

Spring 2013

## Predicting Impact of Maintenance Resource Management Training Utilizing Individual Difference Variables

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### Scholarly Commons Citation

Bowen, E. E. (2013). Predicting Impact of Maintenance Resource Management Training Utilizing Individual Difference Variables. *Journal of Aviation/Aerospace Education & Research*, 22(3). <https://doi.org/10.15394/jaaer.2013.1315>

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**PREDICTING IMPACT OF MAINTENANCE RESOURCE MANAGEMENT TRAINING  
UTILIZING INDIVIDUAL DIFFERENCE VARIABLES**

Erin E. Bowen

**Abstract**

Human error has been identified as a leading cause of accidents and incidents in many “high-consequence” industries, such as aviation and medicine. These industries have evolved widespread employee training programs to prevent such errors or to mitigate their impact on the public. In addition, common perceptions exist in these industries regarding the role of age, employee tenure, and type of position held in an employee’s responsiveness to such training. This study was conducted to identify the predictive role individual difference variables may play in the impact of maintenance resource management training programs in an aviation maintenance setting. Using multiple regression analyses, the study identifies common misperceptions in the industry regarding the effect of these variables on employees’ responses to training.

The pervasiveness and complexity of organizational training continues to increase as organizations strive to maintain their human capital and competitive edge, and deal with an aging, changing workforce demographic (Salas & Cannon-Bowers, 2001). In a general sense, training is intended to change the current state of organizational members, either through increasing information awareness or requesting members perform new behaviors or develop new skills. Organizational training relies on a fundamental assumption: that participating in it will cause change.

In the aviation industry, one critical aspect of successful performance is safety - the avoidance of accidents and incidents and the promotion of behaviors and organizational norms considered ‘safe’. While safety may be a concern in many organizations, aviation is considered a “high-consequence industry” (as are fields such as medicine or nuclear energy); that is, an industry in which the consequences of poor performance are potentially significant, such as deaths of both employees and customers, damage to multi-million dollar equipment, federal

investigations and punishments, etc (Bowen & Bigda-Peyton, 2011). The high-consequence nature of these types of organizations means that they are heavily invested in identifying and appropriately measuring factors that may affect safety performance. Human factors are one area that has received increased scrutiny in recent years for its potential impact on aviation safety.

Following several highly-publicized major accidents directly attributed to human error (FAA, 1990), the last 20 years have seen significant growth in the implementation of human factors training programs in a variety of high-consequence industries (Bowen, Sabin, & Patankar, 2011; Bowen & Bigda-Peyton, 2011). A growing focus on the role of human factors in aviation incidents and accidents and the growth of a systems-based approach to the aviation organization has led to the development of several human factors training programs. Crew Resource Management (CRM) training for flight crews developed in the 1980s (Taylor & Patankar, 2001), while more recently Maintenance Resource Management (MRM) training has been developed for aviation maintenance workers.

## *Predicting MRM Training Impact*

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According to Taylor & Patankar (2001), the first reported CRM program geared toward aviation maintenance workers began in November 1989; this and other programs eventually became known as MRM programs (Taylor & Christensen, 1998).

### *Measuring MRM Training Impact*

The Cockpit Management Attitudes Questionnaire (CMAQ) was developed to assess flight crew attitudes regarding human factors considerations, and has been found useful for training, evaluation, and research in CRM (Helmreich, Foushee, Benson, & Russini, 1986). Taggart (1990) was among the first to adapt CRM evaluation methods for the maintenance environment, revising the CMAQ for use with aviation maintenance employees. This modification was called the Crew Resource Management/Technical Operations Questionnaire (CRM/TOQ); later renamed the Maintenance Resource Management/Technical Operations Questionnaire (MRM/TOQ) (Bowen, et al., 2011).

Assessments of the success of MRM training programs have primarily focused on basic pre-post evaluations of attitude change using this MRM/TOQ (e.g., Taylor, 2000a; Taylor, 2000b), and little research has attempted to understand, measure, or discuss the various organizational and individual variables that are influencing employees' attitudes as they complete MRM training. The present study is a critical first step in measuring and analyzing these individual difference factors in order to start the evidence-driven discussion in these industries of the role they may play in influencing employees' attitudes regarding training impact. Given the importance of these training programs in preventing major accidents or incidents that affect both the organization, its employees, and public consumers in very significant ways, all variables which may affect the performance of these programs must be carefully analyzed, something that has not yet been presented for these types of industries.

### *Role of Individual Differences in Attitude Change*

A large number of studies over the years have addressed various influences on attitude change, methods for improving or preventing attitude change, or described types of attitude change; Petty & Wegener (1998) provide a useful review of the established attitude change literature. One facet of attitudinal change investigated in the attitude research is the role of demographic or individual difference variables in affecting and predicting attitude change. Predicting the likelihood or direction of attitude change based on existing characteristics or behaviors may improve the ability of change agents to move attitudes in the desired direction. Age, years in an organization, and previous

experience have each been shown to be among the variables that affect an individual's likelihood of attitude change (e.g., Alwin, Cohen, & Newcomb, 1991; Sears, 1975; Visser & Krosnick, 1998). Visser and Krosnick, for example, found across three studies that the likelihood of attitude change decreased with age until approximately age sixty, at which time it begins to increase; this is characteristic of the *life stages* model of attitude change (Sears, 1981). Hrebiniak and Alutto (1972) similarly found a positive correlation between age and organizational commitment attitudes. The reasons for this relationship are not completely clear, though there is evidence to suggest that the perceived importance of an attitude, perceived knowledge about the attitude topic, and certainty about the attitude may contribute to the likelihood of attitude change (Visser & Krosnick, 1998).

The number of years an employee has been with the same organization may also affect attitudes toward organizationally-sponsored change, though this link is by no means guaranteed. Hrebiniak and Alutto (1972), for example, found that the longer employees had been with an organization, the more positively they viewed it and the more committed to it they felt. This may be because they have invested so much time into the organization that to view it negatively devalues the years that they have put into it. In contrast, Gibson and Klein (1970) demonstrated a negative linear relationship between job satisfaction attitudes and the length of time an employee had been with the organization, while Tyler and Schuller (1991) found that more established employees exhibited as much attitude change as their less established counterparts.

Attitude change may also depend on the employees' background and experiences. Visser & Krosnick (1998), for example, found that attitude change was more common among less educated respondents, as did Zaller (1990). Whether "education" includes the type of extensive technical training required in aviation maintenance is unclear from the literature. Tyler and Schuller (1991) found that the relationship between age and attitude change may hinge more on the types of personal experience an individual had than on a direct age-attitude linkage or a current organizational tenure-attitude linkage. As with length of organizational tenure, the relationship between type of previous experience and attitude change has shown mixed results. Helmreich and Wilhelm (1991), for example, found no significant differences in overall CRM course evaluations when comparing employee backgrounds.

### *Present Study*

There is also growing interest in aviation research regarding the study of "boomerang" participants - individuals whose attitudes following an attempted

intervention move to a more extreme position in the undesired attitude direction. The boomerang effect has been described in several studies of attitude change (e.g., Capozza, Volpato, & Falvo, 2003; Laroche, 1977; Ringold, 2002). It is of particular interest in aviation and other high-consequence industries, as even a comparatively small number of “boomerangs” may affect overall safety. As such, aviation researchers (e.g., Helmreich & Wilhelm, 1991) advocate the development of tools and techniques to identify potential boomerang participants before their attitudes become too extreme and strongly held (as these are more difficult to change; Petty & Wegener, 1998). This may include eventually developing additional training techniques to reduce the likelihood of occurrence of the boomerang effect in human factors training.

The attitude literature provides some evidence to suggest that individual difference variables may be used to predict the likelihood of attitude change, though this has not been demonstrated in the highly structured and comparatively unique aviation environment. The present study seeks to identify the predictive role of demographic variables in both general patterns of attitude change, as well as in boomerang attitude change. The present study is an attempt to create an exploratory profile of variables that may predict the degree of employees’ reported change intentions following MRM training, the overall type of attitude change they experience post-training (whether positive or negative), and the likelihood of the boomerang effect. In particular, discussion in the literature regarding the “boomerang effect” suggests that negative attitude change following training may be especially problematic in high-consequence industries, even if the percentage of employees in MRM training who experience this effect is comparatively small (Helmreich & Wilhelm, 1991).

### Method

#### *Participants*

Participants were 1458 employees at seven maintenance locations for a United States-based airline who had completed an MRM training course within an established 12-month time frame. Completing the paper-based pre- and post-training MRM/TOQ was included as a portion of the training day for all maintenance employees participating in the MRM course during this time frame, creating a response rate above 90% of total MRM course attendees (exact response rate cannot be calculated based upon the nature of the collection process). MRM trainers then collected completed MRM/TOQ forms and sent them to the researcher.

#### *Procedure*

Participants were asked to complete the

MRM/TOQ immediately before training began, and again immediately following training. The MRM/TOQ is a 17-item questionnaire developed to measure the attitudes and intentions of participants in airline maintenance training workshops (Taylor, 2000b). Attitudes are measured on a Likert-type scale, with possible responses ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire consists of a series of statements regarding attitudes and perceptions of human factors areas determined to affect safety-related behavior, and evaluate pre- and post-training attitudes on four constructs: Communication/coordination, recognition of stress effects, conflict avoidance, and relational supervision (generally marked as the awareness of and ability to discuss organizational and work issues with leadership). The post-training questionnaire also collected responses on three general outcome items: 1) this training has the potential to increase aviation safety and crew effectiveness; 2) this training will be useful for others; and 3) this training is going to change your behavior on the job.

Reliability and validity of the MRM/TOQ were previously assessed by Taylor (2000b) and Bowen, Sabin, and Patankar (2011), who reported adequate reliability (with regard to both stability and consistency) as well as evidence of good concurrent and construct validity in the instrument. Pre- and post-training responses were matched through detailed demographic information provided by respondents. This method of pairing data maintained the anonymity of participants while providing information on individual-level changes in attitudes, as well as facilitating the analysis of patterns of attitude change.

Individual difference data were collected on a number of participant characteristics, presented in Table 1. Based upon the outlined literature, multiple regression analysis was employed to evaluate the potential influence of these employee individual difference characteristics on attitudes regarding MRM training concepts, as measured by the MRM/TOQ.

### Results

#### *Descriptive Analyses*

As seen in Table 1, the mean age of respondents was 49.74 years ( $SD = 8.03$ ), mean years in maintenance at the target organization was 17.55 ( $SD = 7.07$ ), and a majority of the participants were male (96.6%). There were no differences among the seven sites on mean age ( $F_{7, 608} = 1.81, ns$ ). There were significant differences in years at the organization across the seven sites ( $F_{7, 1362} = 7.323, p < 0.05$ ).

Post hoc analyses (Scheffé procedure) indicated that these significant differences were between site one ( $N = 646$ ) and sites two ( $N = 279$ ) and five ( $N = 90$ ), as well as

*Predicting MRM Training Impact*

between site four ( $N = 132$ ) and site five. The discrepancies in sample size may have been a contributing factor to these differences, however; to assess this, the harmonic mean of the sample size was used for an additional post hoc analysis (Howell, 2002). Post hoc (Scheffé) results using the harmonic mean indicate site five participants report significantly lower number of years experience compared to sites one, three, and seven. No other differences among the sites on this variable were found when sample size discrepancies were taken into account. Mean number of

years of experience within the organization for site five is 13.81 years, lower than the means for the remaining sites. Subsequent analyses were conducted both including and excluding site five data, to ensure that this difference did not affect other aspects of the data. The presence of site five data did not cause significant change in results of additional analyses; as such, site five data was included in all results reported here.

Table 1

*Participant Demographics*

<b>Location</b>	<b>Sample N</b>	<b>Percent</b>	<b>Mean Age</b>	<b>SD Age</b>	<b>Mean Yrs. In Maint. at Org.</b>	<b>SD Yrs. In Maint. at Org.</b>
Site 1	646	44.3	50.77	7.80	18.47	6.46
Site 2	279	19.1	49.77	8.32	16.37	7.28
Site 3	150	10.3	48.55	7.02	17.18	6.71
Site 4	132	9.1	50.22	8.55	17.90	7.50
Site 5	90	6.2	47.41	8.22	13.81	5.51
Site 6	56	3.8	49.12	6.95	17.30	4.30
Site 7	21	1.4	47.65	7.76	17.90	10.48

  

<b>Location</b>	<b>Percent with Military Experience</b>	<b>Percent with Trade School Experience</b>	<b>Percent with College Experience</b>	<b>Percent with Other Aviation Experience</b>
Site 1	27.6	63.0	34.5	24.8
Site 2	41.6	41.9	47.7	31.9
Site 3	47.3	59.3	50.0	44.0
Site 4	28.8	47.7	54.5	39.4
Site 5	34.4	61.1	51.1	34.4
Site 6	26.8	44.6	48.2	48.2
Site 7	33.3	42.9	38.1	19.0

*Predicting Training Impact*

Study data were analyzed to provide initial assessment of the ability of available demographic variables to predict behavioral change intentions post-training as well as predict the overall degree of attitude change (positive or negative) and the occurrence of negative attitude change following training (the ‘boomerang’ effect). Full-model multiple regression analyses were conducted to test each of these areas. Hypothesis one posited that age, number of years of experience in the organization, job site location (dummy-coded), and background (dummy-coded) may be used to predict employees’ intentions to change behavior post-training. Despite previous research (Alwin, Cohen, & Newcomb, 1991; Visser & Krosnick, 1998) suggesting that age and years spent in an organization should predict attitude change intentions, analysis of the data did not support these assertions. Results revealed that these items did account for a significant amount of variance in change intentions,  $R = 0.201$ ,  $F_{13,1142} = 3.69$ ,  $p < 0.05$ ; however, only 4.0% of the variance in intention to change behavior on the job was explained by these variables – suggesting a lack of practical significance in the data.

In order to test hypothesis two that age, experience, background type, and site location could be used to predict degree of attitude change following training, MRM/TOQ items were combined into the four factors identified by Taylor (2000b) and confirmed in factor analyses described in Bowen, Sabin, and Patankar (2011). Pre-training scores were subtracted from post-training scores to create a training difference score for each factor. This score represents the shift in attitude on each of the four MRM/TOQ factors prior to and following participation in the MRM training.

Regression equations were then calculated for each of the four attitude change factors. For three of the four factors the overall prediction equation was non-significant: communication ( $R = 0.119$ ,  $F_{14, 1376} = 1.412$ ), conflict avoidance ( $R = 0.111$ ,  $F_{14, 1376} = 1.232$ ), and recognition of stress effects ( $R = 0.124$ ,  $F_{14, 1376} = 1.535$ ). For the factor “relational supervision” the prediction equation was significant ( $R = 0.144$ ,  $F_{14, 1376} = 2.074$ ,  $p < 0.05$ ), though only 1.5% of the variance in attitude change on this factor was explained by the four individual difference variables. Based on these results, and contrary to some previous findings, attitudinal change post-training cannot be predicted for any of the four MRM/TOQ factors based upon individual difference characteristics (such as age and job experience).

*Boomerang Participants*

Net attitude change scores were dummy-coded to identify participants with negative attitude change on each of the four factors following training. Logistic regression analyses were then done to predict occurrence of negative attitude change on each of the four MRM/TOQ factors. Similar to the results obtained for the general degree of change, demographic variables for boomerang participants accounted for only a small percentage of the variance in predicting boomerang participants (Nagelkerke  $R^2 = .031$  and lower for each of the four factors), and overall prediction equations for communication and conflict avoidance were non-significant. Prediction equations for relational supervision and stress recognition were significant, though the low amounts of explained variance suggest these are not meaningful effects. Pearson correlation analyses indicated no significant relationships between age and years in maintenance and any of the four factors (either before or after MRM training), or on negative attitude change following training. In summary, analyses did not support any of the three hypotheses related to prediction of change intentions or attitude change following training.

**Discussion**

Understanding the role of human factors in the aviation industry is a complex challenge, balancing individual psychological perceptions with systemic organizational and inter-organizational factors. This study sought to explore the attitude changes occurring in a real-world training situation, and to use this information to improve MRM training, human-factors based safety attitudes, and the factors impacting training effectiveness.

*Prediction of Boomerang Effect*

Results of the multiple regression procedures yielded unanticipated findings. Demographic variables predicted little variance in overall change intentions, post-training attitude change, or occurrence of negative (“boomerang”) attitude change. Although researchers such as Alwin, Cohen, and Newcomb (1991) and Visser and Krosnick (1998) indicated that the types of demographic data used in the present study can be used to aid in predicting attitude change, the present study does not support this assertion. It is possible that these findings are a result of the type of sample under investigation; discussions of the role of the organizational context in encouraging or discouraging attitude change (e.g., Bem, 1965; Petty & Wegener, 1998) suggest that when organizational norms are particularly strong, personal motivations or individual differences may have less power to affect behavioral change. If there are norms present (or perceived to be

## Predicting MRM Training Impact

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present) that conflict with or discourage change intentions, those change intentions may not materialize even with a well-designed training message.

Given the nature of the aviation maintenance industry, with its formal, regulated structure, stringent requirements and oversight, and substantial union presence (which contributes its own behavioral norms and reinforcement—Terry & Hogg, 1996), the situational influences and subjective norms present in the organization may be overriding the influence of relevant demographic variables on training impact.

### *Broader Implications*

These unsuccessful prediction equations do, however, suggest variables that should likely *not* be included in future attempts at predicting boomerang effects or impact following training. While industry-pervasive common perceptions and extensive anecdotal experience of the aviation industry exhibit a frequent temptation to blame negative attitudes on “old-timers” (employees with lengthy tenure in the organization), particular types of employees (e.g., engineers or mechanics), or certain locations (e.g., “that location is always negative about training!”), these results provide evidence that these attributions are unlikely to be true. Future research that is able to identify the types and strength of various situational variables and organizational norms (and their influence on attitudes) may resolve the results found here and provide a more complete picture of MRM training impact.

The inability to use available demographic variables to predict either change intentions or degree and type of attitude change following training in the present study reminds trainers and those involved in aviation human factors to check such perceptual biases to avoid making unsupported attributions regarding reasons for training success or failure. The strength of relevant situational cues, which have been described by various researchers (e.g., Petty & Wegener, 1998; Terry & Hogg, 1996), may be overpowering the effects of individual differences in this

organization’s operating environment. Additional data on situational effects in aviation organizations, and the role of union norms in attitude changes, would be enlightening for future research.

The influence of situational context on the ability of individual differences to support or mitigate training impact is a key issue across all high-consequence industries. Analyses presented here initially demonstrate that individual difference variables cannot be considered to have a significant impact without placing them in the context of the operating environment. Since high-consequence industries generally function in a relatively rigid, highly organized infrastructure that relies heavily on written rules, legal regulations and extensive task knowledge, attempts to address the human component of accidents and errors that do not address this environment will inevitably meet with only limited success. This study provides support for future work of the criticality of developing an organizational systems model of training impact in these types of highly structured industries; in aviation a model that builds on the initial aviation maintenance systems model of Bowen, Sabin, and Patankar (2011) would be a significant step forward in improving analysis of training impact.

It is anticipated that the results presented here may provide the impetus for additional research on the role of individual differences in predicting training impact, particularly in high-consequence industries that rely on successful human factors training programs to prevent a leading cause of accidents/incidents. Results of the present study should also encourage aviation organizations to review their methodology for measuring the impact of MRM training, and to make appropriate revisions to their assessment tools in order to provide the most useful and accurate data. The information gained here about demographic factors *not* likely to contribute to change intentions and the ‘boomerang’ effect, may increase understanding of human factors-related safety attitudes in aviation and other high-consequence industries.➔

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### **Acknowledgments**

This research was funded in part by FAA grant #2003- G-013. The author would like to thank Dr. Brent Bowen, Dr. Ed Sabin, and Dr. Manoj Patankar for guidance and support.



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