

Human Factors in Approved Maintenance Organizations: An International Survey

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Abstract

The Federal Aviation Administration (FAA), in cooperation with the Joint Aviation Authority (JAA) Human Factors Working Group, completed the first international survey of maintenance human factors. The study focused on training, error management, fatigue management, and other human factors issues. The 400+ responses to the web-based survey were from 54 countries representing an estimated 200 approved maintenance organizations. Results show that strong regulations foster robust human factors programs. Respondents acknowledged that fatigue is a major challenge in the maintenance workforce yet is not addressed by many respondents. While many companies collect event data, a low percentage reported using the data to its full potential. This paper is a summary of the full report (Hackworth, et al., in press).

International Regulatory Diversity on Maintenance Human Factors

There are a variety of approaches to the regulation of human factors programs for maintenance organizations. Transport Canada (TC) and the European Aviation Safety Agency (EASA) have established specific, yet differing, rules regarding maintenance human factors. The FAA has not yet established regulations, but instead, has created guidance documents and developed voluntary reporting programs for maintenance organizations.

This paper describes the status of a variety of safety practices and opinions prevalent among international human factors managers, quality control managers/executives, human factors

trainers, and labor organization representatives.

Survey Method

We identified potential respondents in coordination with the Joint Aviation Authority Human Factors Working Group (primarily comprised of EASA member states), several airlines, and with FAA representatives. Respondents volunteered to participate in advance of receiving the questionnaire. Based on our sampling technique, we likely obtained responses from the more progressive companies. Therefore, we are reasonably certain that the sample represents the “best case” status of international human factors programs.

The e-mail invitation was sent to 647 potential respondents. Of the 630

¹ This research and report were completed in cooperation with a research team from the FAA Civil Aerospace Medical Institute, the FAA Flight Standards Service, the Oklahoma State Department of Health, and the University of Oklahoma, led by Dr. Carla Hackworth, all of whom are named in the Acknowledgements.

valid e-mail invitations, 414 returned a valid survey using the web-based survey system.

Survey Content

The survey contained approximately 70 questions. They were organized into eight categories: (1) demographics, (2) error management, (3) human factors training, (4) fatigue management, (5) proactive human factors support, (6) motivation for a human factors program, (7) human factors metrics, and (8) organizational policies. The complete survey is included in the final FAA report.

Who Responded

Respondents included: management, quality control, training, and labor representatives. The respondents were employed in over 54 countries. The highest percentage of

respondents (39.8%) worked within the United States. Some of the other countries included: Canada (8.7%), United Kingdom (7.2%), Australia (3.2%), Norway (3.0%), and Singapore (3.0%). Appendix A lists all participating countries. Figure 1 shows a geographic distribution by country. Figure 1 also summarizes additional demographics.

The survey sample covered the entire aircraft maintenance industry with over one-third from an airline maintenance department, 27.3% from a repair station, 8.9% in a general aviation/business operation, and 5.6% at a training facility or maintenance school. We estimate that about 200 organizations responded. For privacy reasons, we did not keep specific company names. See Figure 2 for a complete break out of respondent by type of organization.

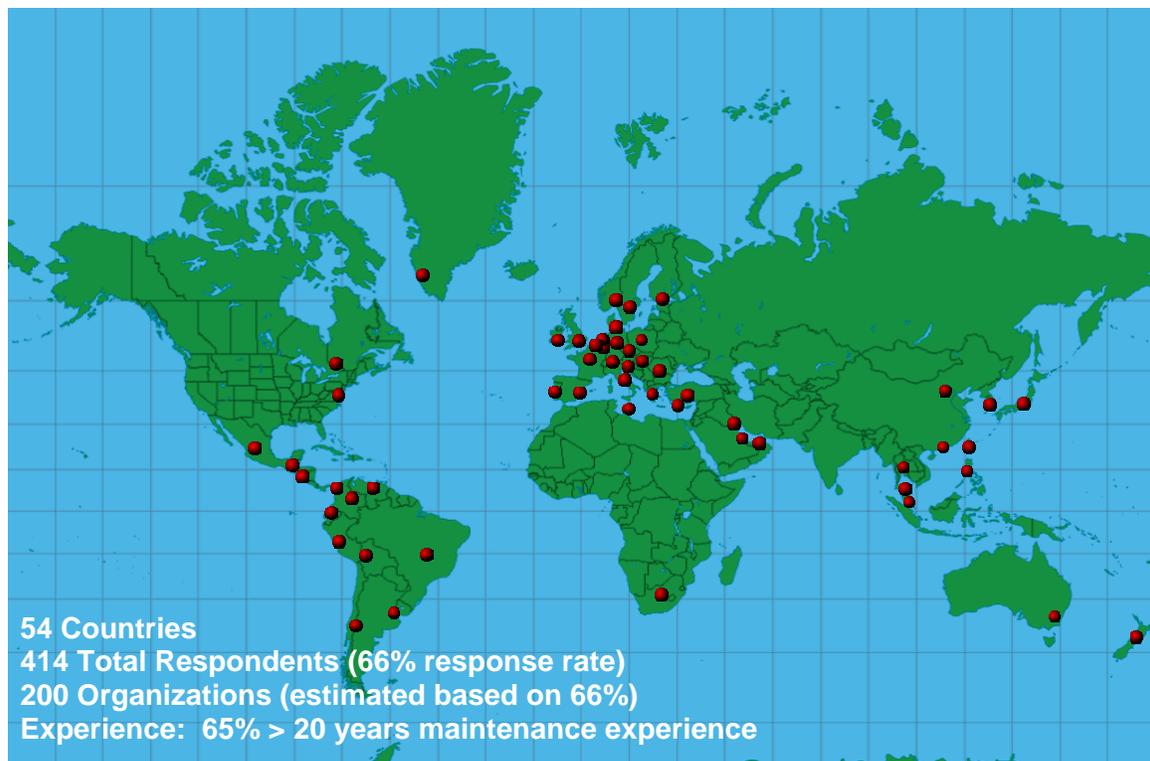


Figure 1: Geographic and Other Demographics Summary.

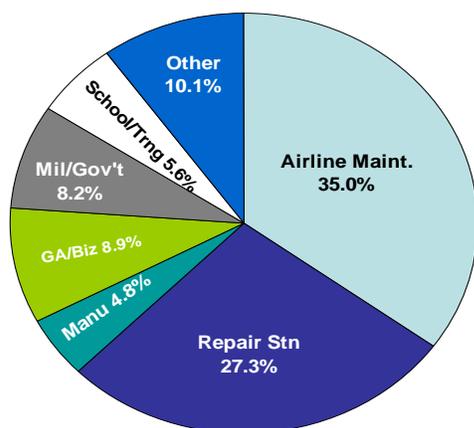


Figure 2. Employment Facility of Respondents.

Table 1 summarizes the regulatory authorities of the respondents.

Table 1. Primary Regulatory Authority of Respondents.

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

Results

Motivation for a Human Factors Program

Nearly 86% reported that flight safety was of the most important reason to have a human factors program. Worker safety was also a high priority at 80.9%. About 80% rated regulatory compliance as the strong motivator for a program. Overall, cost was the least important at 59.7%.

Regulator Support

Slightly over 40% reported receiving support from their regulator for the implementation of their human factors program and 33.9% worked closely with their regulator to monitor their human factors program. When support and working closely were broken out by regulator, respondents complying with TC reported the highest level of support (57.1%), while those under Other-National Aviation Authority (O-NAA) indicated the closest working relationship (44.4%). See Table 2 for all responses.

Table 2. Level of Support based on Regulator.

Regulator	% Support	% Work Closely
TC	57.1	35.7
CASA	46.2	28.6
O-NAA	39.3	44.4
EASA	39.1	28.6
FAA	38.3	31.9

Human Factors Training

One third of the respondents deliver human factors training to new employees. Further, 79.6% recognized the return on investment of initial human factors training and 76.1% recognized the return on investment of recurrent human factors training.

Given differences in human factors requirements across regulatory agencies, we suspected that there could be differences in the maturity of training programs. Indeed, this is what we found; in that TC (77.4%) and EASA (71.6%) respondents reported having an existing course that met requirements. Respondents regulated by FAA had the lowest percentage (43.4%) regarding an existing human factors course. Seventeen percent of respondents from

FAA-regulated companies had no human factors training. See Figure 3 for all responses.

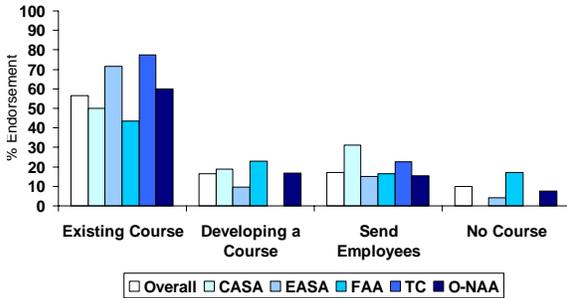


Figure 3. Current Human Factors Training.

Training of the Trainers

The majority of respondents (68.5%) reported that their trainers had maintenance and/or engineering work experience. Many trainers attended a two- to five-day human factors course (61.7%) and/or a two- to five-day instructors' skills course (46.8%). Only a few (12.9%) reported that their human factors trainers had no formal human factors training. When we examined the results by regulatory model, Australia's Civil Aviation Safety Authority (CASA), EASA, and TC clearly had well-trained instructors with an experienced background (Figure 4). For those companies regulated by FAA, a higher percentage (23.4%) of their trainers reported no formal training for the human factors trainers.

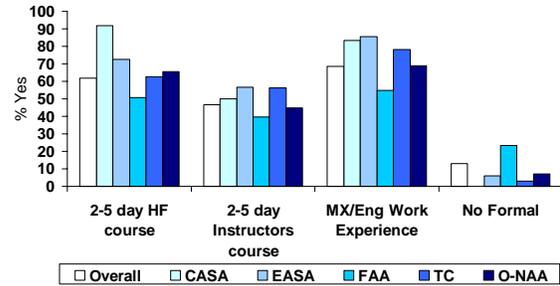


Figure 4. Amount of Training of Human Factors Trainers.

Error Management

One of the key factors for a successful human factors maintenance program is application of an event reporting system. Over half (55%) of the respondents reported that their error data were stored in a database. Companies using EASA requirements reported the highest storage of error data (65.1%), while those using the FAA were the lowest at 49.1%. See Table 4 for all responses.

Table 4. Percentage Storing Error Data.

Regulator	% in Database
Overall	55.0
EASA	65.1
O-NAA	57.4
TC	56.3
CASA	53.8
FAA	49.1

Overall, organizations reported employing either a formal (64.8%) or informal (19.1%) program for their human error investigations. Of these organizations, 32.2% reported using Boeing's Maintenance Error Decision Aid (MEDA), 10.5% used Human Factors Analysis and Classification System (HFACS), 36.6% some modification of MEDA, and 35.1% indicated they used another program not listed.

Companies are not fully using the data from event reporting systems. For example, fewer than half (46.5%) of our respondents indicated that their company reviewed their database in a proactive manner. See Table 5 for a summary.

Many respondents (70.5%) indicated that their company generated recommendations from individual incidents, but did not evaluate the effectiveness of interventions.

Table 5. Use of Human Error Data.

Recommendations are made from individual incidents investigated.	70.5%
We review our error database periodically to identify concerns and plan interventions.	46.5%
Senior management uses the information as part of a formal quality management process.	43.1%
Within the past year, processes and procedures were changed as a result of the analysis of the error database.	33.7%
Interventions are evaluated to assess their effectiveness.	26.9%
We do not use our human error data.	10.8%

Fatigue Management

Eight-two percent recognized the safety impact of fatigue. However, only 24.9% of respondents indicated that their organization had a fatigue management system. The inconsistency between belief and action was further evident in the fact that only 35.9% reported that their organization provided training on fatigue management. The responses were consistent across regulatory authority, with Transport Canada respondents being ahead of the others. The good news is that half (51.3%) indicated that managing fatigue was an important element of their safety management system.

Human Factors Metrics

Over half (54.4%) measure the economic and other effects of errors/incidents. At present, less than 10% performed a cost benefit analysis to justify their human factors interventions. However, 51% recognized that their company must improve their return on investment data regarding human factors.

For some respondents, realization of the benefits from this investment has begun, with 27.2% reporting cost benefit success stories as a result of their human factors interventions. When asked for examples of success stories, respondents shared that their companies experienced a reduction in errors, improved on-time performance, improved workplace design, and had a reduction of on-the-job injuries.

Summary Discussion

The high response rate (66%; N=414) from experienced personnel (65% had 20+ years) from 54 countries is indicative of the high level of international interest in maintenance human factors. The respondent sample likely represents the world's best case examples due to the voluntary nature of the survey. The largest number of respondents was somewhat evenly divided between airlines and repair stations, with representatives from training organizations and general aviation maintenance facilities also participating. The generalizations here are most reflective of larger maintenance organizations. That is appropriate, since they were the primary target audience of the study. Forty percent of the respondents were from the U.S., which is also consistent with the current distribution of international aviation maintenance activity completed within the U.S. (K. Michaels, personal

communication, February 11, 2007). In summary, we can make reasonably accurate conclusions due to the outstanding participation of our diverse participants.

During the design of this study, we expected to find extensive differences among countries because of national regulations regarding human factors. The charts presented throughout this report have shown rankings, level of interest, and the nature of human factors programs based mostly on regulatory model. There were more similarities than differences in the data.

Maintenance organizations institute human factors initiatives because such programs help ensure flight safety and worker safety. Most respondents rated those factors as highly important. Of course, regulatory compliance is very important for companies following regulations from TC and EASA. Nearly 1,200 U.S. repair stations comply with EASA regulations; therefore, they are also motivated by requirements beyond the FAA.

Respondents rated cost issues as the fourth most important reason for having a human factors program. It is admirable that safety and compliance are rated higher.

Support from the Regulator

TC was reported as providing the most support as a regulator. The FAA, EASA, and other local national authorities received about the same rating for their support. In response to these findings, the FAA, and hopefully other authorities, could identify the best ways to empower the aviation safety inspector workforce to provide additional human factors support to industry. One example of recent FAA maintenance human factors support to the industry is

the *Operator's Manual for Human Factors in Aviation Maintenance* (FAA, 2006a). The FAA is also redoing the maintenance human factors website (www.hf.faa.gov) and is developing a new edition of the web-based *Human Factors Guide for Maintenance and Inspection*. FAA Flight Standards Service is also taking proactive measures to enhance and clarify additional guidance material for industry and FAA personnel. FAA is also providing mandatory three-day human factors training to all inspectors.

Providing Human Factors Suggestions

Over half of respondents reported that there were means for workers to provide human factors suggestions to the company. EASA companies were well above the average. This is a very positive finding that is likely related to the European requirements for significant human factors initial and continuation training for everyone, including managers. The result is that human factors issues and language become a shared value among all segments of the workforce. That appears to be happening in Europe, and the rest of the world is evolving in a similar fashion.

Event Reporting – The Good News

We were extremely encouraged to see the level of agreement regarding formal application of event investigations. Most had a formal or informal system. Over two-thirds of respondents said they were using MEDA or some modification of it. This extensive use of the same reporting format could foster data sharing sometime in the future. Event reporting systems are the fundamental foundation for exceptional human factors programs and safety management systems.

Industry Involvement

Another similarity among the respondents was their company's and personal involvement in industry and government committee work related to human factors in maintenance. Over one-third of the respondents participated in such activities. This figure reinforces the earlier statement that our respondents represent the industry's best companies. Of course, this could also be an area of improvement.

With respect to formalized business processes and safety policies, there were similar responses from most respondents. That means that a transition to a safety management system will not be a difficult concept for many maintenance organizations.

Differences in Responses

Over half of the respondents indicated that their company had an existing human factors course. As expected, the respondents from FAA-regulated companies had the lowest response rate regarding an existing human factors training course. TC and EASA companies reported over 75% with an existing course. Because human factors courses are not a regulatory requirement in the U.S., it was not surprising to find that the largest percentage where no course existed was from companies that followed the FAA rules. Obviously, this demonstrates that regulations are a very good means to insure that there is a human factors training program.

Training the Trainer

As mentioned above, it is reasonable to expect that companies that follow the FAA regulations would have less training than companies that were required to have training. The question related to training for human

factors trainers clearly indicated that companies that designed their programs in compliance with FAA regulations are not training their trainers, in comparison to the rest of the world.

Many human factors instructors build their company-specific courses from the general materials they obtain by participating as students in other courses. Many such courses can be found with a simple internet search. The importance of such training for the trainers cannot be discounted. Of course, trainers can also gain a lot of knowledge by their participation on industry committees, attending conferences, and relying on self-study materials.

Getting the Information to Management

Training and safety personnel who are involved in human factors programs are frequently in a position to hear stories about events that often are not significant enough for formal reporting. However, these small events lead to other larger ones. Attention to small events will prevent larger ones. About 40% of the respondents said that human factors personnel have formal means to communicate human factors issues to senior management. While that is a respectable number, there is significant opportunity to expand such communication. Scheduled meetings -- bi-weekly or monthly -- dedicated to the discussion of human error and events in the maintenance environment are a very easy way to formalize this reporting.

The Human Factors of Technical Documentation

Proper use of technical documentation remains a high priority for the industry. Failure to follow procedures is the number one cause of most negative events. Often, the failure

to use the documentation is associated with a human factors-related issue. Many respondents' companies had a formal or informal policy to apply human factors considerations to the development or modification of documentation. Effective use of error reporting systems is an excellent way to raise human factors-related attention to technical documentation and procedures. Event investigations must drill down to reason(s) that people did not use the documents. Human factors issues are often a root cause of documentation events.

Using Error Data – The Challenges

We have already commented on the excellent efforts to report and record event data. A majority of respondents said that event investigations lead to recommendations. However, fewer respondents reported that processes and procedures were changed in the last year as a result of the event database. We found that slightly over a quarter of companies have evaluated the effectiveness of their interventions. These numbers strongly suggest that the error data are not being used to their full potential. It may be easier to collect the data than to analyze it and then apply the results.

Human Factors Metrics

Thirty-one percent reported that their organization conducted some type of human factors audit. Fewer respondents were planning such an audit for 2006-2007. These questions did not define what was meant by a human factors audit, thus it is difficult to draw reasonable conclusions about audits. However, the numbers are low, thus this appears to be a fertile opportunity for improvement.

Over half of the respondents reported that their company measured

the cost of events. Few respondents' companies try to cost justify human factors interventions, while over half of the respondents recognize the importance of demonstrating the return on investment in human factors programs. The FAA *Operator's Manual for Human Factors in Aviation Maintenance* offers a method to calculate return on investment. Companies must track errors, estimate the cost of errors, and take into account the cost of the interventions to calculate savings in order to calculate ROI.

Fatigue Management Systems

One of the strongest findings of this survey is related to fatigue in aviation maintenance. The majority of respondents acknowledged the impact of fatigue on maintenance work. However, only a quarter of respondents had a fatigue management system and slightly over one-third deliver training related to fatigue management. These numbers strongly suggest that the aviation maintenance industry and the regulators must monitor this situation and implement programs to ensure that worker fatigue management systems provide continuing safety.

Summary

This study reinforces the fact that maintenance human factors programs are valuable and important, with a variety of such programs throughout the world. In organizations with regulatory requirements, the human factors programs are more widely adopted and the human factors instructors are given more instructions to prepare them for their responsibilities. In spite of the variety of international regulations on maintenance human factors, industry reports that flight safety and worker safety are the primary reasons to have such programs.

Human factors programs reduce cost and foster continuing safety and control of human error in maintenance. This survey indicates that the best targets of opportunity for improvement are use of event data reporting, creation of a fatigue management program, increased use of data to provide cost justification of human factors programs, and greater attention to the human factors aspects of the development and use of technical documentation and procedures.

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Appendix A

List of Participating Countries

Argentina	Greece	Peru
Australia	Greenland	Philippines
Austria	Guatemala	Poland
Bahrain	Hong Kong	Portugal
Belgium	Hungary	Romania
Bolivia	Ireland	Singapore
Brazil	Italy	Slovenia
Canada	Japan	South Africa
Chile	Korea	Spain
China	Kuwait	Sweden
Colombia	Luxembourg	Switzerland
Cyprus	Malaysia	Taiwan
Denmark	Malta	Thailand
Ecuador	Mexico	Turkey
El Salvador	Netherlands	United Arab Emirates
Finland	New Zealand	United Kingdom
France	Norway	United States of America
Germany	Panama	Venezuela