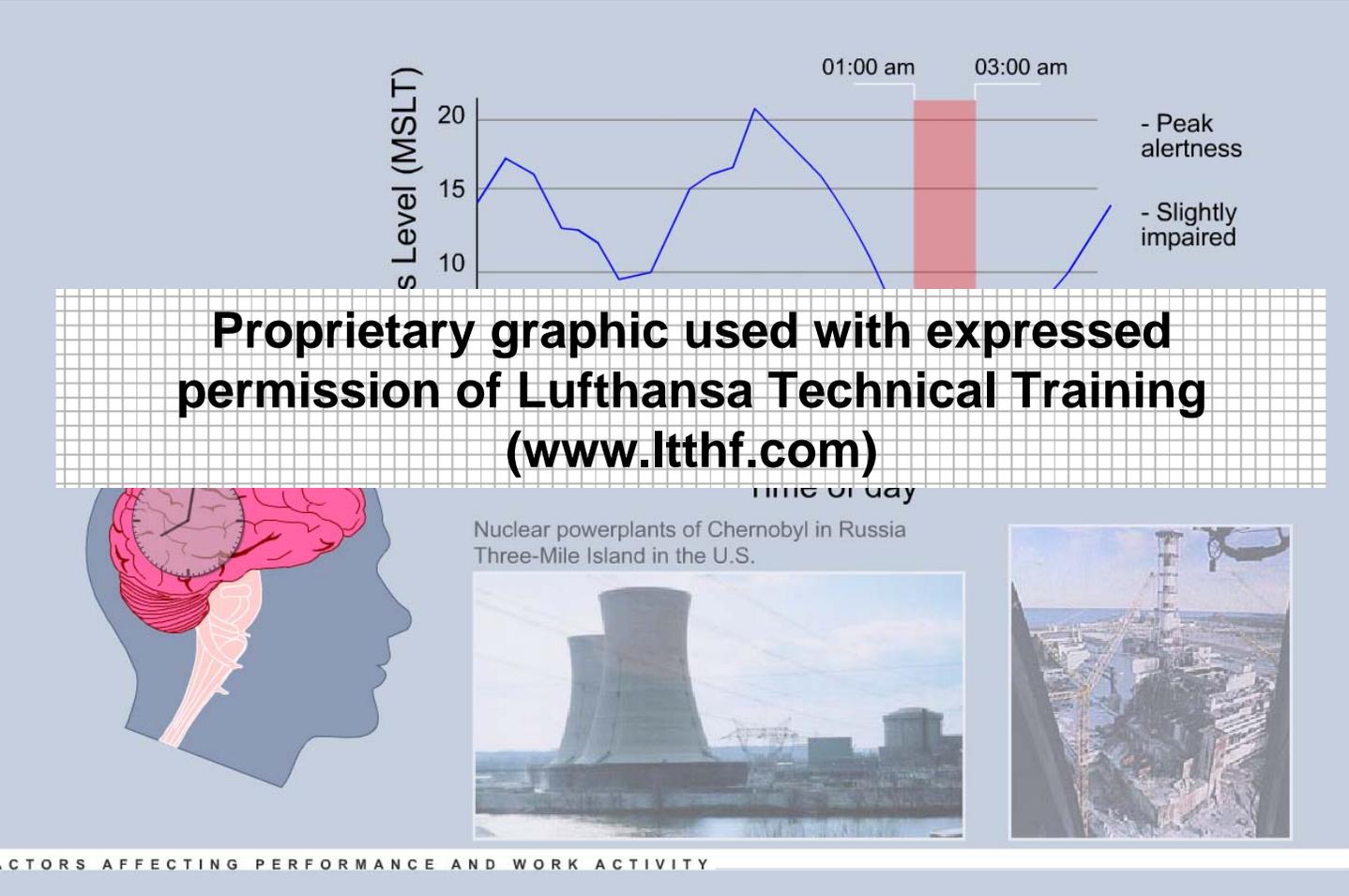
“O sleep, O gentle sleep, Nature’s soft nurse”

*William Shakespeare*



1564-1616

# Bad Things can happen when not alert!



[Link](#)



# Types of Fatigue

## Acute Fatigue

Intense

Short Duration

Cured with a good night's sleep

Proprietary graphic used with expressed permission of Lufthansa Technical Training ([www.ltthf.com](http://www.ltthf.com))

Fatigue

Acute fatigue

Chronic fatigue

## Chronic Fatigue (harder to fix)

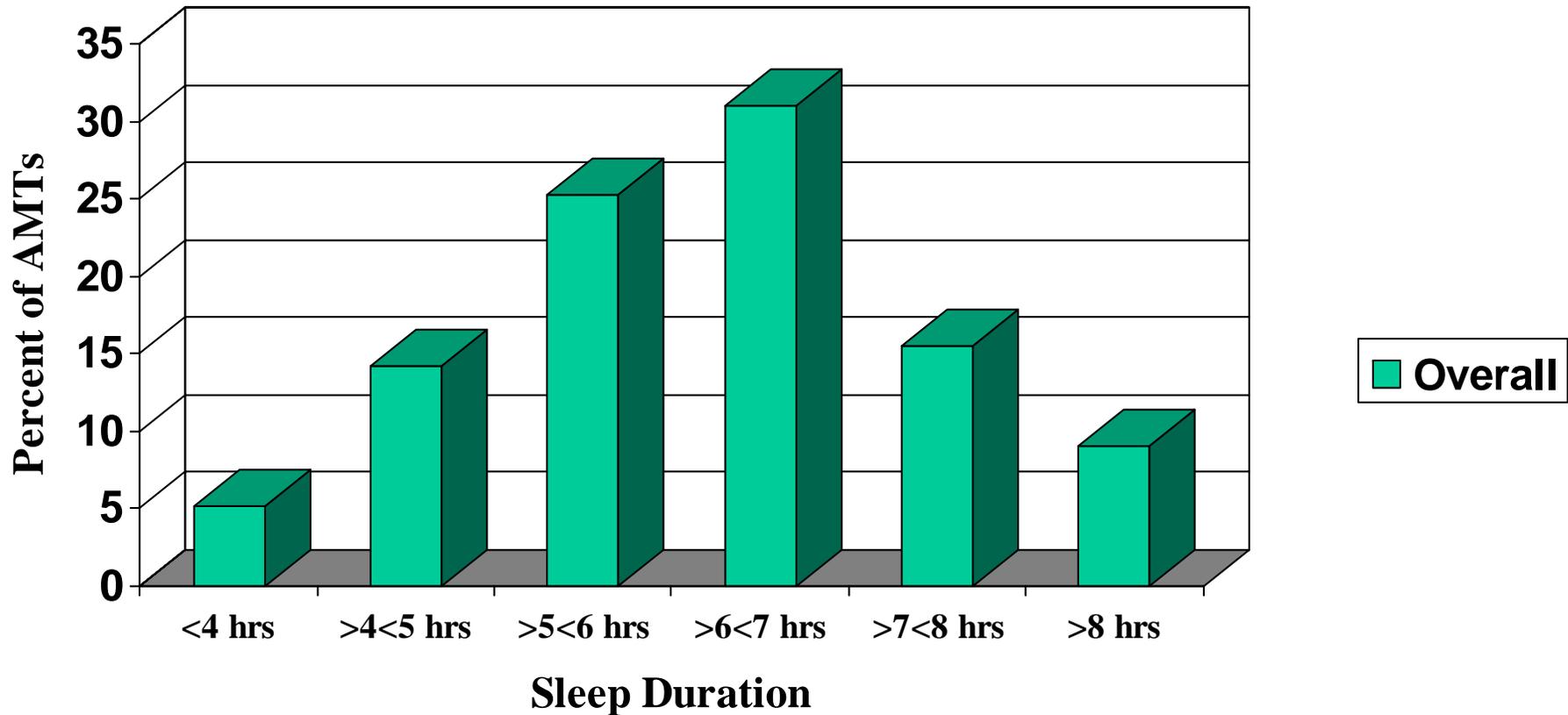
Frequent recurrence

Long duration

Slow recovery

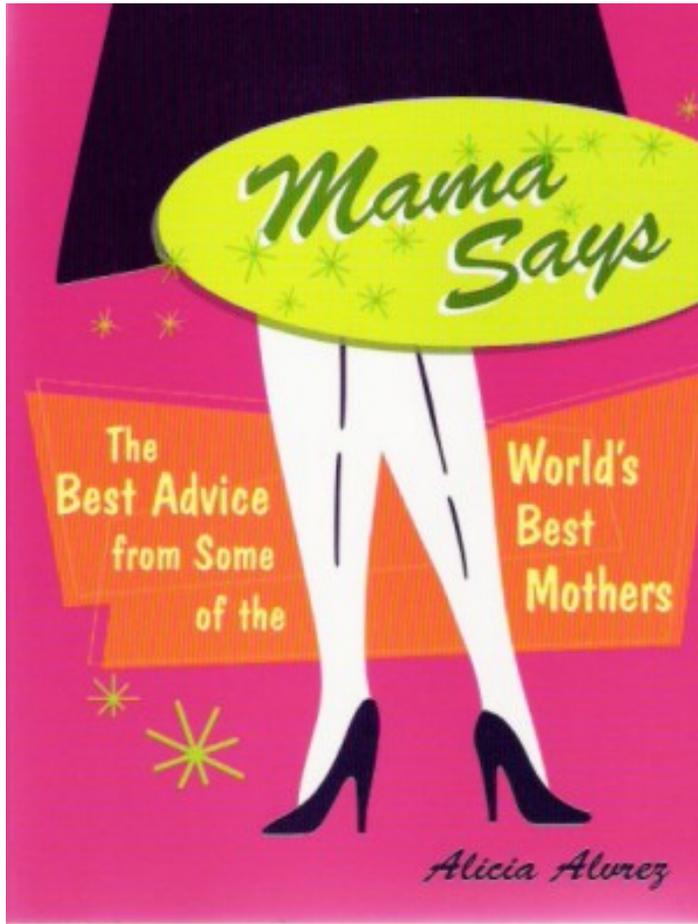
Often a physical sickness or mental stress causing chronic fatigue.

# Percent of AMTs from All Shifts by Sleep Duration



Johnson, et al, 2001

Regarding sleep: Do what your mama told you.



# Agenda

2005 International Safety Data with Human Factors Implications

Human Factors Fundamentals and Review

**Break**

Status of US & International Regulations

Operator's Manual for HF in Aviation Maintenance

2006+ FAA Human Factors Activities



# Comparing International Regulations

| Topic                                    | ICAO                         | EASA  | TC                                | FAA   |
|--|------------------------------|---|-----------------------------------|---|
| HF for Initial Certification             | Annex 1                      | 145.A.30(e)<br>incl AMC&GM<br>145.A.30(i)   | CAR 573.06                        | No  |
| Continuation Training for HF             | Annex 6                      | 145.A.35 (d)                                | CAR 573.06                        | Recommended in ACs                                |
| Error Management System                  | Guidance                     | 145.A.60                                    | CAR 1                             | Rec, 145.211                                      |
| Fatigue Management System                | Guidance                     | 145.A.30(d)<br>incl. AMC                    | Proposed, now<br>awaiting consul. | Guidance in Tech Pubs<br>121.377                  |
| Accountable Executive                    | No                           | 145.A.30                                    | CAR 106                           | No  |
| Published HF Guidance Materials          | Doc 9683-AN/950              | GM145.A.30 (e)<br>&Part 66 Appendix I<br>M9 | TP 13459                          | AC120-72  |
| Documentation Reporting Requirement      | Guidance                     | 145.A.45                                    | CAR 573.08                        | 145.109<br>121.369                                |
| Safety Culture/Safety Management System  | Under development<br>Annex 6 | 145.A.65                                    | CAR 573.30                        | Continuing Analysis<br>and Surveillance<br>System |
| Procedural Non-compliance                | Guidance                     | 145.A.65 (c)                                | CAR 571.05                        | No  |
| Planning of tasks, equipment, and spares | Guidance                     | 145.A.47                                    | No                                | 145.109   |
| Shift and task handover                  | Guidance                     | 145.A.47                                    | CAR 573.08                        | 121.369 (b) 9<br>135.427(b) 9                     |
| Error capturing (duplicate inspections)  | Guidance                     | 145.A.65 (b)3                               | CAR 571.10                        | 121.371   |



U.S. Department  
of Transportation  
**Federal Aviation  
Administration**

AC 145-10

Date: 7/8/05

## **ADVISORY CIRCULAR**



### **REPAIR STATION TRAINING PROGRAM**

Flight Standards Service  
Washington, D.C.

Initiated By: AFS-300



# FAA HF Guidance for Part 145

- FAA AC 145-10, Ch. 3, §301(c)

- The FAA **concur**s with European Authorities in that human factors training related to maintenance practices would provide an additional margin of safety to the repair industry;
- A human factors training program should be related to **maintenance practices** where possible;

- At this time it is recommended. It is not an FAA regulation.
- EASA Certificate holder's must follow EASA rules

## HBAW 06-04 Accepting an HF Training Program

- (1) Attend an entire training session.
- (2) Do training requirements match and company priorities (Ref. AC 120-72) ?
- (3) Is the human factors training is a cooperative development between the workforce and management.
- (4) Is training is provided to appropriate work groups?
- (5) Is content and delivery techniques match the audience.



## HBAW 06-04 Accepting an HF Training Program (Con't)

- (6) Check for training evaluation. Verify that feedback is provided to the instructors and management.
- (7) Key references in the Operator's Manual for Human Factors in Aviation Maintenance provide additional information helpful for evaluation.
- (8) These same steps are applicable to acceptance or approval of an EASA Human Factors Training Program.



# Agenda

2005 International Safety Data with Human Factors Implications

Human Factors Fundamentals and Review

Status of US & International Regulations

**Operator's Manual for HF in Aviation Maintenance**

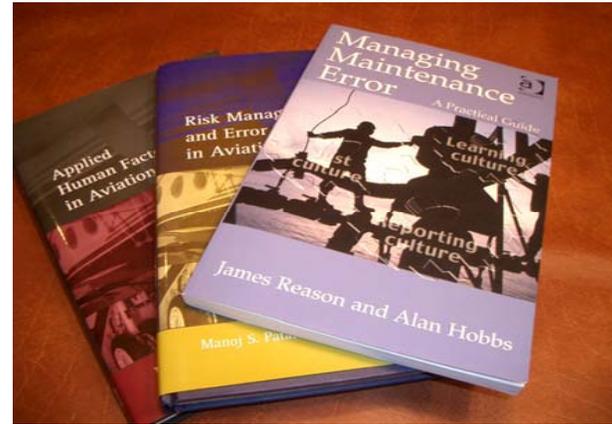
2006+ FAA Human Factors Activities



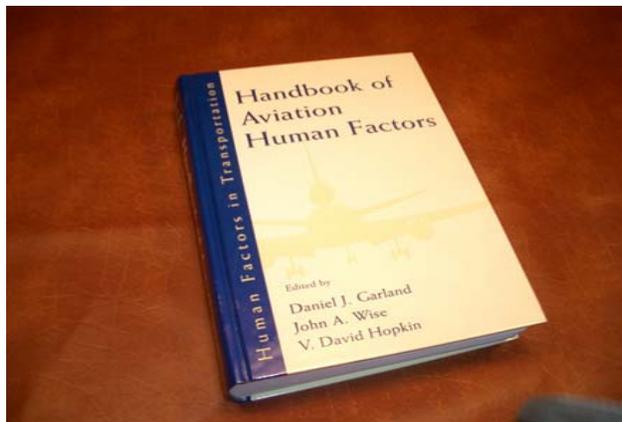
# Plenty of HF Guidance in the World!



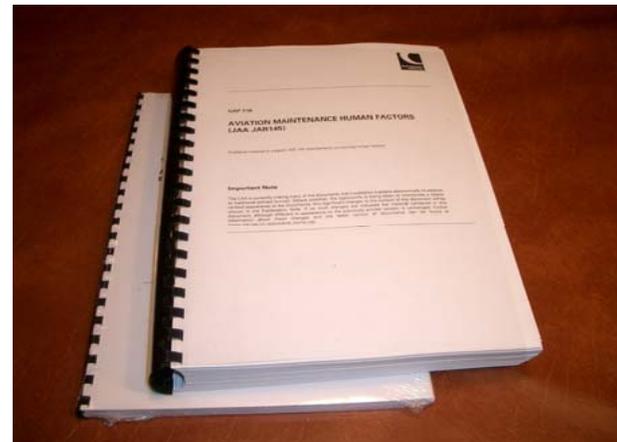
900 pgs.  
1996



551 pgs.  
2003-04



695 pgs.  
1999



1000 pgs.  
2002

# This is Website Home Page

 Operator's Manual  
Human Factors  
in Aviation Maintenance  
*Last update: 10/5/2005*

 Download Document

**Search**

**Introduction**

|   |
|---|
| 1.0 Event Investigation                   |
| 2.0 Documentation                         |
| 3.0 Human Factors Training                |
| 4.0 Shift/Task Turnover                   |
| 5.0 Fatigue Management                    |
| 6.0 Sustaining & Justifying an HF Program |
| Acknowledgements                          |

**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:

[www.hf.faa.gov/opsmanual](http://www.hf.faa.gov/opsmanual)

## Goals for *The Operator's Manual*

- **Keep it short**
- **Keep it straightforward & applied**
- **If author has to explain then not included in *The Manual***
- **The “Automobile Owner’s Manual” test**
- **Chapter Titles may be enough!**
- **Web-based and nice print-outs**





*"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

## 1. Event Investigation

of 5 > >>



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

NTSB/AAR-04/01

## 2. Documentation



*"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

## 3. HF Training

of 5 > >>



*"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 EAGLE LAKE

## 4. Shift Turnover

>>



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

AIRPORT INTERNAL REPORT

## 5. Fatigue/Alertness

5 > >>



*"...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

## 6. Sustainment & Cost

5 > >>

## All Chapters are the same format

1. Brief Description
2. Why it is important
3. How to implement a program
4. How to know if it is working
5. Key References (3)



# Sample Display from Operator's Manual



Operator's Manual  
Human Factors  
in Aviation Maintenance  
Last update: 10/25/2005



Download Document

Search

Introduction

1.0 Event Investigation

2.0 Documentation

3.0 Human Factors Training

4.0 Shift/Task Turnover

5.0 Fatigue Management

## 6.0 Sustaining & Justifying an HF Program

6.1 Why Program Sustainability is important

6.2 How to sustain a MHF program

6.3 How to know it is working

6.4 Why Cost Justification is important

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

6.6 Key References

Acknowledgements



*"...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

## 6.0 Sustaining & Justifying an HF Program

The first five topic areas of this document recommended 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.



# Key References for Each Chapter



## 6.0 Sustaining & Justifying an HF Program

### 6.6 Key References

- A. Sustaining & Justifying an HF Program presentation ([Download Document](#)).
- B. 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. ([Download Document](#)).
- C. Patankar, M.S., and Taylor, J.C. (2004). *Risk management and error reduction in aviation maintenance*. Aldershot, U.K.: Ashgate Publishing ([Amazon.com](#)).
- D. 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. ([Download Document](#)).

3 key references  
plus slides



# This is Website Home Page

 Operator's Manual  
Human Factors  
in Aviation Maintenance  
*Last update: 10/5/2005*

 Download Document

**Search**

**Introduction**

- 1.0 Event Investigation
- 2.0 Documentation
- 3.0 Human Factors Training
- 4.0 Shift/Task Turnover
- 5.0 Fatigue Management
- 6.0 Sustaining & Justifying an HF Program

Acknowledgements

**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:

[www.hf.faa.gov/opsmanual](http://www.hf.faa.gov/opsmanual)

# Agenda

2005 International Safety Data with Human Factors Implications

Human Factors Fundamentals and Review

Status of US & International Regulations

Operator's Manual for HF in Aviation Maintenance

2006+ FAA Human Factors Activities



- **International Conference (ATA)**  
September 4- 6, 2007 Orlando ([www.airlines.org](http://www.airlines.org))



18th FAA/ATA International Symposium  
**Human Factors**  
Maintenance and Ramp Safety

- **Unmanned Aerial Systems (NASA)**



- **International Survey on HF in Maintenance (CAMI)**

## Survey Goals and Methods

- **Purpose:** Assess status of maintenance HF
- **Look at:** HF programs, fatigue management, error management, and training.
- **Distribution:** Online survey (80 items) to 630 addresses.
- **Distribution:** Online survey (80 items) to 630 addresses.
- **Returns:** 414 respondents (66%) from 54 countries.
- **Experience:** 65% > 20 yrs. maintenance experience.



# Respondent Representation and Experience



54 Countries

414 Total Respondents (66% response rate)

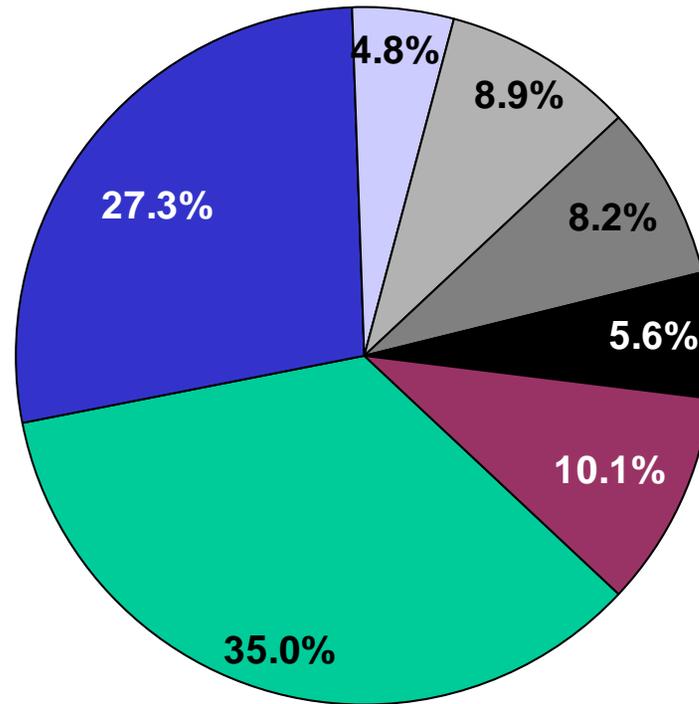
Experience: 65% > 20 yrs. maintenance experience

PAMA Regional Meeting  
Savannah, GA  
November 2, 2006



Federal Aviation  
Administration

# Where do you work?



- Air Maint
- Repair Stn
- Manufacturer
- GA/BIZ
- Mil/Govt
- School/Trn
- Other

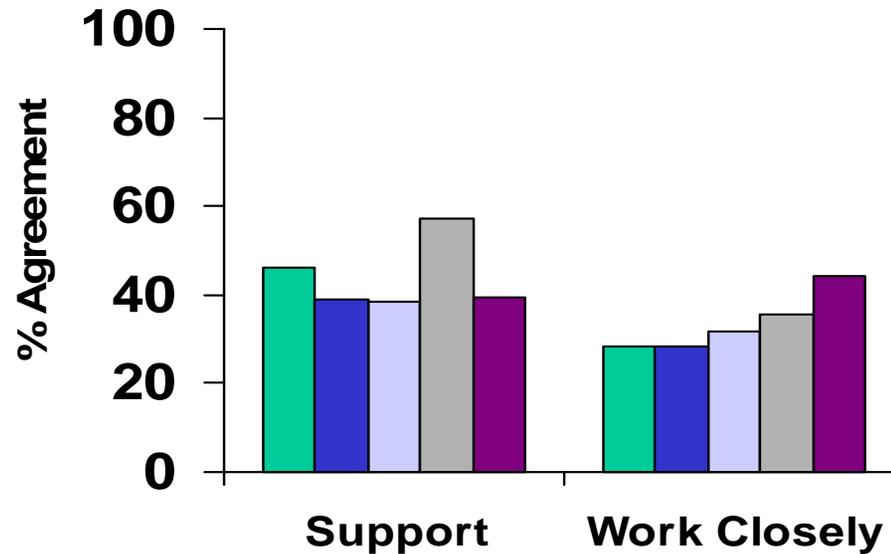


# Who is your Regulator? (N=404)

|   |       |
|---|-------|
| Civil Aviation Safety Authority (CASA) N=19 | 4.7%  |
| European Aviation Safety Agency (EASA) N=95 | 23.5% |
| Federal Aviation Administration (FAA) N=182 | 45%   |
| Transport Canada N=36                       | 8.9%  |
| Other National Aviation Authority N=72      | 17.8% |

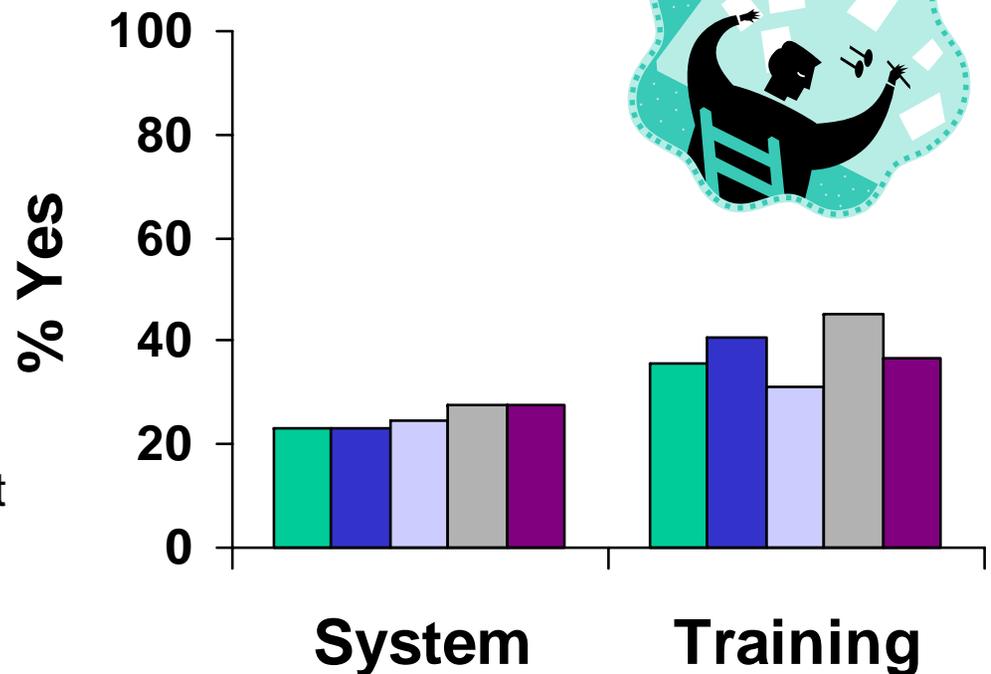


# Regulatory Support and Close Work

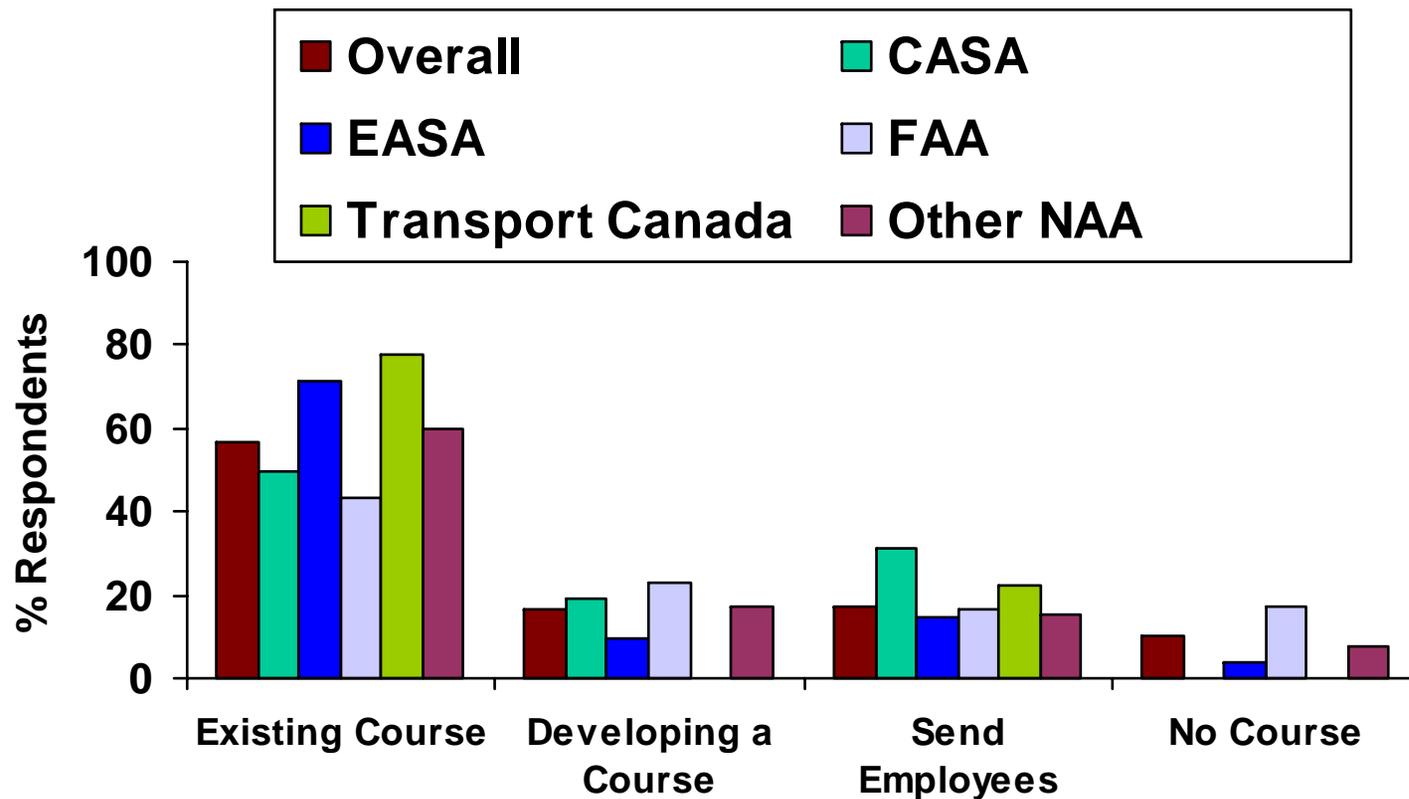


# Fatigue is “Important” but few programs

- ❖ Fatigue is important to 82.1%.
- ❖ Fatigue Management System
  - ❖ Overall, 25% have a fatigue management system.
- ❖ Training on Fatigue Management
  - ❖ 35.9% have fatigue training.



# Canada and EASA have the most HF Training



# Challenges – High Priorities

- **Maintenance HF Regulations: 65, 121, 135, 145, 147.**
- **Fatigue R&D? Guidance? Regulation?**
- **Advanced Technologies, VLJs, Rotorcraft, UAVs, Avionics, Commercial Space travel, Aging Aircraft, .....**
- **General Aviation Maintenance HF**
- **SMS in Maintenance**



# Summary

2005 Safety Data with HF Implications

Human Factors Fundamentals and Review

Int'l Regulations

Operator's Manual for HF in Aviation Maintenance

2006+ FAA Human Factors Activities

Inspection Authorization Workshop  
February 25, 2006



Federal Aviation  
Administration



## What to Remember

- **PEAR**
- **Human Factors Spectacles**
- **Dirty Dozen**
- **Remember what your mother told you about sleep**
- **Don't forget your sleep calculator**
- **Look at [www.hf.faa.gov/opsmanual](http://www.hf.faa.gov/opsmanual)**

*Thank You*

