13.0 REDUCTION OF MAINTENANCE ERROR THROUGH FOCUSED INTERVENTIONS

Barbara G. Kanki, Ph.D.
NASA Ames Research Center
and
Diane Walter, M.A.
Human Performance Applications

It is well-known that a significant proportion of aviation accidents and incidents are tied to human error. In flight operations, research of operational errors have shown that so-called "pilot error" often involves a variety of human factors issues and not a simple lack of individual technical skills. In maintenance operations, there is similar concern that maintenance errors which may lead to incidents and accidents are related to a large variety of human factors.

Although maintenance error data and research are limited, industry initiatives involving human factors training in maintenance have become increasingly accepted as one type of maintenance error intervention. Conscientious efforts have been made in re-inventing the "team" concept for maintenance operations and in tailoring programs to fit the needs of technical operations. Nevertheless, there remains a dual challenge: 1) to develop human factors interventions which are directly supported by reliable human error data, and 2) to integrate human factors concepts into the procedures and practices of everyday technical tasks.

VARIETIES OF HUMAN FACTORS INTERVENTIONS

In flight operations, three phases of human factors training (or Crew Resource Management training) are typically implemented: awareness training, practical training and integrated training. Generally speaking, awareness training takes place in the classroom as initial indoctrination while practical training involves the use of line operational simulation during annual recurrent training. Integrated training refers to the incorporation of crew resource management training into the technical training requirements and evaluation. Clearly, there are areas where technical operations may follow a similar approach, but there are also important task differences which should be carefully considered so that training is tailored to be as operationally relevant and effective as possible.

As mentioned above, significant progress has been made by maintenance organizations with respect to the implementation of human factors training. Such training usually takes an "awareness training" format and provides an introduction to human factors concepts as they apply to maintenance operations. However, the counterparts to line operational simulation and integrated training have yet to be determined by the maintenance community. For the purpose of this talk, we shall simply call the human factors training in the practical and integrated phases an operationally-based intervention (e.g., "Operational MRM" as in Figure 13.1) since it is designed to address the operational issues of everyday tasks. In addition, we propose two other maintenance error interventions in which human factors are integrated into specific practices and procedures: 1) structured on-the-job training, and 2) procedure re-design. These are not substitutes for awareness training; merely different types of interventions which are intended to reduce maintenance error by incorporating human factors into the practice of everyday technical tasks.

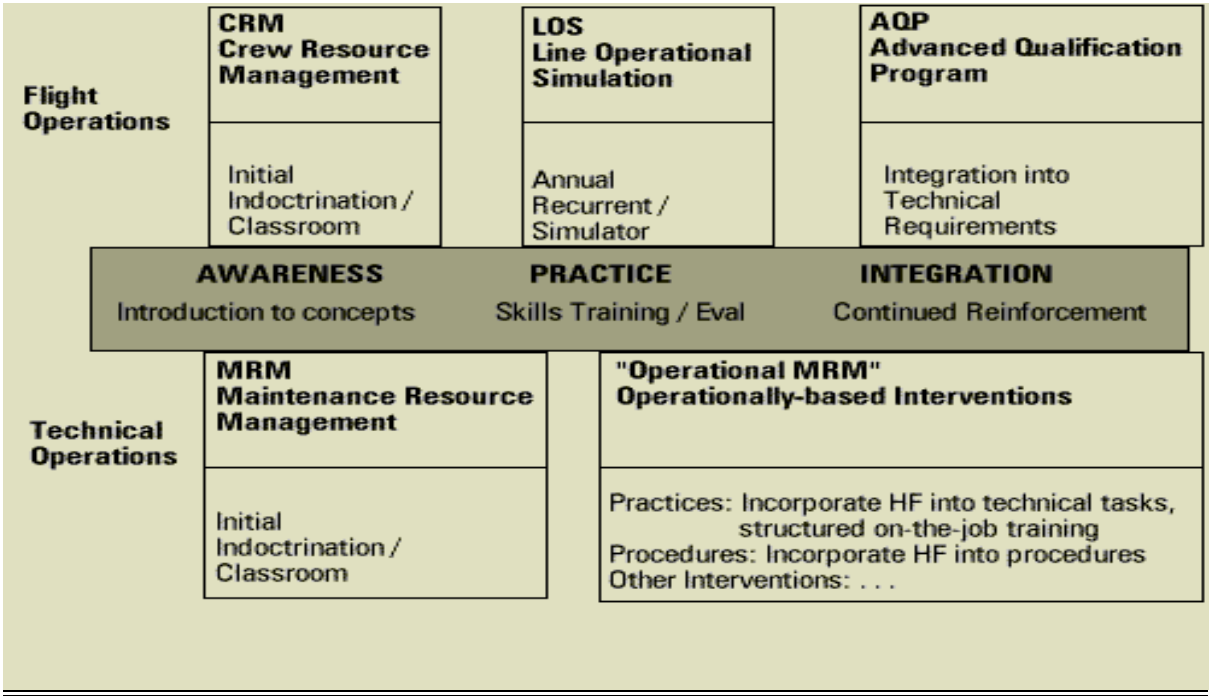

Figure 13.1 Varieties of Human Factors Interventions: Technical Operations compared to Flight Operations

FOCUSED INTERVENTIONS

In order for these to be *focused* interventions, however, we must begin with the identification and characterization of problem areas derived from a reliable operational error database (Figure 13.2). A systematic analysis of operational errors which analyzes and describes the contribution of human factors to specific processes is then possible. It is essential to achieve a clear understanding of the numerous and often complex turns of events which can lead to unsafe, inefficient and expensive outcomes. Once human error information is collected, analyzed and understood, focused interventions may be developed which match specific problems. For example, information from the Aviation Safety Reporting System (ASRS) incident database helps to identify general, industry-wide human factors issues while the Maintenance Error Decision Aid (MEDA) helps in the analysis of specific incident events. On the basis of an operational errors analysis, focused interventions may be developed which are direct countermeasures. For instance, many of the topics in human factors training are taken directly from incident and accident data which illustrate human factors problems and error chains. But problem targets may also suggest interventions which are directly tied to operational practices and procedures. In these cases, alternative interventions such as TATS (Task Analytic Training System), a program of team-driven, structured on-the-job training, and human factors enhanced procedures may be appropriate.

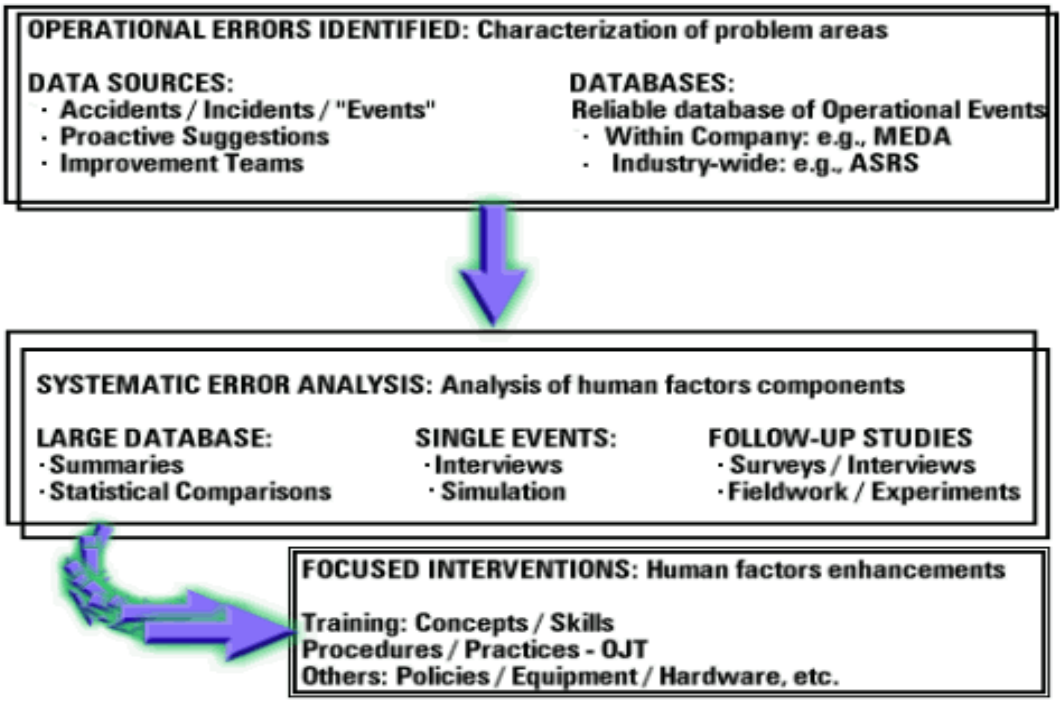

Figure 13.2 From Operational Errors to Focused Interventions

OPERATIONALLY-BASED INTERVENTIONS

TATS is a performance-based system that involves full workforce participation in its design, development and implementation.1 It was originally developed to provide comprehensive, structured, on-the-job training. Through incorporation of basic human factors principles such as decision making, communication, team building, and workload management, either directly or as a function of the workforce participation involved, the TATS process has proven successful in providing not only better training and procedures, but overall improvement of attitude and morale. Major elements of the program include: 1) needs identification, 2) job task analysis, 3) writing and verifying training procedures, 4) training implementation strategies, 5) employment of tracking mechanisms, 5) debugging, evaluating, and establishing a maintenance/audit plan. Since TATS produces a workforce whose performance can be observed and measured against explicitly defined standards, it is an effective intervention against unreliable, error-prone practices which can be inadvertently perpetuated when on-the-job training is an unstructured, unmonitored buddy system.

Just as TATS may enhance maintenance practices, human factors principles may also be incorporated into maintenance procedures themselves. Procedure evaluation and re-design for the purpose of human factors enhancement provides another type of focused intervention which targets specific maintenance problems. We shall describe a study in which a Boeing engine-change procedure, revised by Repp, was analyzed and systematically compared to its predecessor.2 On the basis of coding each procedural change in terms of its structure and function, we were able to catalogue the ways in which procedure changes were linked to human factors elements (e.g., workload distribution, planning and communication, situation awareness, crew coordination, and safety considerations. As this project nears completion, we intend to produce a guidelines document for operators to incorporate human factors into their own procedure design enhancements.

In summary, we describe how maintenance error may be reduced through human factors interventions which target specific procedures and practices. We hope to demonstrate that the key to leveraging the impact of these solutions comes from focused interventions; that is, interventions which are derived from a clear understanding of specific maintenance errors, their operational context and human factors components.

REFERENCES

1. Walter, D. (1990). An innovative approach to NDT inspector training at Boeing. In J. F. Parker, Jr. (Ed.) *Human factors issues in aircraft maintenance and inspection, training issues*. Washington, D.C.: Federal Aviation Administration.

2. Repp, T. (1995). Improving 737 CFM56 engine change times. In *Airliner* (Oct-Dec 1995), Seattle: Boeing Commercial Airplane Group.

DR. BARBARA G. KANKI

After receiving a Ph.D in Behavioral Sciences from the University of Chicago, Dr. Kanki began her tenure at NASA Ames Research Center as a researcher of crew communication and coordination in both aviation and space systems. For more than 10 years, she has been a principal investigator in the Crew Factors group whose purpose is to enhance system safety through training and procedural design based on team process analysis. The research utilizes a variety of methods including high fidelity simulation, surveys, interviews and on-site field techniques. While much of her work has been directed toward commercial transport flight crews, this work has expanded to other parts of the aviation system, most notably including maintenance operations and air traffic management. On the space side of the house, Dr. Kanki has also conducted crew research in ground support operations such as shuttle maintenance and payload integration.

MS. DIANE WALTER

Diane Walter is founder and president of Human Performance Applications, a Seattle-based consulting firm specializing in competency-based on-the-job learning systems. She was until recently, a Maintenance Human Factors Engineer with Boeing Commercial Airplane Group. Prior to coming to Boeing, she created and developed the Task Analytic Training System (TATS). Over the past eight years, TATS has been implemented by Boeing inspectors, mechanics, engineers, and pilots. During the last two years, four of Boeing's customer airlines have used the TATS program.

Diane has a B.S. in Metallurgical Engineering and an M.A. in Psychology. She holds memberships in the American Society for Training and Development, the American Psychological Association, and the International Society for Performance Improvement.
