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# A Multidimensional Scaling and Participatory Design Approach to Classify Open Ended Aircraft Maintenance Data

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**A MULTIDIMENSIONAL SCALING AND PARTICIPATORY DESIGN  
APPROACH TO CLASSIFY OPEN ENDED AIRCRAFT MAINTENANCE DATA**

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A Dissertation  
Presented to  
the Graduate School of  
Clemson University

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In Partial Fulfillment  
of the Requirements for the Degree  
of Doctorate of Philosophy  
Industrial Engineering

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by  
Kunal Kapoor  
December, 2006

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Accepted by:  
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## ABSTRACT

The quality assurance data to be analyzed by the web-based surveillance and auditing tool (WebSAT) is both qualitative and quantitative. The forced responses to checklist questions provide a definitive outcome identifying the effectiveness of the four quality assurance work functions. On the other hand, open-ended responses, the second type of response for capturing maintenance errors, are qualitative in nature since they reflect what the auditors and quality assurance representatives observe during their interactions at vendor locations. This research proposes to apply the statistical technique of multidimensional scaling (MDS) and the User centered Design (UCD) method of Participatory Design (PD) to categorize open-ended responses into suitable performance metrics of aircraft safety and organizational cost.

Given the importance of the open-ended comments made in the quality assurance process, it is critical to capture all open-ended response data in addition to the attribute data acquired from the forced responses. While WebSAT proposes to capture both types of information, the open-ended responses require interpretation to ensure their appropriate application in the maintenance/inspection process; that is, this data must be associated with the appropriate measures of the maintenance process. This research then establishes performance measures implying the impact of audit and surveillance findings on aircraft safety and establishes another list of performance measures implying the impact of audit and surveillance findings on the organization. These performance measures are referred to as aircraft level impact (ALI) and organizational categories (OC), respectively.

Five phases were the basis of this research. In the first phase of the research Multidimensional Scaling (MDS) was used to identify performance measures for ALI. The five performance measures were identified as Safety, Regulatory Compliance, Procedure / Paperwork Inadequacy, Operational, and House-Keeping and Storage.

In the second phase Linear Regression was used to interpret the relevance of the identified performance measures in the first phase. It was concluded that the five identified performance measures are interpreted as relevant by the quality assurance personnel.

In phase three the Participatory Design methodology was adopted to finalize a set of performance measures for OC. A 'Risk Management Matrix' was finalized as a solution to categorize surveillance and audit findings in terms of OC. This matrix indicates a 'risk' associated with surveillance or an audit finding.

In the fourth phase of the research the utility of the performance measures was tested. The alternate hypotheses stated that the availability of information on performance measures for ALI allowed the participant to generate better prediction scores based on allocations of surveillance and audit findings, compared to participants without information on performance measures. It was concluded that participants with information on identified performance measures had higher prediction scores compared to participants without information on identified performance measures.

The other research hypotheses confirm that the availability of information on organization level performance measures allows participants to make reliable allocations within the cells of the Risk Management Matrix.

The fifth phase evaluated aspects of the interface which allowed the users to document surveillance and audit findings in terms of ALI and OC in WebSAT. The time required to document a finding in terms of performance measures was better than the ideal value (of time required) to complete the task.

This research has shown that Multidimensional Scaling is a useful technique to classify open ended aircraft maintenance data to establish performance measures indicating the safety of an aircraft. The Participatory Design approach helped establish a Risk Management Matrix to classify open ended maintenance data at an organizational level.

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## TABLE OF CONTENTS

	Page
TITLE PAGE .....	i
ABSTRACT .....	ii
ACKNOWLEDGEMENTS .....	v
LIST OF TABLES .....	xi
LIST OF FIGURES .....	xii
CHAPTER	
1. INTRODUCTION .....	1
2. LITERATURE REVIEW .....	4
Aircraft Maintenance .....	4
Maintenance Error Classification .....	5
Quantitative Aircraft Maintenance Data .....	6
Statistical Models .....	8
Participatory Design .....	9
Problem Statements .....	12
3. MULTIDIMENSIONAL SCALING AND CARD SORTING .....	14
Research Requirements .....	14
Multidimensional Scaling .....	14
Research Phases .....	17
Card Sorting Technique .....	17
Participants .....	18
Task .....	18
Apparatus and Settings .....	19
Procedure .....	19
Results .....	19
Identified Dimensions .....	20

Table of Contents (Continued)	Page
4. RATING RESPONSES ON IDENTIFIED DIMENSIONS....	22
Linear Regression to Interpret Multidimensional Solutions .....	22
Linear Regression .....	23
Rating of Responses.....	25
Participants.....	25
Task.....	25
Apparatus and Settings .....	26
Procedure .....	26
Results for regression analysis.....	26
Regression analysis for Quality Assurance personnel.....	27
Regression analysis for Internal audit personnel .....	29
Regression analysis for Surveillance personnel .....	30
Regression analysis for Technical audit personnel.....	32
Discussion.....	33
5. PARTICIPATORY DESIGN .....	35
Participatory Design .....	35
Participants.....	36
Setting .....	36
Procedure .....	36
Problem statement description.....	37
Data collection process .....	37
Semi-structured interviews .....	38
Interview data .....	39
Interview with the Internal audits manager .....	39
Interview with the Technical audits manager.....	43
Interview with the Surveillance manager .....	46
Discussion.....	47
6. RESEARCH HYPOTHESES .....	48
Research Hypothesis 1.....	48
Research Hypothesis 2.....	49



Table of Contents (Continued)	Page
7. EVALUATION OF CATEGORIZATION SCHEMES .....	52
Participants.....	52
Experimental Design.....	52
Apparatus and Settings .....	54
Independent Variables .....	55
Dependent Variables.....	55
Procedure .....	56
Conditions for Research Hypothesis I .....	56
Results for Research Hypothesis I for stage 1 .....	57
Conclusion for stage 1 .....	57
Results for Research Hypothesis I for stage 2 .....	57
Conclusion for stage 2 .....	58
Criteria for Research Hypothesis II .....	58
Results for Research Hypothesis II – Stage 1 .....	60
Conclusion for Research Hypothesis II – Stage 1 .....	61
Results – Stage 2.....	63
Conclusion – Stage 2 .....	63
Discussion.....	64
Stage 3.....	64
Results – Stage 3.....	65
Discussion.....	66
8. INTERFACE DESIGN AND EVALUATION .....	69
Identification of User Needs .....	69
Establishing Product Specifications.....	72
Interface Design and Development.....	73
Interface Evaluation.....	73
Participants.....	73
Apparatus and Settings .....	74
Procedure .....	74
Task.....	75
Performance Measurement .....	75
First Iteration.....	77
Results – First Iteration.....	96
Second Iteration .....	99
Discussion.....	118

Table of Contents (Continued)	Page
9. CONCLUSIONS AND RECOMMENDATIONS .....	119
Importance of this Research .....	121
Suggestions for future Research .....	124
APPENDICES .....	126
A: Information Concerning Participation in a Research Study.....	127
B: Response Loading for Four Dimensions.....	129
C: Response Loading for Five Dimensions .....	136
D: Response Loading for Six Dimensions.....	143
E: Response Loading for Seven Dimensions .....	150
F: Loading for Responses for Rating Task.....	157
G: .....	158
G-I: Survey for Regulatory Compliance .....	158
G-II: Survey for Procedures and Paperwork Inadequacy ...	160
G-III: Survey for Operations.....	162
G-IV: Survey for House-Keeping and Storage .....	164
G-V: Survey for Safety .....	166
G-VI: Information Concerning Participation in a Research Study .....	168
G-VII: Information Concerning Participation in a Research Study .....	170
G-VIII: Interview Script.....	172
H: Data Set for Response Ratings for Regression Analysis.....	173
I: .....	175
I-I: Rating of Quality Assurance personnel .....	175
I-II: Rating of Internal audit personnel.....	177
I-III: Rating of Technical Audit personnel .....	179
I-IV: Rating of Surveillance personnel .....	181
I-V: Loading values of responses used for the regression Study .....	183
J: Consent form for the Evaluation of categorization Schemes .....	185
K: Research study participation request e-mail .....	187
L: .....	188

Table of contents (Continued)	Page
L-I: Risk Matrix with Information .....	188
L-II: Risk Matrix without Information .....	189
L-III: Responses for aircraft level impact categories.....	190
L-IV: Responses for organizational categories .....	191
M: .....	194
M-I: Prediction scores for Research Hypothesis I – Stage 1 .....	194
M-II: Results for Research Hypothesis I- Stage 1 .....	195
M-III: Prediction scores for Research Hypothesis I – Stage 2.....	196
M-IV: Results for Research Hypothesis I – Stage 2 .....	197
N: .....	198
N-I: Co-occurrence frequency distribution – Stage 1.....	198
N-II: Co-occurrence frequency distribution – Stage 2.....	199
N-III: Time taken to categorize findings – Research Hypothesis II.....	200
N-IV: Co-occurrence frequency distribution – Stage 2.....	201
N-V: Co-occurrence frequency distribution – Stage 2.....	202
N-VI: Frequency distribution with the correction factor.....	203
O: .....	204
O-I: Consent to participate in a research study.....	205
O-II: E-mail request draft.....	206
O-III: WebSAT Usability Study test session introduction...	207
P: After-Scenario Questionnaire .....	208
REFERENCES .....	209

## LIST OF TABLES

Table		Page
1.	Needs Hierarchy.....	70
2.	Needs rating .....	71
3.	Target Specifications .....	72
4.	Time taken to do tasks .....	77
5.	Marginally Acceptable and Ideal Values .....	77
6.	Results of Technical Audit group .....	96
7.	Results of the Internal Audits group .....	96
8.	Results of the Surveillance group .....	97

## LIST OF FIGURES

Figure	Page
1. Stress plot for identifying the number of dimensions.....	20
2. Risk Management Matrix .....	41
3. Login page – Iteration One .....	80
4. Resume audit page for Internal Audits – First Iteration .....	81
5. Checklist Data entry page for Internal Audits – First Iteration.....	82
6. Checklist answer is ‘No’ for Internal Audits – First Iteration .....	83
7. Drop down indicating Aircraft Level Impact categories – First Iteration.....	84
8. Drop down indicating Organizational Categories – First Iteration.....	85
9. Resume Audit screen for Internal Audits – First Iteration.....	86
10. Checklist Answers page for Technical Audits – First Iteration.....	87
11. Drop down for Aircraft Level Impact categories First Iteration.....	88
12. Drop down for Organizational Categories – First Iteration .....	89
13. Start New Surveillance Screen – First Iteration.....	90
14. Work Order Details screen – First Iteration.....	91
15. Surveillance Schedule screen – First Iteration.....	92
16. WorkCard Data screen – First Iteration.....	93

## List of Figures (Continued)

Figure	Page
17. Drop down indicating Aircraft Level Impact categories – First Iteration.....	94
18. Risk Matrix for Organizational Categories – First Iteration.....	95
19. Login page – Second Iteration .....	100
20. Resume Audit for Internal Audits – Second Iteration .....	101
21. Checklist Data Entry screen for Internal Audits – Second Iteration.....	102
22. A ‘No’ documented against a checklist question – Second Iterations .....	103
23. Risk matrix to document Organizational Categories .....	104
24. Risk matrix to document Organizational Categories .....	105
25. Resume Audit screen for Technical Audits – Second Iteration.....	106
26. Checklist Data Entry screen for Technical Audits – Second Iteration.....	107
27. No’ selected for a checklist answer in Technical Audits – Second Iteration .....	108
28. Drop down indicating Aircraft Level Impact categories for Technical Audits – Second Iteration.....	109
29. Explanation for Aircraft Level Impact categories – Second Technical Audits – Second Iteration.....	110
30. Risk matrix for Organizational Categories for Technical Audits – Second Iteration.....	111
31. Surveillance Schedule Screen – Second Iteration.....	112

## List of Figures (Continued)

Figure	Page
32. Work Order Details screen – Second Iteration .....	112
33. Surveillance Schedule Details screen – Second Iteration .....	113
34. Activity Data – Second Iteration.....	114
35. Drop down indicating Aircraft Level Impact categories – Second Iteration .....	115
36. Risk matrix for Organizational Categories – Second Iteration .....	116
37. Drop down indicating selected risk index for Organizational Categories – Second Iteration .....	117

## CHAPTER 1

### INTRODUCTION

Scheduled maintenance on an aircraft is typically associated with work cards, the purpose of which is to instruct vendors and their personnel on the specific areas requiring maintenance at a particular time. During the subsequent walk-around on the shop floor, the quality assurance representative checks the areas noted on these work cards, inspecting for maintenance errors and rating vendor performance based on the acceptance or the rejection of the work performed. If the quality assurance representative discovers a particular maintenance task mandated by the work card not done to satisfaction, the vendor is instructed to correct and/or complete it before the aircraft leaves the facility. Each time the task mandated by the work card is rejected by the quality assurance representative, an open ended comment is documented.

In addition, the quality assurance representative may discover aspects of the aircraft requiring attention that are not part of the scheduled surveillance. In this case, the maintenance issue is resolved during the surveillance event. If the finding is critical, during the next scheduled maintenance event this aspect may be re-examined by both the vendor and the quality assurance representative. The typical surveillance response either accepts or rejects the quality of maintenance at the vendor location. The response to almost all rejects issued may also be associated with open-ended comments. These responses are vital sources of documented maintenance observations, carefully watched until the safety of the aircraft requires their resolution.



Given the importance of the open-ended comments made in the quality assurance process, it is critical to capture all open-ended response data in addition to the attribute data acquired from the forced responses. The quality assurance data to be analyzed by the web-based surveillance and auditing tool (WebSAT) is both qualitative and quantitative. WebSAT proposes to capture both types of information, the open-ended responses require interpretation to ensure their appropriate application in the maintenance/inspection process; that is, this data must be associated with the appropriate performance measures of the maintenance process, reaching the personnel responsible for specific work functions. These performance measures indicate the impact of maintenance findings on the safety of an aircraft and the organization.

This data reduction is required at two levels. The first is the effectiveness of vendor performance in surveillance and technical audits, effectiveness of in-house processes measured by internal audits, and effectiveness in loading and tracking airworthiness directives. This first level, referred to as Tier-1 in the proposed research, should indicate the impact of surveillance and audit findings, and the findings of the airworthiness directives control group on an aircraft. The second level, designated as Tier-2, involves the maintenance data captured by quality assurance representatives, auditors, and the airworthiness directives control group, reflected in terms of cost implications at a managerial level.

The research proposed here attempts to transform qualitative observations of vendor task performance into useful measures of aircraft safety and organizational cost. To accomplish such a transformation, it is important to assign an appropriate performance measure to qualitative observations.

A strategy could be adopted where each documented open ended response for a discrepancy is categorized into a performance measure by the quality assurance representative (QAR) or an auditor. This is a straightforward way to transform qualitative observations into measures of aircraft safety and cost to the organization. This strategy has a drawback. The QARs and auditors each have their own interpretation of the documented discrepancies. If the transformation of the open ended responses is done by the QARs and the auditors there will be several similar performance measures within WebSAT. There is also a possibility that several of the measures will have similar meanings, creating redundancy. The managers warned us about this problem, and expressed the desire of having established measures for QARs and auditors to make a selection from. Hence a better strategy needs to be adopted to transform qualitative data into meaningful performance measures.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Aircraft Maintenance

Air transportation is complicated. To ensure safe and reliable air transportation, the Federal Aviation Administration (FAA) issues and enforces regulations and standards. Maintenance error is a crucial factor in aircraft accidents (Boeing and US ATA, 1995). The significance of the maintenance function was captured by Weick et al., who stated that: ‘Maintenance people come into contact with the largest number of failures, at earlier stages of development, and have an ongoing sense of the vulnerabilities in the technology, sloppiness in the operations, gaps in the procedures, and sequences by which one error triggers another’ (Weick, Sutcliffe, and Obstfeld, 1999).

It is important to take a closer look at the humans involved in aviation maintenance, understand the causal factors for the occurring maintenance errors and the possible solutions to counter this situation.

Research involving the analysis of a maintenance incident database and the associated incident investigation reports indicated factors such as inadequate training, poor supervision and individual factors such as stress and fatigue as causes of maintenance related incidents (Helmreich, 2000, and Sarter, 2000). This approach involved a series of focus groups and interviews with maintenance personnel and their supervisors to ascertain their perceptions of factors that impact maintenance work. The

insight of maintenance personnel in such a strategy is advantageous. The drawback of this strategy is that this approach is reactive in nature, i.e. these strategies depend on reacting to documented information once a maintenance incident is reported. This reactive strategy does not allow prediction based on problematic trends to avoid the maintenance incident from occurring.

## 2.2 Maintenance Error Classification

Various airlines have developed internal procedures to track maintenance errors. One such methodology employs the failure modes and effects analysis approach (Hobbs and Williamson, 2001) and classifies the potential errors by expanding each step of a task analysis into sub-steps and then listing all the failure modes for each sub-step. The US Navy safety center developed the Human Factors Analysis and Classification System and the follow up web-based maintenance error information management system to analyze naval aviation mishaps (Shappell and Wiegmann, 1997; Schmidt, Schmorow, and Hardee, 1998; and Shappell and Wiegmann, 2001). Later this system was used to analyze commercial aviation accidents (Wiegmann and Shappell, 2001). The Maintenance Error Decision Aid (MEDA) (Rankin et al., 2000) helps analysts identify contributing factors that lead to an aviation accident. The problem with this strategy was the implementation of the process. The MEDA process is dependent on the erring technician's willingness to be interviewed about the error.

Research on error classification schemes is valuable (e.g., Patankar, 2002). The problem with classification schemes, however, is that there is no causal model embedded in the schemes to show weak points in a system (Iyengar et al., 2004). Classification

schemes may also require empirical models to illustrate how the weak points in a system influence outcomes (Iyengar et al., 2004).

Maintenance management is of considerable importance (Pintelon and Puyvelde, 1997) to predict problems in time to make necessary adjustments. Neely et al. (1995) have provided a review for performance measurement. For an organization to take precautionary measures against maintenance problems, sound performance reporting is indispensable (Pintelon and Puyvelde, 1997). Research has indicated the importance of performance reporting from an operational point of view (Pintelon and Puyvelde, 1997). The same research also indicated that personnel within an organization perceive maintenance performance from their own perspective. Organizations often have access to data, but seldom do maintenance managers receive information which is structured and aggregated. It is important to process data to obtain useful insights on maintenance. It is important to understand how to measure maintenance performance and to know what to measure to gain sufficient insight into the maintenance operation (Pintelon and Puyvelde, 1997). A system that analyzes maintenance data could effectively utilize the expertise of the maintenance personnel (Hui, Qin, and Shigeyuki, 1996).

### 2.3 Quantitative Aircraft Maintenance Data

Maintenance data could identify potential problem areas which may be indicators of aircraft safety. Maintenance data is both qualitative and quantitative. Quantitative models can predict system performance, whereas qualitative models may address important concepts that are not easy to quantify (Wang and Hwang, 2004).

Patankar et al. (2003) conducted a study utilizing the descriptive data from self-reported maintenance errors that are available through the Aviation Safety Reporting System (ASRS). They reported that the maintenance data provided a means to understand the relationship between causal factors that contribute to maintenance errors and the effect of these maintenance errors. Holmgren (2005) conducted a study to identify maintenance related losses and their causes. The study was conducted on the impact of maintenance related losses for Swedish railways, but Holmgren states that such a strategy is of value to all concerned with transport and safety.

The Safety Performance Analysis System (SPAS) contains the Service Difficulty Reporting (SDR) system as a data source to identify abnormal and potentially unsafe conditions in an aircraft or aircraft components/equipment. A higher number of SDRs suggests a greater possibility of maintenance problems (Shyur, Luxhoj, and Williams, 1996). In their research on SPAS, Shyur et al. (1996) worked with performance indicators, the tracking of which helped identify unfavorable trends. Once performance indicators are identified, it is important to identify unfavorable trends from maintenance data.

Weckman et al. (2001) developed a forecasting methodology based on actual field data for repairable systems in the aviation industry. Prediction models to determine aircraft maintenance errors can be based on multiple regression models. Multiple regression is a general statistical technique to analyze the relationship between a single dependent (predicted) variable and several independent (predictor) variables (Shyur, Luxhoj, and Williams, 1996). An effective maintenance classification and prediction method can help ensure a safe and operational aircraft. Appropriate data interpretation

approaches can be utilized to find relationships between aircraft maintenance data and unsafe conditions of an aircraft (Brence and Brown, 2002). The discovery, collection, classification, and understanding of events for the purposes of developing specific error reduction strategies are recommended by Adams et al. (1997).

The computerized support system for analyzing human errors (COSFAH) is a unique approach to support the analyst during analysis. Yoon and Kim (1996) state that the analysis reveals the cognitive causations among activities and system state, which in turn allow COSFAH to capture and provide rich insights into the causes of the errors.

Quantitative data is also a rich source of knowledge on aviation maintenance performance. It is critical to find hidden patterns in data sets to classify maintenance error. Thus, data mining is an aspect to be considered for a classification scheme. Data mining theories or techniques can be categorized into two categories. The first is the neural network and regression approach, which creates a model based on a training data set. The second category involves machine learning algorithms generating a number of models in the form of decision rules. Data mining approaches have been successfully applied to industrial data analysis to derive useful and comprehensive knowledge (Hans and Micheline, 2001).

#### 2.4 Statistical Models

Statistical language models have been found to be useful in encoding knowledge, making linguistic information available to data analysis systems. A review of the literature suggests that the most effective tool for the study proposed here should capture topic-related dependencies, i.e., assign an appropriate category to a certain type/kind of

information, thereby translating existing linguistic knowledge into more useful responses through semantic information processing (Landauer, Foltz, and Laham, 1998). This type of approach appears to be critical to the current study involving the Web-based surveillance and auditing tool (WebSAT), as it allows the transformation of open-ended comments to meaningful maintenance performance measures, important because the open-ended responses of the quality assurance representatives and auditors track maintenance issues until they require action.

Multidimensional scaling (MDS) is a set of mathematical techniques enabling the hidden structure of data bases to be uncovered (Kruskal, and Wish, 1983). This class of techniques uses proximities among any kinds of objects as input, with proximity being defined as the number indicating how similar or how different two objects are, or are perceived to be. The resulting output is a spatial representation consisting of a geometric configuration of points that reflect the hidden structure of the data.

One of the attractive features of MDS is that it is not necessary to prejudge the structure of the data bases (Rosenberg, Nelson, and Vivekananthan, 1968). The identification of the underlying patterns is the purpose of using a technique such as MDS.

### 2.5 Participatory Design

In the current research to identify the categories for the cost to the organization, it seems important to incorporate the expertise of the managers. The auditors and quality assurance representatives need to be kept abreast of what the managers intend on achieving with the immense amount of maintenance data. A statistical technique such as MDS does not seem practical to identify performance measures of cost to the



organization, since, in the case of our industry partner, there are only four managers, and the outcome of such a strategy would not be statistically significant. The Scandinavian school of thought of Participatory Design offers techniques in which users can directly influence the outcome of key design issues. Such a strategy could be useful to finalize the categories of cost to the organization.

The method of Participatory Design (PD) revolves around the concept that users and designers have equal significance in the development of a product. In conventional user-centered design practice, the users are often a part of the development process via user requirements gathering through interviews, questionnaires, observations, and evaluation sessions. The users typically do not participate directly in the decision making process.

In PD, the user/s are involved with the decision making directly, as they are part of the design team. The team of users and designers is referred to as a multidisciplinary team. The study of PD has been an active research field for several decades, an indication that user involvement has an influence on the decision making process and that it generates insight and knowledge (Luck, 2003). Researchers have generally cited two reasons for adopting a PD approach: first being the fact that the study focuses on the verbal exchange of design ideas that is required during the early stages of the design process. The process is iterative and a better understanding emerges as a result of verbal exchange of ideas. The second reason hinges on the ideology of PD which supports the participation of the users in the decision-making process (Luck, 2003).

The data collection process is primarily through semi-structured interviews to gather information from respondents. The rich information which is produced provides

invaluable information for the design team (Luck, 2003). The key to this approach is that there is no right answer. Each response is supposed to be the user's personal response and experience. The analysis of the interview data deals with content analysis (Luck, 2003). This requires the researcher to be familiar with the data and to make objective inferences about characteristics within the text data. The textual data may have general user needs and may range to very specific user needs.

Strategies such as PICTIVE (Plastic Interface for Collaborative Technology Initiatives through Video Exploration) have been successfully implemented during a development process. This technique was introduced at Bellcore in 1990 within the framework of PD (Muller, 1992). This strategy has been successfully implemented to allow the direct participation of users who may not be computer literate in the software design process. The basic idea was to capture ideas expressed during the PICTIVE sessions on video, for later interpretation and implementation in the design process. The expertise of the researcher, the commitment of the users and stakeholders to a successful product, and workplace democracy would be key requirements for the success of PD in the workplace (Muller, 1992).

PD has questioned traditional work practices, especially in an era when businesses are abandoning their traditional practices to embrace new ideas (Muller, Wildman, and White, 1993). PD researchers have been exploring the appropriate conditions for user participation in the design and introduction of computer based systems at work (Kensing, and Blomberg, 1998). According to Kensing and Blomberg (1998) PD projects have varied with respect to how and why workers have participated. In some cases, worker participation is limited to providing designers with access to workers' skills and

experiences, while in others, workers participate because their interests in the design outcome are critical. Cooperative Experimental Systems Development (CESD) is characterized by user involvement throughout the development process (Gronbaek et al., 1997), while Contextual Design focuses on early design activities (Beyer and Holtzblatt, 1997).

Blomberg and Henderson (1990) have defined 3 tenets of the PD approach which should influence the interaction between developers and users of computer-based systems: 1) the goal should be to improve the work life of the users; 2) the orientation should be toward collaborative development; and 3) the process should be iterative.

## 2.6 Problem Statements

This research, then, proposes to apply multidimensional scaling (MDS) to the open-ended responses of quality assurance representatives and auditors, to transform qualitative maintenance data to established performance measures implying the impact of maintenance findings on the safety of the aircraft. Both Taguchi philosophy and robust design methodology support the importance of this data reduction, emphasizing that effective data analysis depends directly on the appropriateness with which a system, in this case WebSAT, reduces all the associated work function information (Cho, Kim, Kimbler, and Phillip, 2000; Kim, and Cho, 2000a; Kim, and Cho, 2000b; and Taguchi, 1986). It is especially critical that textual data associated with open-ended responses be analyzed accurately, as these responses indicate aspects of an aircraft requiring future maintenance attention. As such, it is important to identify which attribute of a work function is affected.

In the second phase of the research, PD methodologies will be applied to enable the managers of the quality assurance department at our industry partner, to form appropriate performance measures against which maintenance data may be categorized in terms of cost to the organization.

#### Problem statement 1

Each time a QAR or an auditor observes a reject or a “No”, respectively, an open-ended response is documented. The impact on the safety of the aircraft is not indicated by the open-ended comment. Each time a reject or a No is documented, an associated aircraft level impact (ALI) needs to be associated with the finding. The first phase of the research, then, proposes to apply MDS to categorize the open-ended maintenance data into useful performance measures. Each open-ended response indicates a possible risk to the aircraft and will be associated with an ALI.

#### Problem Statement 2

The users of WebSAT at the managerial level are concerned with the implications of discrepancies observed by quality assurance representatives and auditors in terms of a potentially different set of managerial-level categories (Organizational Categories). There are not enough managers to allow a statistical technique such as MDS to be appropriately used to establish this set of categories. This research then proposes to use Participatory Design to finalize the set of Organizational Categories.

## CHAPTER 3

### MULTIDIMENSIONAL SCALING AND CARD SORTING

#### 3.1 Research requirements

Each time a reject is observed by a quality assurance representative, an open-ended comment is documented. A categorization of this response is then made in terms of its effect on aircraft safety. Such a categorization is defined by the surveillance personnel as the effect of the rejection on the safety of an aircraft. Currently, only the quality assurance representatives categorize a reject into an 'effect' category. The categories for 'effect' are general workmanship, hanger safety, safety immediate, lubrication, regulatory compliance, safety personnel, and operational. Although the auditors do not currently categorize audit findings, the open-ended responses which they document could also be utilized to identify the effect of the finding on the safety of an aircraft. The open-ended responses from previous surveillance findings and audits will be presented to quality assurance representatives and auditors for this research. They will be asked to categorize the findings into performance metrics indicating the effect of a finding on aircraft safety. This research then proposes to use MDS to utilize these open-ended responses to establish categories for the safety of an aircraft.

### 3.2 Multidimensional Scaling

Multidimensional Scaling (MDS) refers to a class of techniques. MDS uses proximities among any kinds of objects as input. Proximity is a number which indicates how similar or dissimilar two objects are. The output is a spatial representation of a geometric configuration of points (Kruskal and Wish, 1983). Each point in the configuration corresponds to one object. The configuration represents the structure in the data. This makes the data easier to understand. The larger the dissimilarity between two objects, the further apart they will be in a spatial configuration.

A common procedure to obtain proximity data is to ask people to directly judge the closeness of the stimulus objects (Kruskal and Wish, 1983). In order to discover dimensions and not impose them, the attributes on which the stimuli are to be judged are not specified. A simple method for large stimulus sets (approximately 50 to 100 objects) is to have subjects sort or cluster the stimuli according to perceived similarity (Rosenberg et al., 1968).

The subjects in this study were asked to place the stimuli into exclusive and exhaustive categories. Thus, stimuli in the same category are more similar to each other than to those in other categories. In MDS analysis greater distance between objects reflects less interaction between the associated entities (Jones and Young, 1972).

The data for analysis could pertain to some collection of objects (Kruskal and Wish, 1983). The stimuli could be either real or conceptual. The objects can be primarily indexed by the letter  $i$  and secondarily by  $j$ , and  $i$  and  $j$  run from 1 to  $I$  if there are  $I$  objects. The proximity associating object  $i$  and  $j$  can be represented by  $\delta_{ij}$ . There is no effective difference between  $\delta_{ij}$  and  $\delta_{ji}$ . There is no effective value associated with  $\delta_{ii}$ .

The distance between points plays an important role in MDS (Kruskal and Wish, 1983). The distance between two points  $x_i$  and  $x_j$  can be represented by  $d(x_i, x_j)$ , and this is usually simplified further to  $d_{ij}$ . The distance is always Euclidean distance, unless stated otherwise.

For any set of data (Kruskal and Wish, 1983), the objective function yields a single number which shows how well or how poorly the data fit the configuration. Thus,  $f(\delta_{ij}) = d_{ij}$ , where  $f$  is some specified type of function. The discrepancy between  $f(\delta_{ij})$  and  $d_{ij}$  is then  $f(\delta_{ij}) - d_{ij}$ .

Kruskal and Wish (1983) state that:

If  $f(\delta_{ij}) = d_{ij}$ , then we have exact equality.

The “f-stress” is a measure of the configuration (Kruskal and Wish, 1983). The larger the f-stress, the worse the configuration is. The value for f-stress is  $\geq 0$ , since we account for squared distances. If we have exact equality, then f-stress = 0.

A rough rule of thumb is that there should be at least twice as many stimulus pairs as parameters to be estimated. This assures an adequate degree of statistical stability (Kruskal and Wish, 1983).

The MDS technique appears to be suited to the current problem of understanding and describing the multidimensional structure of aircraft maintenance data. The application of MDS for the study will start with the selection of a set of objects, a large and diverse set of open ended maintenance data documented by quality assurance representatives and auditors. The basic datum required for MDS (Rosenberg et al., 1968) is a number for each pair of objects in the selected set of objects reflecting how closely the two objects are related to each other. What MDS then does is provide a geometric

representation of the set of these objects (or responses in the case of this research) so that the inter item distance in space corresponds to the empirical measure of psychological relatedness (Rosenberg et al., 1968).

### 3.3 Research phases

There are three phases to identify and validate the categories of impact to aircraft safety. These are as follows: 1. Card-sorting technique to understand proximity distances between audit and surveillance findings; 2. Validate dimensions or categories identified in the first phase by rating the relationship between the findings and the dimension (or categories) identified; and 3. Validate the utility of the dimensions (or categories).

### 3.4 Card Sorting Technique

A card sorting technique was used to generate a set of categories of the documented audit and surveillance findings. The results from this study were used to establish an initial set of categories which indicate the effect of maintenance error on the safety of an aircraft. The audit and surveillance findings which were used for this study were documented findings by technical auditors, internal auditors, and quality assurance representatives from the surveillance department for the fiscal years 2003 to 2005, 2002 to 2006, and 2003 to 2005, respectively. The researcher selected unique findings from the entire data set for the work functions of technical audits, internal audits and surveillance. Three-hundred and four responses were selected for this study. The researcher and three other graduate students from the Department of Industrial Engineering, Clemson University, who were aware of the card sorting technique then did a pilot study involving



the sorting task. This was done to determine an approximate time range which would be required to do the card sorting task for such a large and diverse set of findings. The average time was approximately 90 minutes. The time for the participants for the actual study was set at 120 minutes. Since the task was designed to be a self paced task, 120 minutes was only a recommended time limit. The participants could take more or less time for the task, than the recommended time limit.

### 3.5 Participants

Fifteen participants from our industry partner for this research were asked to participate in the card sorting study. Seven quality assurance representatives from the surveillance department, five internal auditors, two technical auditors, and a manager from the technical audit department were involved in this study.

### 3.6 Task

The participants were given the task of categorizing the responses into clusters of similar responses. There was no restriction on the number of categories the participants could generate. The subjects were asked to keep the responses on the cards face up and to place a slip of paper next to each cluster of responses indicating an apt name for the cluster of similar responses. They were allowed to change their assignments of responses to a new category at any time before they completed the task. Even though the informational letter provided to the subjects indicated that the task would take approximately two hours, the researcher stressed the fact that the task was self paced, and the participants could take more time. This never happened during the study, since the

longest time taken by any participant was approximately 115 minutes. The range of times for this task was between 90 and 115 minutes, while the mean time for the task was 107.33 minutes.

### 3.7 Apparatus and Settings

The card sorting technique was conducted at the industry partner headquarters in Memphis, Tennessee, and at aircraft vendor locations at Greensboro, North Carolina, and Mobile, Alabama. Three hundred and four cards representing audit and surveillance findings were presented to the participants.

### 3.8 Procedure

Participants were invited to participate in the card sorting study through phone calls. An Informational Letter was presented to the participants (Appendix A). The instructions for the study were documented in this letter. The instructions were also read aloud to the participants. The participants were allowed to ask questions regarding the study, and only when each participant knew exactly what needed to be done, did they proceed with the study.

### 3.9 Results

The number of categories used by the fifteen participants ranged from three to fifteen with a mode of five categories. Kruskal and Wish (1983) suggest that a stress of 5% is 'good', while 10% is 'fair'. The plot in Figure 1 suggests that the stress value improves from two dimensions onwards. For four dimensions the stress value is 0.08181

and for five dimensions the stress value is 0.07019, or approximately 7%. Even though the stress values for six and seven dimensions are lower than that for five dimensions, the loadings or association of responses on the sixth and seventh dimension are largely insignificant (Appendix D and Appendix E, respectively). The loading values for four and five dimensions are in Appendix B and Appendix C, respectively.

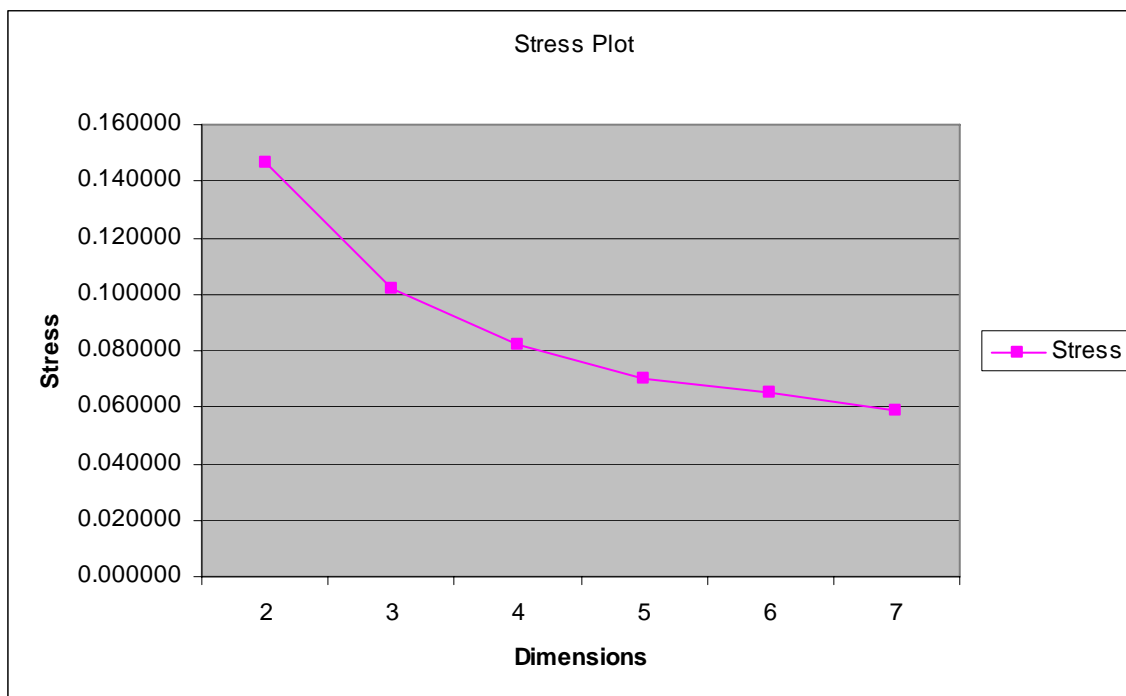


Figure 1. Stress plot for identifying the number of dimensions

According to Kruskal and Wish (1983) the stress value should stabilize and the cut off point where the value stabilizes will be the number of dimensions which account for the most items. The dimensions or categories were finalized at five at this stage of the research.

### 3.10 Identified Dimensions

The ten responses with the highest loadings on the five dimensions (Appendix F) were studied carefully. The selection criteria for the responses are explained in section

4.2. Each of the responses was then associated with the names of clusters which the participants provided during the study. The five dimensions are as follows: Safety, Regulatory Compliance, Procedure / Paperwork Inadequacy, Operational, and House-keeping and Storage.

Typical findings for safety would be: 1. Pulled circuit breakers without "Lock Out Tags" in cockpit of N673FE, and 2. Found fire extinguisher #EE 4328 past due inspection on lift truck # 10165.

Findings for regulatory compliance would be: 1. Several AMT training records contained multiple and / or outdated copies of MOPs and several AMT records had incomplete MOPs past the 60 day time limit for completion, and 2. Internal audits are not being conducted in accordance with the frequency outlined in the Base Maintenance Desktop Procedure Manual (DTPM).

Findings for procedure and paperwork inadequacy would include findings such as: 1. Investigation revealed that stamp control per the Base Maintenance DTPM was not being followed consistently, and 2. Found engine received and released for service with incorrect or missing component airworthiness approval documentation.

Typical operations findings include responses such as: 1. Several ball-mats were found without serviceability documentation in two separate locations, and 2. Found numerous main A/C batteries on pallets in the warehouse area without paperwork attached to identify them.

House-keeping and storage includes findings such as: 1. Scrap trailers full and outside area overflowing, and 2. Found box with loose hardware at nose of aircraft.

## CHAPTER 4

### RATING RESPONSES ON IDENTIFIED DIMENSIONS

This phase of the research was important to establish a set of stable dimensions with empirical data. At the end of section 3.10 five dimensions were uncovered in the configuration space. The loading values for five dimensions (Appendix C) indicate that the loading values for the fifth dimension are comparatively low. This phase will then generate empirical data to establish a final set of dimensions.

#### 4.1 Linear regression to interpret multidimensional solutions

The directions in the MDS configuration have interesting interpretations. The positions in the configuration may be associated with characteristics of the items which were scaled (Kruskal and Wish, 1983). One of the key expectations of MDS is to understand which characteristics are more important than the others. Linear regression is the most common way to identify these characteristics. Kruskal and Wish (1983) explain the utility of linear regression. Assume there is some variable associated with items which has a systematic relationship to position in the configuration. One way to establish this relationship is to perform linear regression using this variable as the dependent variable and the coordinates of the configuration as the independent variables. Generally participants in a study are asked to rate the association of a response with the identified dimensions. The mean value of the ratings forms the dependent variable. The ordinary

multiple R provides a quantitative estimate of the degree to which an item actually corresponds to a dimension in the space configuration (Rosenberg et al., 1968).

#### 4.2 Linear regression

The mean rating of each response on each dimension is the dependent variable. There are five dependent variables: the mean ratings on each of the five identified dimensions. The coordinates of the configuration (or loadings) for the five dimensions are the independent variables. Five regression studies were conducted, one for each of the dimensions.

Regression analysis is a statistical technique that allows the assessment of the relationship between one dependent variable (DV) and several independent variables (IV). The regression equation takes the following form:

$Y' = A + B_1X_1 + B_2X_2 + \dots + B_kX_k$ , where  $Y'$  is the predicted value on the dependent variable,  $A$  is the  $Y$  intercept (the value of  $Y$  when all the  $X$  values are zero), the  $X$  (i) s represent the independent variables (of which there are  $k$  in the above case), and the  $B$  (i) s are the coefficients assigned to each of the independent variables during regression. The goal of regression analysis is to obtain a set of  $B$  values, known as regression coefficients, for the IVs that bring the  $Y$  values predicted from the equation close to the  $Y$  values obtained by measurement (Tabachnick, and Fidell, 2001).

In this stage of the study, the responses used for clustering were used to obtain regression coefficients for the association between the independent and dependent variables. Three hundred and four maintenance findings were used in the initial study to categorize these findings. The participants for the earlier study and for the regression

study are auditors and quality assurance representatives. It was difficult to secure the participation of these stakeholders for extended periods of time. Thus, a reduced number of findings were used for this next study. Green (1991) provides a discussion regarding the sample size requirement. The simplest rule of thumb is that the sample size,  $N$  be greater than or equal to  $50 + 8m$ , where  $m$  is the number of IVs, to test the multiple correlation and that  $N$  be greater than or equal to  $104 + m$  to test individual predictors. Green (1991) offers a more complex rule of thumb which accounts for the effect size:  $N$  be greater than or equal to  $(8/f\text{-sq.}) + (m-1)$ , where  $f\text{-sq.} = 0.01, 0.15,$  and  $0.35$  for small, medium, and large effects, respectively.

For five dimensions, and a medium effect size, the sample size should be approximately fifty seven. It was then decided to select an equal and appropriate number of responses from each of the identified dimensions. It was decided that the highest loading values on the negative and positive axis would be accounted for. The minimum acceptable loading value for a response was set at 0.7. This created problems since for the third, fourth and fifth dimensions, the loading values were much lower than 0.7. The acceptable threshold was then lowered to 0.5. In Appendix C it is evident that the loading values for the fourth and fifth are lower than 0.5. The five highest loading values for the fifth dimension range between -0.521 and -0.318 on the negative axis and between 0.453 and 0.29 on the positive axis. Beyond this the loading values have a dramatic drop much below the acceptable loading values. It was then decided to consider five responses each on the negative and positive axis for each dimension.

By considering ten responses for each dimension, the sample size for this study is fifty. This is close to the fifty seven which Green (1991) proposes. There are three

responses which have similar loading values on two dimensions, hence there were forty seven responses used in the study.

#### 4.3 Rating of Responses

Each subject in this phase was given a list of forty seven responses. The subjects were asked to rate these responses on a scale of one to seven. Five such scales were used to identify the association of responses with the identified dimensions (Appendix G-I to Appendix G-V). The responses used in this stage (Appendix H) were surveillance and auditing findings. The five highest loading values on both the positive and negative scale for each dimension (Appendix C) were included in the response set. The higher the negative or positive value of a loading for a response on a dimension, the more strongly this dimension is associated with the response (Appendix F).

#### 4.4 Participants

All the participants were personnel from the quality assurance department of our industry partner. There were fifteen participants in this study. There were five technical auditors, five internal auditors, and five quality assurance representatives from the surveillance department.

#### 4.5 Task

Each participant was given a set of forty seven responses on a word document (Appendix G-I to Appendix G-V). They were then asked to indicate on a scale of one to



seven, the association of these responses with each of the five dimensions identified. There were five rating tasks, one for each identified dimension.

#### 4.6 Apparatus and Settings

The rating study was conducted at the industry partner headquarters in Memphis, Tennessee, and aircraft vendor locations at Greensboro, North Carolina, and Mobile, Alabama. A word document was provided to each participant for each of the five rating schemes.

#### 4.7 Procedure

Participants were invited to participate in the rating of responses study through phone calls. An Informational Letter was presented to the participants (Appendix G-VI). The instructions for the study are documented in this letter. The instructions were read aloud to the participants. The participants were allowed to ask questions regarding the study, and only when each participant knew exactly what needed to be done, did they proceed with the study.

The average rating of the responses presented to the quality assurance personnel are in Appendix I-I through Appendix I-IV. The loading values from MDS associated with the selected responses for the study is in Appendix I-V.

#### 4.8 Results for regression analysis

The results were interpreted in two stages. In the first stage the data was analyzed for the study as it happened, i.e. for the common pool of participants from the quality

assurance department. In the second stage the dimensions were verified for individual work function participants. This was done to make concrete sense of identified dimensions.

There were three statistical estimates used to interpret the results. These were the p-value (p), regression coefficient (R-sq.), and the un-standardized coefficients (B). The un-standardized coefficients of the regression analysis are the most important estimate indicating the similarity or dissimilarity of identified dimensions.

In the initial stages, qualitative aircraft maintenance data was used to identify performance measures (dimensions for MDS) indicating the safety of an aircraft. There were five dimensions which were identified. These dimensions were interpreted as safety, regulatory compliance, procedures and paperwork inadequacy, operations, and housekeeping and storage.

In the next stage linear regression was used to verify the association between the identified dimensions from MDS and how the quality assurance personnel interpret these as performance measures to quantify qualitative aircraft maintenance data. The loading values of the dimensions from MDS are the independent variables for this study, while the rating value obtained for each open ended response is the dependent variable.

Safety, regulatory compliance, procedures and paperwork inadequacy, operations, and housekeeping and storage are referred to as dimension 1 through dimension 5, respectively.

#### 4.9 Regression analysis for quality assurance personnel

For safety (rating associated with dimension 1), the p-value is 0.012. This is significant. The R-sq. is 0.29. The B value for procedures and paperwork inadequacy (loading on dimension 3 from MDS) is -2.79. What this signifies is that dimension 1 and dimension 3 are opposite to each other.

At this point it is critical to explain the significance of the statement that dimension 1 and dimension 3 are opposite to each other. In the context stated above, the participants felt that certain responses can be explained more in the context of 'safety' (dimension 1), and have less to do with 'procedures and paperwork inadequacy' (dimension 3). A B value of negative also indicates the fact that dimension 1 and dimension 3 are perceived to be different.

This can further be interpreted as follows: as the loading on dimension 3 (procedures and paperwork inadequacy) is increased by one unit, the inferred rating for dimension 1 (safety, which is the predicted variable or the dependent variable) goes down by -2.79 units.

The p-value for regulatory compliance (rating associated with dimension 2) is insignificant at 0.156. The R-sq. is 0.172. None of the B values are interpreted to anything of significance.

For procedures and paperwork inadequacy (rating associated with dimension 3), the p-value is 0.002, which is very significant. The R-sq. is 0.364. The B value for dimension 3 is 2.072, which interprets to the fact that dimension 3 was found to be significant and meaningful to the quality assurance personnel. For each unit increase in

the loading on dimension 3, the inferred increase in the rating goes up by 2.072 units for procedures and paperwork inadequacy.

The p-value for operations (rating associated with dimension 4) is 0.607, which is not significant. The R-sq. is 0.081. None of the B values are significant. The B value for dimension 5 is -1.004, indicating that the participants did interpret dimension 4 and dimension 5 as opposite measures of quantitative maintenance data. This can be interpreted further: for each unit increase of loading on dimension 5 (housekeeping and storage), the inferred rating goes down by -1.004 units on dimension 4 (operations).

The p-value for housekeeping and storage (rating associated with dimension 5) is 0.23, which is not significant. The R-sq. is 0.15. The B value for operations (dimension 4) is -2.396, indicating that the participants found dimension 4 and dimension 5 to be opposite to each other. Further, for each unit increase in the loading values for dimension 4, the inferred rating on housekeeping and storage (dimension 5) goes down by -2.396 units.

#### 4.10 Regression analysis for Internal audits personnel

The p-value for safety (rating associated with dimension 1) is 0.009, which is significant. The R-sq. is 0.302. The B value for dimension 3 is -2.929, indicating that the internal audit personnel interpret dimensions 1 and 3 to be opposite to each other. For each unit increase in the loading for dimension 3 (procedures and paperwork inadequacy), the inferred rating value for safety (dimension 1) goes down by 2.929 units. The B value for dimension 3 has increased compared to the observed B value for dimension 3 when the participant data was pooled together, indicating that internal audit

personnel interpret dimension 1 and 3 to be opposite to each other more significantly than what was indicated in the pooled data set.

The p-value for regulatory compliance (rating associated with dimension 2) is insignificant with a value of 0.262. The R-sq. is 0.142. None of the B values are of any significance.

The p-value for procedures and paperwork inadequacy (rating associated with dimension 3) is significant at zero ( $0 < 0.05$ , where alpha is 0.05). The R-sq. is high at 0.53. The B value for dimension 3 is very high at 3.762, indicating that the internal audit personnel found dimension 3 indicative of procedures and paperwork inadequacy. For each unit increase in the loadings for dimension 3 (procedures and paperwork inadequacy), the inferred increase in the rating for procedures and paperwork inadequacy (dimension 3) is 3.762 units. The B value for dimension 3 increases compared to the observed B value for dimension 3 for the analysis of pooled data for quality assurance personnel.

The p-value for operations (rating associated with dimension 4) is insignificant at 0.142. The R-sq. is 0.177. None of the B values indicate anything significant.

The p-value for housekeeping and storage (rating associated with dimension 5) is insignificant at 0.211. The R-sq. is 0.155. The B value for dimension 4 is -3.108, indicating that internal audits personnel observed dimension 4 and dimension 5 to be significantly different. Further, for each unit increase in the loading for dimension 4, the inferred decrease in the rating value is 3.108 units. The B value for dimension 4 indicates that internal audits personnel find dimension 4 and 5 to be different with a higher degree of certainty than the quality assurance personnel.

#### 4.11 Regression analysis for Surveillance personnel

The p-value for safety (rating associated with dimension 1) is significant at 0.04. The R-sq. is 0.24. The B value for dimension 3 is -2.816, which is marginally higher than that observed for the data associated with the quality assurance personnel, but lower than what was observed for the internal audits personnel. The B value for dimension 3 indicates that the surveillance personnel observe dimension 1 and 3 to be opposite indicators of qualitative aircraft maintenance data. Further, for each unit increase in the loading value for dimension 3 (procedures and paperwork inadequacy), the decrease in the inferred rating for safety (dimension 1) is by 2.816 units.

The p-value for regulatory compliance (rating associated with dimension 2) is insignificant at 0.163. The R-sq. is 0.169. None of the B values indicate anything significant.

The p-value for procedures and paperwork inadequacy (rating associated with dimension 3) is significant at 0.047. The R-sq. is 0.232. The B value for dimension 3 is 1.444, which is less significant than that for the internal audits personnel. For a unit increase in the loading value for dimension 3 (procedures and paperwork inadequacy), the inferred increase in the rating for procedures and paperwork inadequacy is by 1.444 units.

The p-value for operations (rating associated with dimension 4) is insignificant at 0.329. The R-sq. is 0.127. The B value for dimension 4 (operations) is 1.383, indicating that surveillance personnel observed dimension 4 to be a true indicator of operations as a performance measure of qualitative aircraft maintenance data. For each unit increase in

the loading value for dimension 4 (operations), the inferred increase in the rating for dimension 4 (operations) is 1.383 units.

The p-value for housekeeping and storage (rating associated with dimension 5) is significant at 0.04. The R-sq. is 0.24. The B value for dimension 4 is -1.030, indicating that the surveillance personnel observed dimensions 4 and 5 to be opposite to each other. For each unit increase in the loadings for dimension 4 (operations), the inferred decrease in the rating for housekeeping and storage (dimension 5) is by 1.03 units.

#### 4.12 Regression analysis for Technical audits personnel

The p-value for safety (rating associated with dimension 1) is significant at 0.027. The R-sq. is 0.258. The B value for dimension 3 (procedures and paperwork inadequacy) is -2.573, indicating that the technical audits personnel observed dimension 1 and 3 to be opposite to each other. For each unit increase in the loading for dimension 3 (procedures and paperwork inadequacy), the inferred decrease in the rating for safety (dimension 1) is by -2.573 units. The B value for dimension 4 is 2.385, indicating that the technical audits personnel observed dimensions 3 and 4 to be significantly opposite to each other. For each unit increase in the loading value for dimension 4 (operations), the inferred increase in the rating for safety (dimension 1) is by 2.385 units.

The p-value for regulatory compliance (rating associated with dimension 2) is insignificant at 0.267. The R-sq. is 0.14. None of the B values indicate anything of significance.

The p-value for procedures and paperwork inadequacy (rating associated with dimension 3) is insignificant at 0.587. The R-sq. is 0.084. The B values for dimensions 4

and 5 are -0.735 and 1.697, indicating that these two dimensions are observed to be opposite to each other. For each unit increase in loading for dimension 4 (operations) the inferred decrease in rating for procedures and paperwork inadequacy (dimension 3) is by 0.735 units. For each unit increase in the loading for dimension 5 (housekeeping and storage), the inferred increase in the rating for procedures and paperwork inadequacy (dimension 3) is by 1.697 units.

The p-value for operations (rating associated with dimension 4) is insignificant at 0.307. The R-sq. is 0.132. The B value for dimension 4 (operations) is 1.007, indicating that this dimension is an indicator of the performance measure, operations, which is the identified dimension 4 in this case. Each unit increase in the loading values for operations (dimension 4), has an inferred increase on the rating for operations (dimension 4) by 1.007 units.

The p-value for housekeeping and storage (rating associated with dimension 5) is insignificant at 0.069. The R-sq. is 0.214. The B value for dimension 4 (operations) is -4.175, indicating that dimension 4 and 5 are observed to be opposite to each other by the technical audits personnel. For each unit increase in the loading for dimension 4 (operations), the inferred decrease in the rating for housekeeping and storage (dimension 5) is by 4.175 units.

#### 4.13 Discussion

Results confirm that dimensions 1 (safety), 3 (procedures / paperwork inadequacy), 4 (operations), and 5 (house-keeping and storage) are inferred by various



work function groups to be valid. Dimension 2 (regulatory compliance) surprisingly did not have significant p-values for any group.

Based on the loading values for five dimensions it is concluded that Regulatory Compliance (dimension 2) was better discriminated between items (open ended qualitative maintenance data). This is explained further. Dimension 2 was more conclusive a dimension to explain the impact on aircraft safety, than were dimensions 3, 4, and 5. Within the inductive approach of MDS, dimension 2 meant something to the quality assurance representatives and auditors. They were able to discriminate between items on dimension 2.

The R-sq. describes the sample size effect and not the population effect. The effect sizes (R-sq. values) for this study were low. The B-values for this study were promising.

Thus, taking the loading values from MDS and linear regression analysis results into account, it is concluded that the five identified dimensions are interpreted to be useful and meaningful by the quality assurance personnel.

## CHAPTER 5

### PARTICIPATORY DESIGN FOR ORGANIZATIONAL CATEGORIES

A requirement of WebSAT is that it transform the open-ended responses associated with reject and 'No' into categories of system cost at the managerial level. No such categories currently exist for the quality assurance department. However, the managers of the quality assurance department have suggested that categories such as Human Factors, Economics, and Quality might be appropriate to describe cost implications at the managerial level. The research, then, proposes to present open-ended responses to managers in the Quality Assurance department and apply the strategy of Participatory Design to conduct a study with the managers to finalize a new set of managerial-level categories (Organizational Categories).

#### 5.1 Participatory Design

Participatory design is a design strategy to include designers and users in a multidisciplinary team to allow a verbal exchange of ideas through semi-structured interviews to gather information from respondents. It is critical for the researcher to derive objective inferences from these sessions. The experiences of the users and their interests in the design outcome improve the work life of the users through collaborative development.

In this phase of the research, participatory design methodology will be utilized to establish Organizational Categories to categorize audit and surveillance findings.

## 5.2 Participants

Three participants from the quality assurance department were asked to participate in this study. One manager from the surveillance department and one manager each from the technical and internal audits department were a part of this study.

## 5.3 Setting

The participatory design study was conducted at the industry partner headquarters in Memphis, Tennessee. The researcher had a list of questions which were the basis for a semi-structured interview.

## 5.4 Procedure

The participants were asked for their consent to participate in the study prior to the start of the study (Appendix G-VII). The managers were presented with two alternative categorization schemes which the research team had developed through interactions, interviews and studies conducted with the quality assurance personnel. The first set of categories includes performance metrics such as Human Factors, Quality, and Economic, which the managers had mentioned. The second set of categories was developed on the basis of a card sorting study with auditors and quality assurance representatives. The results of this study revealed only one relevant dimension, at three levels. The auditors and quality assurance representatives understood the relevance of organizational categories, but indicated that they think of organizational categories with respect to cost only. Hence the only dimension which was uncovered was cost, at the three levels of low, medium, and high.

A series of questions were asked (Appendix G-VIII) which allowed the end users of the product to be a part of the final decision making process.

### 5.5 Problem statement description

The stakeholders of the project required the qualitative maintenance data to be interpreted to indicate the implications of aircraft maintenance findings on the organization. WebSAT will collect and analyze data associated with aircraft maintenance. The departments associated with aircraft maintenance are surveillance, technical audits and internal audits. None of these departments have any kind of performance measures to indicate the implications of aircraft maintenance findings at an organizational level. The purpose of this research is to establish performance measures associated with the impact of aircraft maintenance findings on the organization.

### 5.6 Data collection process

The process of Participatory Design to identify the performance measures depends on interview data gathered from managers associated with the departments of surveillance, technical audits and internal audits. This data illustrates the understanding and interpretations of managers who directly influence the organizational level decision making process associated with aircraft maintenance findings.

The interviews were conducted with the managers of the quality assurance department to understand the expectations of the managers regarding performance measures at an organizational level. The number of managers interviewed was small, just three. One manager from each department took part in the study.

The interview was documented by the interviewer so that it could be reviewed at a later stage before the performance measures for organizational categories were finalized. The documented notes from the interviews reflect an iterative decision-making process where the managers helped the interviewer reach a final decision. The advantage of this study was the interaction with managers who were the primary stakeholders of this aspect of the project. A previous study with the auditors and quality assurance representatives to finalize performance measures for organizational categories did not work out. The study involved quality assurance representatives and auditors. The participants were given the task of categorizing maintenance findings into clusters of similar responses. Each cluster was associated with a category implying the impact of maintenance findings on the organization. The failure is attributed to the fact that the auditors and the quality assurance representatives were a non-representative group to uncover meaningful organizational categories.

### 5.7 Semi-structured interviews

A questions checklist (Appendix G-VIII) was used to help the interviewer conduct the semi-structured interview. The checklist questions were developed based on experience in user centered design and understanding of the problem at hand to finalize performance measures for organizational categories. The series of questions were aspects which needed to be discussed with the managers to understand their interpretation of the performance measures. Each question prompted comments from the managers, which furthered the discussion. The rich information this produced was valuable for the study and the researcher. It helped reach a final decision on organizational categories which

would be used to indicate the implications of surveillance and audit findings at an organizational level.

The interviews were conducted using the same questions checklist for each manager. This allowed consistency across the managers interviewed but did not impose a structure on the responses of managers. The responses were spontaneous and unbounded. This approach generated rich and valuable information about the personal perceptions of the managers. The advantage of such an approach was that the managers were interviewed separately and hence they had the advantage to put across their ideas individually, without the influence of the other participants.

Each response was an idea which helped reach a final decision on an attribute of the product.

#### 5.8 Interview data

Each interview varied in length and took 1-1.5 hours to complete. The interviews were scripted into a text document. The researcher made several inferences based on the data which was generated. The researcher read the data several times to become familiar with the interview data. This helped the researcher identify the significant factors in determining the performance measures.

#### 5.9 Interview with the Internal audits manager

The manager of the internal audits department was reminded of categories such as Human Factors, Economic, and Quality which were recommended to the product development team by the quality assurance managers as appropriate categories to indicate

the impact of surveillance and audit findings at an organizational level. The manager responded by saying that these categories were considered as a good starting point to finalize worthwhile and meaningful organizational categories. These categories were recommended to the product development team, of which the researcher is a member, in the initial stages of the project. The manager felt that now these categories appeared vague to him. He mentioned that during the initial stages of the project these categories might have been mentioned to motivate the quality assurance department and the product development team to research the aspect of organizational impact associated with surveillance and audit findings. The manager felt now the mentioned categories did not make much sense to him and he offered his reasons.

According to the manager Human Factors, Economic, and Quality are very broad categories. The manager expressed his uncertainty about having any of these categories as established categories for organizational categories. According to the manager there are two major concerns regarding the mentioned categories. Firstly, each category appears to require sub-categories to make some concrete sense out of their implications. Secondly, the manager mentioned that categories such as Economic and Quality work two ways. They could either imply a root cause category indicating what caused an audit finding, or they could be used to imply the consequence of the audit finding at an organizational level. He said that this would create more uncertainty in the minds of the auditors while documenting audit findings and categorizing an appropriate organizational category associated with the audit finding.

The manager expressed additional concerns. He said that Human Factors is a gigantic category which will create more problems in the mind of the auditor, than help resolve anything.

The organizational category was referred to by the manager as consequences after a condition is found in an audit. The manager informed the interviewer about the risk management matrix used by the internal audit management group (Figure 2).

				<b>A</b>	<b>Catastrophic</b>	<b>Severity</b>	Accident / Incident / Declared Emergency	Death or Hospitalization	Hull Loss or \$ 1 million loss
		High Risk		<b>B</b>	<b>Critical</b>		Violations of Rules or Regulation / Unsafe Deviation	Medical treatment required	More than \$ 100,000 loss
				<b>C</b>	<b>Marginal</b>		Poor Performance / Schedule disruption / Deviation within safe limits	First aid required	More than \$ 50,000 loss
			Low Risk	<b>D</b>	<b>Minor</b>		Minimal System Consequence	No injury sustained	Less than \$ 50,000 loss
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>			<b>Performance</b>	<b>People</b>	<b>Machine</b>
<b>Probability</b>									
	Constantly Experienced	Likely to occur in the next quarter	Likely to occur in the next year	Unlikely to occur in the next five years	<b>Occurrence</b>				
	More than 1 in 5,000 cycles	More than 1 in 60,000 cycles	More than 1 in 250,000 cycles	Less than 1 in 1,000,000 cycles	<b>Rate</b>				
	<b>Continuous</b>	<b>Frequent</b>	<b>Occasional</b>	<b>Remote</b>					

Figure 2. Risk Management Matrix used by the Internal Audits department



The Risk Management Matrix consists of four severity categories and four likelihood categories or probabilities. Each audit finding is associated with a risk level depending on the severity of the finding, and the likelihood associated with the occurrence of the finding. The management currently uses this matrix to indicate a 'risk' associated with an audit finding. The combination of a severity and the probability of occurrence help the management identify the risk level of an audit finding. Further, each severity is associated with three factors which help define the extent of the problem. The three factors are performance, people, and machine.

The 'performance' associated with each severity defines the typical situation which may arise due to an audit finding (Figure 2). For example, a 'minor' severity occurs when the audit finding has a minimal system consequence.

The risk management matrix also has a factor termed 'people' which is associated with the severity (Figure 2). This helps the auditor or the manager identify the risk to people when the audit finding occurs. For example, if personnel required first aid due to an injury, the severity associated would be 'marginal'.

The third factor is 'machine'. This indicates the dollar value assigned to the loss sustained by the organization due to an audit finding (Figure 2). A 'critical' severity is associated with an audit finding that accounted for losses worth more than \$100,000.

The Risk Management Matrix (RMM) has definitions for the probability in terms of 'occurrence' and 'rate' (Figure 2).

The manager said that the internal auditors have been using the RMM for a while now and the strategy is working for their department to identify the 'risk' associated with audit findings at an organizational level.

The manager informed the interviewer that an internal auditor should indicate the risk associated with audit findings. The manager should be able to edit the auditors' classification of risk associated with audit findings.

The manager felt that a 'hovering matrix' should be used to associate a risk with an audit finding in the web application (WebSAT). The manager explained this further: a template of this matrix should be shown to the auditor each time a risk associated with a finding needs to be documented, and the auditor would make his selection by clicking on the appropriate grid in the risk management matrix indicating the risk associated with an audit finding.

The interviewer informed the manager about a research study conducted with quality assurance representatives and auditors to identify suitable performance measures for organizational categories. The study indicated that the auditors and quality assurance representatives categorized surveillance and audit findings in terms of high cost, medium cost, low cost, and no impact to indicate implications of audit and surveillance findings at an organizational level.

The manager was not too impressed with the categories and informed the interviewer that he would much rather have the auditors use the RMM.

#### 5.10 Interview with the Technical audits manager

The interviewer informed the manager about two sets of categories which were uncovered by the WebSAT research team. The first set of categories consist of factors such as Human Factors, Quality, and Economic, which were recommended to the product

development team by the quality assurance managers during the initial stages of the project.

The manager was informed that the second set of categories consists of cost at three levels of low, medium, and high. These categories were uncovered during an unsuccessful attempt to research valid performance measures to indicate the organizational impact of surveillance and audit findings. The study was conducted with quality assurance representatives from the surveillance department and auditors from the departments of internal and technical audits. The manager was informed that some auditors and quality assurance representatives categorized some findings as having no impact to the organization.

The manager was not confident about either set of categories and offered his explanation.

The manager indicated that factors such as Human Factors, Quality, and Economic would indicate the 'cause' of a finding. Human factors are a cause and include a variety of factors such as time, errors, equipment failure, avoidance of work, and lack of knowledge or understanding of a process. Inadequate procedures would also be a cause category and would involve findings caused because of lack of procedures.

Quality as a category appeared vague to the manager and he felt it was best if better categories were established.

The interviewer mentioned the card sorting study associated with aircraft maintenance categories which were carried out with auditors and quality assurance representatives. The manager asked the question as to why so much weight was being thrown on what the auditors have to say about organizational categories. He mentioned

that the auditors are employed to conduct audits and the quality assurance representatives are employed to conduct surveillance on vendor locations during aircraft maintenance processes. Something as complicated as organizational categories is the job of the managers and the higher management to conceptualize and finalize. The manager was not surprised about the inadequacy of the second set of categories (low cost, medium cost, high cost, and no impact).

The interviewer inquired about the potential categories the technical audits manager would want the design team to incorporate. The manager said the implications at an organizational level would include factors such as Safety and Economic. Economic would be at four levels: low, medium, high, and no impact. The manager expressed the need to have a dollar value associated with the levels of the category of Economic, but also informed the interviewer that this was difficult since the dollar value associated with findings are subjective. The manager felt that the four levels of low, medium, high, and no impact was a good start. The manager mentioned that Economic is a very general category because every maintenance finding is either associated with cost or injury, and thus ultimately it is either related to Economical or Safety. He explained further by stating that: "You either crash an airplane or go out of business. It is very difficult to assign a dollar value for a finding".

At this time the interviewer sensed a similarity between the requirements of the manager and the risk management matrix recommended by the manager of the internal audits department. The technical audits department manager was shown the risk management matrix. The manager was impressed and commented that "this is something which we could also use".

The internal audit RMM seemed a good starting point to the manager. He said that the technical audit department may make changes to this matrix as time goes by, depending on peculiar situations specific to the technical audits department.

The manager reiterated the point that they are responsible to set standards to decide what to measure, how to measure, and then analyze the associated data.

### 5.11 Interview with the Surveillance manager

The interviewer reminded the manager of categories such as Human Factors, Quality, and Economic.

The manager was not too keen on these categories anymore. The manager derived an analogy about what ISO standards help achieve, which is quality and oversight of processes. The common denominator according to him was 'risk'. He mentioned how everything in the industry is risk based. The manager mentioned that if risk is determined and evaluated properly, then risk indicates what needs to be done.

The manager mentioned that he wanted to remove subjectivity from the minds of quality assurance representatives regarding the risk level associated with a surveillance finding. This immediately made him mistrust the categories such as low cost, medium cost, high cost, and no impact.

The manager wanted choices to be hard coded for the quality assurance representatives. Yet the manager expressed the need to have the flexibility to tweak the risk level choices of the quality assurance representatives based on his interpretation. The manager stressed the fact that he struggles with the subjectivity of the interpretations of the quality assurance representatives the most.

The manager mentioned that he did not have a starting point for risk levels to indicate the impact of a surveillance finding at an organizational level.

Based on the interviewer's understanding of the problem at hand, the internal audit RMM was recommended to the manager who agreed and said that it was a good starting point. The manager was informed about the acceptance of the RMM as a solution by the manager of the technical audits department. The manager was hopeful that a common approach to resolve the issue would allow the managers to understand problems across the organization, and not be focused on their department alone.

#### 5.12 Discussion

Based on information provided on the RMM by the Internal audits manager, and the subsequent agreement of managers of the Technical audits and Surveillance departments, it was decided that the Risk Management Matrix would be used to classify surveillance and audit findings in terms of implication of a maintenance finding at an organizational level. The RMM allows internal auditors and their manager to classify an audit finding in terms of 'risk', which is associated with a severity of the finding and a probability associated with the occurrence of the finding.

## CHAPTER 6

### RESEARCH HYPOTHESES

#### 6.1 Research Hypothesis 1

The dependent variable for the proposed research was a prediction score. The prediction score is defined as the ability of a quality assurance representative performing surveillance to correctly categorize open-ended responses entered in WebSAT by another quality assurance representative. The open ended responses with the highest coefficients of regression with an associated dimension are considered to be the correct answers. Numerically it is measured as a ratio of the number of correct categorizations reported by the user to the total number of responses the user is asked to categorize.

The research question addressed by this proposed study investigates if data reduction using MDS has an effect on the prediction scores of a quality assurance representative (QAR) (2) generated through evaluation of the open-ended responses documented by QAR (1) in WebSAT during surveillance. Specifically, it considers the hypotheses below:

Null hypothesis: The data reduction technique has no effect on the prediction scores of QAR (2).

Alternate hypothesis: The data reduction technique has an effect on the prediction scores of QAR (2).

For this investigation, the independent variable is the data reduction technique at two levels, with and without its use. The dependent variables are the QAR (2) prediction scores.

A t-test was conducted to test the statistical difference between the prediction scores of the two groups. Analyzing the data of two groups of QARs who independently interpreted the open-ended responses documented by QAR (1) will indicate if the QARs (2) interpreted the open-ended responses better with or without the data reduction technique. The assumption is that the prediction scores of the group with the information provided on aircraft level impact categories will have higher and statistically significant scores when compared to the group without any information provided on aircraft level impact categories.

The t-test assesses whether the mean of the prediction scores of the two groups are statistically different from each other (Tabachnick, and Fidell, 2001). The two groups for this study are information group (data reduction technique available) and no information group (data reduction technique not available).

## 6.2 Research Hypothesis 2

The dependent variable for this study is a measure of reliability of allocation of responses within the cells of the risk matrix. The reliability of allocation is associated with co-occurrence of responses within a specific cell of the risk matrix (Figure 2). The participants will be asked to categorize a set of open-ended responses into categories of organizational costs, also referred to as Organizational Categories.



The research question investigates if a given set of performance measures known as Organizational Categories has an effect on the reliability of allocation of responses within the cells of the risk matrix, based on open-ended responses entered in WebSAT by a QAR or an auditor. Specifically, it considers the two hypotheses below:

Null Hypothesis I: There is no difference in the allocation of responses in the cells within the risk matrix for participants without information when compared to random allocations.

Alternate Hypothesis I: The pattern of responses of the group without information differs from that of random allocation.

Null Hypothesis II: There is no difference in the allocation of responses in the cells within the risk matrix for participants with information when compared to random allocations.

Alternate Hypothesis II: The pattern of responses of the group with information differs from that of random allocation.

The assumption is that the no information group will use random sampling, while the information group has a greater tendency to not be random.

For this investigation the independent variable is the availability of performance metrics for organizational categories at two levels, available (for the information group) and not available (for the no information group), while the dependent variable is a measure of reliability of allocation.

Pearson's chi-square test ( $\chi^2$ ) is one of a variety of chi-square tests - procedures, whose results are evaluated by reference to the chi-square distribution. It tests the null

hypothesis based on the relative frequencies of occurrence of events. The events are assumed to be independent and the outcome of each event is considered to be mutually exclusive. An example to explain this is that the ordinary six-sided die is 'fair', i.e. each outcome is equally likely.

Chi-square is calculated by finding the difference between each observed and theoretical (expected) frequency for each possible outcome, squaring them, dividing each by the theoretical frequency, and taking the sum of the results:

$$\chi^2 = \sum_{i=1}^n \frac{(O_i - E_i)^2}{E_i}$$

where:

$O_i$  = an observed frequency

$E_i$  = an expected (theoretical) frequency, asserted by the null hypothesis.

When the data consists of frequencies in discrete categories, the  $\chi^2$  test may be used to determine the significance of differences between two independent groups (Siegel, 1956).

## CHAPTER 7

### EVALUATION OF CATEGORIZATION SCHEMES

The formal hypothesis states that the use of categorization schemes will provide utility to the stakeholders. Specifically, the documentation of audit and surveillance findings can be done effectively by auditors and quality assurance representatives because of established performance measures of aircraft level impact. The managers can identify the implications of the audit and surveillance findings for the organization reliably because of established performance measures referred to as Organizational Categories.

#### 7.1 Participants

Forty students were selected from a variety of academic disciplines to participate in this study. All the participants were graduate and undergraduate students at Clemson University. Each participant was presented with a consent form (Appendix J). Each participant was contacted via e-mail (Appendix K)

#### 7.2 Experimental Design

A between subjects experimental design was used to evaluate the performance of participants using the categorization schemes. Two groups of twenty participants each performed two different tasks, with each type of task done only once. Thus, a participant performed a total of two tasks during their participation in this study.

Group 1 first performed the task of categorizing surveillance and audit findings into performance measures indicating organizational impact (Organizational Categories). This group had the benefit of categorizing the responses on performance measures which were provided to them. The participants in Group 1 were provided with information associated with severity and probability in the RMM (Appendix L-I). Group 2 was asked to categorize the same findings into performance measures of their own choice. The participants in Group 2 were told that the RMM consisted of sixteen cells, each associated with a probability and a severity. The four probabilities and the four severities were mentioned to the participants and the risk associated with each cell in the risk management matrix was indicated to the participants (Appendix L-II). There was no other information provided to the participants.

In the second task, surveillance and audit findings were categorized by the same participants in Group 2 into performance measures indicating aircraft level impact. The participants in Group 2 had the benefit of categorizing the findings into established performance measures. The participants in Group 1 were asked to categorize surveillance and audit findings into performance measures of their own choice. The participants were told that they could categorize the information into a maximum of five measures, but no further information on the established performance measures was given to the participants in Group 1.

Linear regression was used to identify which items (open ended maintenance findings) had the closest association with dimensions. The assumption is that the empirically established responses of performance measures from the linear regression study are the correct answers for measures indicating aircraft level impact. The highest

regression coefficient for each response for an associated dimension (which indicates a category or a performance measure) will be considered as the correct response. Any deviation from the established performance measure will be an incorrect categorization. In the case of the participants without information, the following example will explain what a correct categorization is. The two responses with the highest loading values on each of the five dimensions (from the MDS study) were selected for this study. If response 1 and response 2 have the highest loading values associated with dimension 4, and a participant categorizes these two responses under the same performance measure (dimension), the categorization is correct. For the participants with information on performance measures, if dimension 4 is Operations and a participant categorizes response 1 and 2 under Operations, then the categorization is correct.

The researcher timed the participants in the first task to establish their information processing times. The co-occurrence of responses within a cell of the RMM was a measure of the reliability of the allocation of responses within the risk matrix. If three participants categorize response 1 in a particular cell, then the co-occurrence of response 1 within this cell is 2. For the second hypothesis the researcher is interested in the reliability of the allocation of responses within the risk matrix.

### 7.3 Apparatus and Settings

The study was conducted in the Human Computer Systems Laboratory at Freeman Hall, Clemson University. The participants were provided with a word document with audit and surveillance findings printed on them (Appendix L-III and Appendix L-IV). The participants were required to categorize surveillance and audit

findings into a performance measure. For the first task a stop watch was used to record the time required by the participants to complete the task. The task for research hypothesis 1 used ten responses. The items with the highest loadings best define and represent a dimension. Hence the items with the highest loading values were used for this study. The study for research hypothesis 2 used forty seven responses based on the recommendation of Fisher's exact probability test for a table of frequency data (Siegel, 1956). The recommended requirement for each cell is three responses. There are sixteen cells in the risk matrix. This meant that there were forty eight required responses. The linear regression study was based on forty seven responses, and the same responses were used for this study.

#### 7.4 Independent Variables

For the first task the independent variable is the availability of information on performance measures for Organizational Categories at two levels, available and not available. For the second task the independent variable is the data reduction technique at two levels, with and without its use.

#### 7.5 Dependent Variables

The dependent variable for the first task is the frequency of co-occurrence of responses within a cell of the RMM, a measure of reliability. The dependent variable for the second task is a score for each participant.

### 7.6 Procedure

The participants were asked for their consent to participate in the study prior to the start of the study. Task instructions were read to the participants, as well as given to them on a sheet of paper. The participants were reminded that the task was self paced. When the participants completed the first task, they were given a break of a maximum of 30 minutes, before proceeding with the second task.

### 7.7 Conditions for Research Hypothesis I

The data analysis for Research Hypothesis I was conducted in two stages. In the first stage the acceptance criterion of an open ended response as a correct allocation was not strict. The following example demonstrates the acceptance of a correct documentation which does not account for strict acceptance criteria for correct allocations.

Each participant was given ten responses. Each response had an assigned impact category (or dimension) based on the highest loading values associated with each of these responses. If category 1 was associated with response 3 and 4, and a participant made allocations of response 1, 3, and 4 in category 1, the participant was given a score of two based on the assumption that there were two correct allocations.

In the second stage the acceptance of correct allocations was tightened to restrict random allocations. In the above mentioned example the number of correct allocations of the participant would be zero. The assumption now to restrict random allocations states that the correct allocation under category 1 is response 3 and 4, only. If an allocation of response 3 was made for category 1, it would be considered an incorrect allocation because response 4 was not allocated to the same category.

### 7.8 Results for Research Hypothesis I for Stage 1

The prediction scores for Group 1 and Group 2 are indicated in Appendix M-I. The mean prediction score for Group 1 (without the data reduction technique) was 0.59 (Appendix M-I). The mean prediction score for Group 2 (with the data reduction technique) was 0.63 (Appendix M-I). The t-test value was -0.602 (Appendix M-II). The p-value for a two-tailed test was 0.551 (Appendix M-II), assuming the variances were equal. The assumption of the alternate research hypothesis I stated that the prediction scores for Group 2 would be higher compared to the prediction scores for Group 1. Hence, Research Hypothesis I is associated with a directional test (also referred to as a one-tailed test). The p-value is  $0.551 / 2 = 0.2755$ . This value is much higher than the alpha value of 0.05. Since,  $p > 0.05$ , we fail to reject the null hypothesis.

### 7.9 Conclusion for Stage 1

The conclusion is that there is not enough evidence to reject the null hypothesis and thus we state that the data reduction technique has no effect on the prediction scores of QAR (2). QAR (2) is the quality assurance representative who categorizes maintenance findings documented by some other quality assurance representative.

### 7.10 Results for Research Hypothesis I for Stage 2

The prediction scores for Group 1 and Group 2 for the second stage are indicated in Appendix M-III. The mean prediction score for Group 1 (without the data reduction technique) was 0.18 (Appendix M-III). The mean prediction score for Group 2 (with the data reduction technique) was 0.33 (Appendix M-III). The t-test value for equal and un-



equal variances was -1.743 (Appendix M-IV). The p-value for a two-tailed test was 0.089 (Appendix M-IV), assuming the variances were equal. For a directional test the p-value was  $0.089 / 2 = 0.0445$ . Since,  $p < 0.05$ , we reject the null hypothesis.

### 7.11 Conclusion for Stage 2

There is enough evidence to reject the null hypothesis and conclude that the mean of the prediction scores of Group 2 (with the data reduction technique) is higher than the mean of prediction scores of Group 1 (without the data reduction technique).

The mean prediction score of Group 1 (no information group) decreased from 0.59 in stage 1 to 0.18 in stage 2. This was a decrease of 69 %. The mean prediction score of Group 2 (information group) decreased from 0.63 in stage 1 to 0.33 in stage 2. This was a decrease of 47 %.

This is evidence of the utility of the aircraft level impact categorization scheme. This utility appears to be present only if incorrect allocations are excluded and the acceptance criterion of correct allocations is tightened. The prediction scores of Group 1 decrease 22 % more than those of Group 2 as the acceptance criterion of correct categorizations is restricted from stage 1 to stage 2.

### 7.12 Criteria for Research Hypothesis II

Each cell within the risk matrix is associated with a co-occurrence frequency. For example, if participants 1, 2, and 3 allocate responses 16, 17, and 20 to a certain cell, the co-occurrence frequency is six. All three participants allocated response 16 to the same cell. Hence the occurrence of response 16 in the cell is 3, but the co-occurrence is 2.

Mathematically, the co-occurrence frequency for any response is the number of participants who allocate that response to a particular cell, minus 1.

Hence,

Co-occurrence of a response = Number of Occurrences of a response in the same cell – 1.

The motive here is to compare the random distribution (inconsistency in allocation) of responses within the cells of the matrix (which is assumed to be the case when participants have no information on organizational categories) against a pattern formed due to consistent and reliable allocations (which is assumed to be the case when participants have information on organizational categories).

Reliability is a measure of consistency of allocation of responses within cells of the RMM. The issue of reliability is absolutely critical. The assumption here is that participants with information on organizational categories will have a consistent pattern of allocation of responses to the cells of the matrix because of their agreement on allocations of responses to specific cells in the matrix.

To study the reliability of allocation of responses within the sixteen cells of the risk matrix the co-occurrence frequency was utilized.

The analysis of data was done in two stages. In the first stage all of the cells of the risk matrix were considered. It was observed that the participants without information allocated a majority of their responses to a particular region of cells within the risk matrix. This bias region was excluded from the analysis in the second stage.

### 7.13 Results for Research Hypothesis II - Stage 1

For the group of participants without information on organizational categories (Appendix N-I) the total number of co-occurrences was 499. There are sixteen cells in the risk matrix, hence the expected value,  $E_i$ , was 31.1875. The expected value is the ratio of the total number of co-occurrences to the number of cells in the risk matrix. The observed frequencies of co-occurrences for each cell are indicated in Appendix N-I. The chi-square value was 270.76.

The chi-square distribution has degrees of freedom,  $df = (r-1)(k-1)$ , where  $r$  = number of rows and  $k$  = number of columns in the risk matrix (Siegel, 1956).

The risk matrix has four columns and four rows. Since the values of  $r$  and  $k$  are both 4, the degrees of freedom associated with the chi square distribution is 9.

For  $df = 9$ , the critical value of chi square is 16.92 for  $\alpha = 0.05$  (Siegel, 1956). The chi-square value for the group without information is 270.76. Hence, the chi-square value is significant. There is enough evidence to reject null hypothesis II.

The following explanation is critical to understand the utility of the expected value and the chi-square value. The expected value for the above scenario is 31.1875, meaning that if the allocation is random, then there should be an equal distribution (with an expected value of 31.1875) of responses across the cells of the matrix. The chi-square value represents the difference between random and reliable allocations. When there is 100 % agreement between participants regarding allocation of responses, then the chi-square value is highest. If the group which does not have any information on organizational categories, makes inconsistent allocations, then the chi-square value will be higher for the group which has information on organizational categories, based on the

assumption that there will be more agreement among participants who have information on organizational categories.

For the group of participants with information on organizational categories (Appendix N-II) the total number of co-occurrences was 491. The expected value,  $E_i$ , was 30.6875. The observed value for each cell is indicated in Appendix N-II. The chi-square value was 173.47. For  $df = 9$ , and  $\alpha = 0.05$ , the critical value of chi-square is 16.92 (Siegel, 1956). The calculated chi-square value is 173.47. Hence, the chi-square value is significant. There is enough evidence to reject null hypothesis II.

The time taken to allocate responses to the cells for the participants without information on organizational categories ranged from 12 minutes, and 14 seconds to 47 minutes, and 46 seconds (Appendix N-III). The mean time required for allocation was 22.15 minutes.

The time taken to allocate responses in the cells for the participants with information on organizational categories ranged from 11 minutes, and 16 seconds to 32 minutes, and 23 seconds. The mean time required for allocation was 19.93 minutes.

#### 7.14 Conclusion for Research Hypothesis II – Stage 1

The assumption was that the group of participants without information on Organizational Categories (referred to as Group 2) would randomly allocate responses into the cells. It was expected that the allocations made by participants with information on Organizational Categories (referred to as Group 1) would exhibit a nonrandom pattern.

The allocation of responses within the cells of the risk matrix (Appendix N-I) indicates that the participants in Group 2 have allocated most of their responses in row C (marginal severity) and column 3 (occasional probability). Referring to the co-occurrence distribution in the risk matrix for participants without information on severity and probability terminology in Appendix N-I, it is evident that the grid column 3 and row C is a bias region for the participants with no information. What seems to have happened is that the participants in both groups have a tendency to allocate responses into the column associated with occasional probability. The participants without information on organizational categories allocated most of the responses into cells associated with marginal severity.

The number of co-occurrences in the bias region is 335. This is 67.13% of the total number of co-occurrences for Group 2.

The number of co-occurrences in the bias region for Group 1 is 282. This is 57.43% of the total number of co-occurrences for Group 1.

It appears that the participants in Group 2 (no information group) are making more allocations within a region in the grid associated with row C (marginal severity) and column 3 (occasional probability). For the second stage of analysis, the co-occurrences associated with these rows and columns will be avoided.

On average, the participants in Group 2 (no information group) took 2.22 more minutes than the participants in Group 1 (information group) to complete their task. Thus, the task completion time was 11.14% longer for the no information group.

No information was provided to Group 2. It might have been expected that this group would make random allocations, but it is not surprising that this group took an

approach where the majority of allocations were made in a bias region of the risk matrix that was associated with marginal severity and occasional probability. At this stage the problem was how to address the biased allocation associated with certain cells. This problem was tackled by removing this bias region from the risk matrix and analyzing the allocations made to the remaining cells. This was done in stage 2.

The key aspect in this research hypothesis is to test the reliability of allocation. This means that a consistent pattern of allocation is expected from the participants, other than a pattern where most allocations are made to a bias region of the risk matrix, because of the lack of information provided to Group 2.

The analysis in stage 2 does not involve the region associated with the occasional probability and marginal severity.

#### 7.15 Results – Stage 2

Appendix N-IV indicates the co-occurrence frequency distribution for Group 2. Appendix N-V indicates the co-occurrence frequency distribution for Group 1. The number of co- occurrences for Group 2 is now 164, and the chi-square value is 185.13. The number of co-occurrences for Group 1 is now 209, and the chi-square value is 198.78.

#### 7.16 Conclusions – Stage 2

The chi-square value for Group 1 (information group) is higher than for Group 2 (no information group), indicating that the participants in Group 1 are not making

inconsistent allocations and are utilizing the information provided to them to make allocations.

The chi-square value decreased from 270.76 to 185.13 for Group 1. This is a decrease of 31.71 %.

The chi-square value increased from 173.47 to 198.78 for Group 2. This is an increase of 14.59 %.

At this stage it is concluded that the chi square values for both groups are high. It remains to be seen if the reliability of allocation between the two groups is different.

#### 7.17 Discussion

There are no criteria to justify what a correct or an incorrect allocation is. In the absence of a criterion to determine a correct or an incorrect allocation, no test of validity can be used. All that is left to test is the reliability of responses across individuals. Hence, reliability is the best measure to test the allocations made by the participants. It is concluded that in the absence of the bias grid where most of the responses are allocated by the participants, the chi square value is higher for the information group.

#### 7.18 Stage 3

It was concluded that the chi square value is higher for the information group, provided the bias region is disregarded. Now the question is if the reliability of allocation for the two groups is significantly different or not.

Another research hypothesis was established for this purpose. The specific hypothesis is stated below:

Null Hypothesis III: There is no difference in agreement of participants' allocations of responses to cells between the information group and the no information group.

Alternate Hypothesis III: There is a difference in the agreement of the participants' allocations of responses between the two groups.

The frequency distribution of co-occurrences for the no information group is assumed to be the base line for this analysis. This group's participants make allocations based on no information. This frequency is assumed to be the expected value for each cell for the information group. The frequency distribution of co-occurrences for the information group was taken to be the observed value.

### 7.19 Results – Stage 3

The chi-square value was calculated to be 122.92. The critical chi-square value for  $df = 9$  and  $\alpha = 0.05$  is 16.92 (Siegel, 1956). Hence, it is concluded that there is enough evidence to reject null hypothesis III.

When cells associated with marginal severity and occasional probability are excluded, there appears to be a difference in the agreement among participants with information and the agreement among participants without information on organizational categories while making allocations of responses to the cells of the risk matrix.

There is a greater tendency for the participants in the no information group to allocate findings in the cells associated with marginal severity. Participants in both groups allocate findings in the column associated with occasional probability. There appears to be a greater tendency for the participants in the information group to use other



cells. The total number of co-occurrences was 499 for the group without information, and 491 for the group with information.

The total numbers of co-occurrences were different for the two groups. A correction factor of 1.02 was applied to increase the values in the frequency distribution for the group with information (Appendix N-VI). The correction factor is defined as the ratio between the numbers of co-occurrences of the group without information and the group with information. Numerically, the correction factor is  $= 499 / 491 = 1.02$ . This correction factor was used to adjust for the differences in numbers of co-occurrences between the two groups.

The fact that the correction factor increases the allocation within cells for the group with information is evident in Appendix N-V. It is suggested that the chi-square value for the hypothesis under consideration will further increase.

The calculated chi-square value now is 126.82. This is an increase of 3.18 % compared to the chi-square value without the correction factor.

### 7.20 Discussion

The group with information better differentiates between cells based on probabilities and severity. The group without information does not discriminate as well between items utilizing probabilities and severity.

It is concluded that providing information to the participants regarding organizational categories allows them to make more reliable allocations of the observed surveillance and audit findings to Organizational Categories. The group without information on organizational categories made most of their allocations in a certain

section of the grid within the risk matrix. This was not surprising because in the absence of any information, the group without information made biased allocations of responses to cells.

The study involved a convenience sample of students, rather than a representative sample of intended users. The researcher did not have access to an organization other than the industry partner for this research. The researcher did not have access to many quality assurance personnel either. The results would have been encouraging with the involvement of intended users. Due to lack of resources such a luxury did not benefit this research.

The study involved forty participants. There were twelve females and twenty eight males. All the twelve female participants were graduate students in the department of Industrial Engineering. There were four male participants who were sophomores. There were fourteen male graduate students from the department of Industrial Engineering. There were two, three, one, one, two, and one male graduate students from the departments of Mechanical Engineering, Electrical Engineering, Civil Engineering, Bio-Engineering, Computer Science, and Material Sciences, respectively, involved in this study.

The students involved in this study had no background in aircraft maintenance technology. The students were unequipped to understand the implications of maintenance findings. The difference in the prediction scores with restricted criterion for task 2 for the two groups was 1.5. Even though the information group performed better than the no information group, the mean prediction score for the information group is low at 3.3.

The p-value was significant for task 2. It is worth mentioning that the researcher was able to demonstrate the utility of the categorization scheme for aircraft level impact with non representative users. The result with representative users is expected to better demonstrate the utility of performance measures for aircraft level impact.

For task 1, both groups allocated majority of the responses within cells associated with occasional probability. This could be attributed to the fact that the students were not representative of the intended user population. Better results are expected with representative users.

The recommended application of a chi square test requires a minimum frequency of five in each cell. There were some cells in task 1 which violated this requirement. Yet, there is utility in the approach adopted in task 1 since the researcher was trying to demonstrate the utility of information to reliably allocate maintenance findings within cells of the RMM.

## CHAPTER 8

### INTERFACE DESIGN AND EVALUATION

Developing an application such as WebSAT requires an understanding of users' work processes. The current work practices for technical audits and internal audits are manual. The internal auditors create checklists on EXCEL spread sheets. The entry of forced responses of either 'Yes' or 'No' are documented on EXCEL based checklists. The technical auditors refer to existing hard copy checklists for audits. The responses to checklist based questions are forced responses which are documented on the checklists by marking out the appropriate forced response. Open ended responses and audit findings are documented against the associated questions on the checklist.

The surveillance department has an existing on-line system where quality assurance representatives document maintenance findings.

The current research involves documentation of audit and surveillance findings at two levels: one, aircraft level impact, and two, organizational categories. Only the quality assurance representatives document surveillance findings in categories similar to aircraft level impact. The quality assurance representatives and managers of the surveillance department were not entirely satisfied with the impact categories they refer to and it was evident during the researcher's interaction with the stakeholders that a revised set of categories was required to categorize findings in terms of aircraft level impact.

### 8.1 Identifying User Needs

The tool will cater to the needs of stakeholders at two levels for associated work functions in the quality assurance department. At the first level the auditors and quality assurance representatives will document audit and surveillance findings in reference to performance measures for aircraft level impact. At the second level the managers, auditors, and quality assurance representatives will document audit and surveillance findings in reference to performance measures for organizational categories. Thus, based on the results of structured and unstructured interviews, focus group sessions, and observing the stakeholders do their task, an initial set of user needs was developed. The user needs involving the research to establish performance measures for aircraft level impact and organizational categories are shown in Table 1. The needs expressed are general in nature, and are a good starting point to develop attributes of the product.

Table 1. Needs Hierarchy

1	The tool	identifies the source of risk factors to the aircraft.
2	The tool	classifies surveillance findings at a managerial level.
3	The tool	classifies the technical audit findings at a managerial level.
4	The tool	indicates the potential risk to the aircraft because of technical audit findings.
5	The tool	allows the internal auditor to view discrepancies which impact the aircraft.
6	The tool	has the ability to report critical findings for internal audits at a managerial level.

Another aspect of user needs identification is developing the relative importance of different needs (Ulrich and Eppinger, 1995). The researcher combined the importance ratings of the product development team, and the managers of the quality assurance department to develop a needs rating list (Table 2).

Table 2. Needs Rating

Need Number	Need	S1	S2	S3	TAM	IAM	SM 1	SM 2	FR
1	The tool identifies the source of risk factors to the aircraft.	5	5	5	NA	NA	5	5	5
2	The tool classifies surveillance findings at a managerial level.	5	5	5	NA	NA	5	5	5
3	The tool presents information which will benefit the quality assurance representatives.	5	5	5	NA	NA	5	5	5
4	The tool classifies the technical audit findings at a managerial level.	5	5	5	5	NA	NA	NA	5
5	The tool indicates the potential risk to the aircraft because of technical audit findings.	5	5	5	5	NA	NA	NA	5
6	The tool recommends information for future technical audits.	4	4	4	5	NA	NA	NA	4.25
7	The tool allows the internal auditor to view discrepancies which impact the aircraft safety.	5	5	5	NA	5	NA	NA	5
8	The tool has the ability to indicate potentially problematic areas in an internal audit.	5	5	5	NA	5	NA	NA	5
9	The tool has the ability to report critical findings for internal audits at a managerial level.	5	5	5	NA	5	NA	NA	5

WebSAT Needs Importance Ratings Survey

1. Need is undesirable. I would not consider a product with this need.
2. Need is not important but I would not mind having it.
3. Need would be nice to have but is not necessary.
4. Need is highly desirable but I would consider a product without it.
5. Need is critical. I would not consider a product without this need.

**NOTE**

S1: Rating of design team member 1

S2: Rating of design team member 2

S3: Rating of design team member 3

TAM: Rating of the technical audits manager

IAM: Rating of the internal audits manager

SM 1: Rating of the first surveillance manager

SM 2: Rating of the second surveillance manager

FR: Final average rating

NA: Not Applicable

8.2 Establishing Target Specifications

Product development teams establish target specifications, which represent precise, measurable details about what the product has to do (Ulrich and Eppinger, 2004).

Table 3 shows the list of target specifications.

Table 3. Target Specifications

Metric Number	Need Numbers	Metric	Units	<u>Value Existing System</u>	<u>Marginally Acceptable Value</u>
1.	1, 4, 5	Time taken to identify and document findings in terms of risk to aircraft.	minutes	2-15 minutes (mean value = 7.25 minutes)	< 2 minutes
2.	2, 3, 6	Time taken to identify and document findings indicating managerial implications.	minutes	1-15 minutes (mean value = 7 minutes)	< 1 minute
3.	1, 4, 5	Ability to identify risk factors.	Binary	No	Yes
4.	2, 3, 6	Ability to classify audit and surveillance findings at a managerial level.	Binary	No	Yes
5.	1,2,3,4,5,6	Ease of use of tool to categorize findings.	Subjective	50	> 50

### 8.3 Interface Design and Development

The decision to develop performance measures for aircraft level impact and organizational categories was made by the researcher to allow the auditors, quality assurance representatives, and managers to better understand the implications of audit and surveillance findings. It was decided that each time an auditor or a quality assurance representative documented 'No' or 'Reject' for an audit or surveillance finding, respectively, they would be expected to make an associated selection from two different lists of performance measures. The first list would consist of a list of performance measures indicating the implication of audit and surveillance findings on the safety of an aircraft. The second list of performance measures indicates the implication of the findings at an organizational level.

### 8.4 Interface Evaluation

The interface evaluation was conducted iteratively to evolve the prototype to enhance the usability of the product. The methodologies of user-centered design (Ulrich and Eppinger, 2004) and usability testing were adopted for this purpose.

### 8.5 Participants

Twenty quality assurance personnel from participated in this study. There were four technical auditors, four internal auditors, seven quality assurance representatives from the surveillance department, a manager each from the technical and internal audit department, and three managers from the surveillance department.



### 8.6 Apparatus and Settings

The study was conducted at our industry partner headquarters in Memphis, Tennessee, and at the aircraft maintenance vendor facility in Greensboro, North Carolina. The study involved participants entering audit and surveillance findings into WebSAT. This was a self paced task. The focus was to facilitate the users to effectively use the tool to categorize maintenance findings for aircraft level impact and organizational categories.

### 8.7 Procedure

The participants were asked for their consent to participate in the study prior to the start of the study (Appendix O-I). A task scenario was presented to the participants who were required to focus on the documentation of audit and surveillance findings. The participants were introduced to the WebSAT system. They were made aware of the fact that the study was meant to evaluate the effectiveness with which the web application allowed them to do their job of documenting findings and that the results from the study and subsequent similar studies would be used to improve the user interface. The participants were asked not to discuss their experiences with their colleagues who may be participating in the study, so as to not bias them. The participants were told that they could ask questions since the purpose of the study was to understand the problems with the interface (Nielsen, 1993). The participants were encouraged to continuously verbalize their thoughts (Lewis, 1982), which would allow the researcher to understand how the participants viewed the system (WebSAT) and also enable the researcher to understand any misconceptions of the users while interacting with the system.

### 8.8 Task

The participants were asked to categorize surveillance and audit findings in terms of aircraft level impact (ALI) and Organization Categories (OC).

### 8.9 Performance Measurement

The task performance measures which were accounted for are:

1. The time the user takes to complete the task to categorize surveillance and audit findings in terms of aircraft level impact, and
2. The time the user takes to complete the task to categorize surveillance and audit findings in terms of organizational categories.

A standardized usability subjective satisfaction survey was conducted using the Software Usability Measurement Inventory (SUMI). SUMI is a method for assessing the quality of use of a software product or prototype, and can assist with the detection of usability flaws before a product is shipped. An After-Scenario Questionnaire (ASQ) was given to the participants at the end of the scenario, to determine the satisfaction of the user while performing the task. The ratings associated with ASQ reflect the satisfaction of stakeholders specifically with aspects of the interface associated with the documentation of findings in terms of aircraft level impact and organizational categories.

The scenarios developed are listed below.

### Surveillance

For a specific Aircraft Tail Number and Work Order number, reject a Work Card, and

- (1) Classify the associated Aircraft Level Impact as Regulatory Compliance

(2) Classify the respective Organizational Category as Medium Risk

#### Technical Audits

For a particular audit on a vendor, a checklist question is associated with a 'no'.

(1) Classify the associated Aircraft Level Impact as Regulatory Compliance

(2) Classify the respective Organizational Category as Medium Risk

#### Internal Audits

For a particular audit on a department, a checklist question is associated with a 'no'.

(1) Classify the associated Aircraft Level Impact as Regulatory Compliance

(2) Classify the respective Organizational Category as Medium Risk

The first scenario helps establish the time taken by the user to identify and document findings in terms of risk to aircraft. The second scenario helps establish the time taken by the user to identify and document findings indicating organizational impact (in terms of Organizational Categories).

The current processes facilitated the quality assurance representatives working for the surveillance department to classify a reject under 'impact' categories. The auditors in the internal audits department used a risk matrix to classify a 'no' to a checklist question to imply an organizational impact.

The benchmarked processes helped establish values for the existing system. Table 4 indicates the time taken to do the above mentioned classifications.

Table 4. Time taken to do tasks

Metric Number	Metric	Units	Internal Audits	Technical Audits	Surveillance
1	Time taken to identify and document findings in terms of risk to aircraft.	minutes	NA	NA	2-15 minutes (mean=7.25 Minutes)
2	Time taken to identify and classify findings in terms of organizational impact.	minutes	1-15 minutes (mean=7 Minutes)	NA	NA

The marginally acceptable and ideal values of WebSAT were established. The marginally acceptable and ideal values are indicated in Table 5.

Table 5. Marginally acceptable and Ideal Values

Metric Number	Metric	Marginally Acceptable Value	Ideal Value
1	Time taken to identify and document findings in terms of risk to aircraft.	< 2 minutes	< 1 minute
2	Time taken to identify and classify findings in terms of organizational impact.	< 2 minutes	< 1 minute

### 8.10 First Iteration

Once the marginally acceptable and ideal values were established for the metrics, and the initial prototype of the internal audit, technical audit, and surveillance modules were ready, user testing was done with users of WebSAT at the headquarters in

Memphis, TN, and vendor locations at Greensboro, NC, and Mobile, AL.

There were twenty participants who were a part of the user testing for the first iteration. There were seven quality assurance representatives: three from the vendor location at Greensboro, NC, and four from the vendor location at Mobile, AL. There were three managers from the surveillance department who were a part of the study at Memphis, TN. The other users were also at Memphis, TN. There were four technical audits auditors, the technical audits manager, four internal audits auditors, and the internal audits manager. An After Scenario Questionnaire (ASQ) was given to each user after the scenario. A Software Usability Measurement Inventory (SUMI) questionnaire was also given to the users to assess the quality of the software (WebSAT).


The path the users had to follow on the web application (WebSAT) to categorize a 'No' or a reject in terms of Aircraft Level Impact (ALI) and Organizational Categories (OC) was the same. The participants were not asked to do the two tasks separately. The product development team felt that this would restrict the participants from doing the second scenario more quickly, since they had seen all the associated screens. The two scenarios were combined and the user was asked to document a 'No' (audit group) or a reject (surveillance group) in terms of an associated ALI and an OC.

The team was allocated an hour and a half with each user. Sixteen scenarios which were given to the audit group and ten scenarios were given to the surveillance group. The team was thus pressed for time. This was another motivation to combine both the scenarios into one task.

### Internal Audits

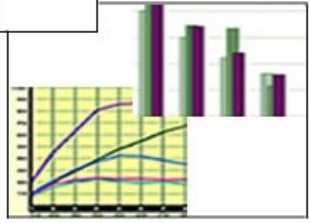
The sequence of screen shots to achieve the scenarios is presented below. The user had to proceed from the login page (Figure 3) to run through scenarios which were given to them. Each user was provided with a user name and password, which were typed in the text fields 'username' and 'password', respectively, on the login page to proceed to the 'Resume Audit' page (Figure 4). Each user was asked to select an audit ID from the column 'Audit ID' on the audit grid on the resume audit page. The audit ID was associated with an audit on a department on which the auditor was conducting an audit. On the resume audit page the default tab selection was 'Checklist Data Entry'. This enabled the user to proceed further with the task.

Clicking on audit ID takes the user to the 'Checklist Data Entry' page (Figure 5). The user (internal auditor) was required to categorize a certain checklist question with a response of 'no', and allocate an appropriate impact category and organizational category.

**WebSAT**  **Web-based Surveillance & Auditing Tool**

**Safer Skies**





**Technical Audits**

Welcome to Login Screen

Username

Password

[Change Password](#)

[Forgot Password?](#)

**Analyze Aircraft Maintenance Data**  
*...Improve Airline Safety*

---

Developed by  
Clemson WebSAT Team @ Human Computer Systems Laboratory  
Department of Industrial Engineering, Clemson University, Clemson, SC 29634  
Research supported by a contract from FAA

Figure 3. Login Page – Iteration One

**WebSAT**  
Internal Audits

LOGOUT

Hello Robin Steven! [Help](#)

**Audit Tasks**   **Checklists**   **Reports**

[Start New Audit](#)   [View Checklist](#)   [Audit Report](#)

**Resume Audit**   [Modify Checklist](#)   [Department](#)

[Corrective Actions](#)   [New Checklist](#)   [Assessment Report](#)

[Search Audits](#)   [Audit Planning](#)

**Resume Audit**

**Checklist Data Entry**   **Audit Details**

You are currently working on the following Audits.  
(Click on the AuditID to view Audit detail)

Audit ID▲	Department Name▲	Audit Start Date▼	Status Name▲
<a href="#">38</a>	Avionics	7/5/2006	Corrective Action
<a href="#">45</a>	Acquisitions	7/12/2006	Opened

Figure 4. Resume Audit page for Internal Audits – First Iteration

Each checklist question has three possible responses associated with them, ‘Yes’, ‘No’, and ‘N/A’ (Figure 5). Not-Applicable or ‘N/A’ is required for questions which do not require a response for an ongoing audit.

If the user is required to give a response as ‘No’ to question 3 on the checklist data entry page (Figure 6), the user would need to check (select) the radio button against ‘No’. The moment the user selects ‘No’ as a response, two drop down boxes will show up. These drop downs are associated with ‘ALI’ (Aircraft Level Impact) and ‘OC’ (Organizational Categories). The reason the entire name is not mentioned here is because acronyms are used by the aviation user group. The product development team felt that the



auditors would prefer such an option. During the research team’s interaction with the stakeholders in the three years of this project, all references were made in acronyms. This was the product development team’s attempt to ‘talk the user’s language’.

2	Is this DTPM controlled and updated as the policy and procedures change within the department?	Ref: GMM 1-0-750
	<input checked="" type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A	
	<input type="text"/>	<a href="#">Add Findings, Comments and Concerns</a>
	<i>Administration</i>	
3	Does the department have a standard training program for all employees?	Ref: FAR 121.375
	<input type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A	
	<input type="text"/>	<a href="#">Add Findings, Comments and Concerns</a>
	<i>Administration</i>	
4	Are the training records for the departments employees available, current, and complete?	Ref: FAR 121.375
	<input type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A	
	<input type="text"/>	<a href="#">Add Findings, Comments and Concerns</a>
	<i>Administration</i>	
5	Are all controlled manuals being properly revised?	Ref: GMM 1-0-405
	<input checked="" type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A	
	<input type="text"/>	<a href="#">Add Findings, Comments and Concerns</a>
	<i>Administration</i>	
6	Are reference manuals labeled "Reference Only" on the exterior of the manual or the spine label?	Ref: GMM 1-0-100
	<input type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A	

Figure 5. Checklist Data entry page for Internal Audits – First Iteration

2	Is this DTPM controlled and updated as the policy and procedures change within the department?	Ref: GMM 1-0-750
	<input checked="" type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A	
	<a href="#">Add Findings, Comments and Concerns</a>	
	<i>Administration</i>	
3	Does the department have a standard training program for all employees?	Ref: FAR 121.375
	<input type="radio"/> YES <input checked="" type="radio"/> NO <input type="radio"/> N/A	
	<b>ALI</b> <input type="text" value="Select One"/> <input type="button" value="v"/> <b>OC</b> <input type="text" value="Select One"/> <input type="button" value="v"/>	
	<a href="#">(What is this)</a> <a href="#">(What is this)</a>	
	<a href="#">Add Findings, Comments and Concerns</a>	
	<i>Administration</i>	
4	Are the training records for the departments employees available, current, and complete?	Ref: FAR 121.375
	<input type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A	
	<a href="#">Add Findings, Comments and Concerns</a>	
	<i>Administration</i>	
5	Are all controlled manuals being properly revised?	Ref: GMM 1-0-405
	<input checked="" type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A	
	<a href="#">Add Findings, Comments and Concerns</a>	
	<i>Administration</i>	
6	Are reference manuals labeled "Reference Only" on the exterior of the manual or the spine label?	Ref: GMM 1-0-100

Figure 6. Checklist answer is 'No' for Internal Audits – First Iteration

The product development team was aware of the fact that acronyms such as 'ALI' and 'OC' were relatively new for the stakeholders and hence just below the labels indicating 'ALI' and 'OC', a link was provided to the user (Figure 6). This link when clicked would allow the reader to learn more about the acronym. At this stage (first

iteration) the definitions document was not ready for 'ALI' and 'OC'. An image of what the user would see when 'What is this' (Figure 6) is clicked is shown in the second iteration of this chapter.

2 Is this DTPM controlled and updated as the policy and procedures change within the department? Ref: GMM 1-0-750  
 YES  NO  N/A  
[Add Findings, Comments and Concerns](#)  
*Administration*

3 Does the department have a standard training program for all employees? Ref: FAR 121.375  
 YES  NO  N/A  
**ALI** Select One (What is this) **OC** Select One (What is this)  
Safety  
Regulatory Compliance  
Procedures and Paperwork Inadequacy  
House-keeping  
Operational  
[Add Findings, Comments and Concerns](#)  
*Administration*

4 Are the training records for the departments employees available, current, and complete? Ref: FAR 121.375  
 YES  NO  N/A  
[Add Findings, Comments and Concerns](#)  
*Administration*

5 Are all controlled manuals being properly revised? Ref: GMM 1-0-405  
 YES  NO  N/A  
[Add Findings, Comments and Concerns](#)  
*Administration*

6 Are reference manuals labeled "Reference Only" on the exterior of the manual or the spine label? Ref: GMM 1-0-100

Figure 7. Drop down indicating Aircraft Level Impact categories – First Iteration

The user now drops the menu down to make a selection to associate the finding with an appropriate aircraft level impact category (Figure 7). Once the required categorization is done by the user, it would end the first scenario. The time taken to complete this scenario would be used to test against the marginally acceptable and ideal values for metric 1.

2 Is this DTPM controlled and updated as the policy and procedures change within the department?  
Ref: GMM 1-0-750

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

*Administration*

3 Does the department have a standard training program for all employees?  
Ref: FAR 121.375

YES  NO  N/A

**ALI**  **OC**

(What is this) (What is this)

[Add Findings, Comments and Concerns](#)

*Administration*

4 Are the training records for the departments employees available, current, and complete?  
Ref: FAR 121.375

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

*Administration*

5 Are all controlled manuals being properly revised?  
Ref: GMM 1-0-405

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

*Administration*


6 Are reference manuals labeled "Reference Only" on the exterior of the manual or the spine label?  
Ref: GMM 1-0-100

Figure 8. Drop down indicating Organizational Categories– First Iteration

The user would have to make a selection from the drop down menu for 'OC' to end the task associated with scenario 2. The time taken to complete this task would allow the product development team to benchmark the performance of the user on WebSAT against the marginally acceptable and ideal values set for metric 2.

### Technical Audits

As for internal audits, the auditors in the department of technical audits had to proceed with their scenarios from the login page (Figure 3).

**WebSAT Technical Audits**  **LOGOUT**

*Hello Pallavi Dharwada!* [Help](#)

**Audit Tasks**   **Checklists**   **Reports**

[Start New Audit](#)   [View Checklist](#)   [Audit Report](#)

**Resume Audit**   [Modify Checklist](#)   [Vendor Assessment Report](#)

[Corrective Actions](#)   [New Audit Type Checklist](#)   [Audit Planning](#)

[Search Audits](#)

---

**Resume Audit**

**Checklist Data Entry**   **Audit Details**

**You are currently working on the following Audits**  
(Click on the Audit ID to perform checklist data entry)

Audit ID▲	Vendor Name▲	Audit Type▲	Audit Start Date▼	Status Name▲
<a href="#">431</a>	LORDO-AZ-United States	Fuel	7/6/2006	Opened
<a href="#">432</a>	TIMAE-AL-United States	Fuel	7/10/2006	Corrective action
<a href="#">425</a>	Bombay Boss-TN-United States	Line_Mx	7/12/2006	Findings
<a href="#">430</a>	BSE-WA-United States	Suppliers	7/14/2006	Opened
<a href="#">438</a>	GEE-LO-United States	Fuel	7/14/2006	Findings

Figure 9. Resume Audit screen for Technical Audits – First Iteration

Statement and the signed sheet is maintained by the signer's manager. Note: - Utilize this policy at locations where management is stationed,  
 Ref: [GMM 2-1-100]

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

2 Controlled manuals, CD-ROM's, checklists, placards, and microfilm cassettes are available for the type of aircraft assigned to the station.  
 Ref: [GMM 1-0-50]

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

3 Controlled publications/forms match the online Station Report.  
 Ref: [GMM 1-1-50]

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

4 Controlled publications contain the current revision, Publication Transmittal, LEP, and required entries on the Revision Record.  
 Ref: [GMM 1-0-100]

YES  NO  N/A

**ALI** Select One **OC** Select One  
 (What is this) (What is this)

[Add Findings, Comments and Concerns](#)

5 Revisions are inserted in the controlled manuals no later than 5 days after the distribution date.  
 Ref: [GMM 1-0-405]

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

Figure 10. Checklist Answers page for Technical Audits – First Iteration

The user (technical auditor) goes to the 'Resume Audit' page as the user logs in. (Figure 9). Clicking on the audit ID on the resume audit page, the user is taken to 'Checklist Answers' page (Figure 10).

Statement and the signed sheet is maintained by the signer's manager. Note: - Utilize this policy at locations where management is stationed, Ref: [GMM 2-1-100]

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

---

2 Controlled manuals, CD-ROM's, checklists, placards, and microfilm cassettes are available for the type of aircraft assigned to the station. Ref: [GMM 1-0-50]

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

---

3 Controlled publications/forms match the online Station Report. Ref: [GMM 1-1-50]

YES  NO  N/A

<b>ALI</b>	Select One	<b>OC</b>	Select One
(What is this)	<div style="border: 1px solid black; padding: 2px;">           Select One            Safety            Regulatory Compliance            Procedures and Paperwork Inadequacy            House-keeping            Operational         </div>	(What is this)	

[Add Findings, Comments and Concerns](#)

---

4 Controlled publications contain the current revision, Publication Transmittal, LEP, and required entries on the Revision Record. Ref: [GMM 1-0-100]

YES  NO  N/A

<b>ALI</b>	Select One	<b>OC</b>	Select One
(What is this)		(What is this)	

[Add Findings, Comments and Concerns](#)

---

5 Revisions are inserted in the controlled manuals no later than 5 days after the distribution date. Ref: [GMM 1-0-405]

YES  NO  N/A

Figure 11. Drop down for Aircraft Level Impact categories – First Iteration

Documentation for an aircraft level impact category and organizational category is made the way it was done in internal audits (Figure 11, Figure 12).



Statement and the signed sheet is maintained by the signer's manager. Note:- Utilize this policy at locations where management is stationed,  
 Ref: [GMM 2-1-100]

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

2 Controlled manuals, CD-ROM's, checklists, placards, and microfilm cassettes are available for the type of aircraft assigned to the station.  
 Ref: [GMM 1-0-50]

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

3 Controlled publications/forms match the online Station Report.  
 Ref: [GMM 1-1-50]

YES  NO  N/A

**ALI** Select One **OC** Select One  
 (What is this) (What is this)

[Add Findings, Comments and Concerns](#)

4 Controlled publications contain the current revision, Publication Transmittal, LEP, and required entries on the Revision Record.  
 Ref: [GMM 1-0-100]

YES  NO  N/A

**ALI** Select One **OC** Select One  
 (What is this) (What is this)

[Add Findings, Comments and Concerns](#)

5 Revisions are inserted in the controlled manuals no later than 5 days after the distribution date.  
 Ref: [GMM 1-0-405]

YES  NO  N/A

Figure 12. Drop down for Organizational Categories – First Iteration

The research team used three categories to populate the drop down menu associated with organizational categories: High Risk, Medium Risk, and Low Risk.



## Surveillance

The user (quality assurance representative) is taken from the login page (Figure 3) to ‘Start New Surveillance Activity’ page (Figure 13). Here the user is expected to provide the aircraft tail number to proceed. Each user was provided with an aircraft tail number to allow them to proceed with the task.

The screenshot shows the 'WebSAT Surveillance' interface. At the top left is the logo and a circular seal. The top right has a 'LOGOUT' link. The user is greeted with 'Hello Steve Johnson!' and a 'Help' link. The main content area is divided into three columns: 'Surveillance Data', 'Activity Types', and 'Reports'. Under 'Surveillance Data', there are links for 'Start New Surveillance', 'View Surveillance Data', 'Activity Distribution', and 'Information'. Under 'Activity Types', there are links for 'Work Cards', 'ADs', 'Vendor NR', and 'NR Info'. Under 'Reports', there are links for 'Vendor Assessment' and 'Productivity Report'. Below this menu is a blue bar with the text 'Start New Surveillance Activity'. At the bottom, there is a form with the label 'Aircraft Tail Number', an empty text input field, and a 'Go' button.

Figure 13. Start New Surveillance screen – First Iteration

Once the user provides the required information, the user is taken to the ‘Work Order Details’ page (Figure 14).

**WebSAT Surveillance** LOGOUT

*Hello Steve Johnson!* [Help](#)

**Surveillance Data**   **Activity Types**   **Reports**

[Start New Surveillance](#)   [Work Cards](#)   [Vendor Assessment](#)

[View Surveillance Data](#)   [ADs](#)   [Productivity Report](#)

[Activity Distribution](#)   [Vendor NR](#)

[Information](#)   [NR Info](#)

**Start New Surveillance > Work Order Details**

**Work Order Details**

**Work Orders generated for the surveillance event**

WorkOrder #	Description	Site	Planned Date	Check Type	Visit #	WRI
<a href="#">4579</a>	Test work order	MAE	8/25/2006	B	2	True
<a href="#">4580</a>	Detailed Work Order	MAE	8/25/2006	A	4	True
<a href="#">4581</a>	Test	MAE	8/25/2006	C	2	True

Figure14. Work Order Details screen – First Iteration

Each quality assurance representative (user) is associated with several work orders (Figure 14). The work orders are synonyms with the audit ID in the case of internal and technical audits. Each work order number allows the quality assurance representative to refer to several work cards. Each work card is associated with a maintenance task which needs to be performed on an aircraft at the maintenance hangar (Figure 15).

**WebSAT Surveillance**  **LOGOUT**

*Hello Steve Johnson!* [Help](#)

**Surveillance Data** **Activity Types** **Reports**

**Start New Surveillance** [Work Cards](#) [Vendor Assessment](#)

[View Surveillance Data](#) [ADs](#) [Productivity Report](#)

[Activity Distribution](#) [Vendor NR](#)

[Information](#) [NR Info](#)

**Start New Surveillance > Work Order Details > Surveillance Schedule**

**Surveillance Schedule**

**Work Order Number** 4579 **Aircraft Tail Number** 7824

Test work order

Type	Number	Title	Last Performed	Completion Status
Work Card	<a href="#">180</a>	Remove Panels - Major Zone 322	9/17/2006	Completed
Work Card	<a href="#">181</a>	Remove Panels - Major Zone 323	8/26/2006	Completed
Work Card	<a href="#">182</a>	Remove Panels - Major Zone 324	8/28/2006	Completed
Work Card	<a href="#">183</a>	Remove Panels - Major Zone 325	8/26/2006	NR
Work Card	<a href="#">184</a>	Remove Panels - Major Zone 326	9/19/2006	Completed
Work Card	<a href="#">184 (Activity 2)</a>	Remove Panels - Major Zone 326	Never	Not Worked on
Work Card	<a href="#">185</a>	Remove Panels - Major Zone 327	Never	Not Worked on
Work Card	<a href="#">186</a>	Remove Panels - Major Zone 328	Never	Not Worked on
Work Card	<a href="#">5597-55-5422</a>	Panel Lubrication	9/20/2006	Completed
Work Card	<a href="#">5597-58-5422</a>	Wire connectors	9/21/2006	NR
Work Card	<a href="#">000466</a>	Fuselage- Repair to cover Access hole	10/3/2006	Completed

Figure 15. Surveillance Schedule screen – First Iteration

Clicking on the link associated with the work card number (column titled ‘Number’ in the data grid in Figure 15) allows the user to access the ‘WorkCard Data’ page (Figure 16). Based on the surveillance stakeholders’ requirement, unlike in internal audits and technical audits, the drop downs associated with the aircraft level impact

categories and organizational categories are provided to the user, immaterial of the fact if the maintenance task associated with the work card, performed by the vendor is rejected by the quality assurance representative. Work card reject is synonymous to a ‘No’ to a checklist question in internal and technical audits.

*Hello Steve Johnson!* [Help](#)

Surveillance Data	Surveillance Details	Reports
<a href="#">Start New Surveillance</a>	<a href="#">Work Cards</a>	<a href="#">Vendor Assessment</a>
<a href="#">View Surveillance Data</a>	<a href="#">ADs</a>	<a href="#">Productivity Report</a>
<a href="#">Activity Distribution</a>	<a href="#">Vendor NR</a>	
<a href="#">Information</a>	<a href="#">NR Info</a>	

[Start New Surveillance](#) > [Work Order Details](#) > [Surveillance Schedule](#) > **WorkCard Data**

**WorkCard Data**

<b>SITE</b>	Indianapolis <input type="button" value="v"/>	<b>WORKORDER #</b>	4578	<b>ACN</b>	9608
<b>WORKCARD</b>	5597-55-5412	<b>WORKCARD TITLE</b>	Grease doors frame		
<b>NON ROUTINE NUMBER</b>	<input style="width: 100%;" type="text"/>				
<b>STATUS</b>	<input type="radio"/> ACCEPT <input type="radio"/> REJECT <input type="radio"/> OTHER				
<b>MX TASK</b>	<input style="width: 100%;" type="text" value="Select One"/>	<b>PROCESS MEASURE</b>	<input style="width: 100%;" type="text" value="Select One"/>		
<b>MX SOURCE</b>	<input style="width: 100%;" type="text" value="Engineering Maintenance Program Specification (work card) (EMPS)"/>				
<b>AIRCRAFT LEVEL IMPACT</b>	<input style="width: 100%;" type="text" value="Select One"/>	<b>ORGANIZATIONAL CATEGORIES</b>	<input style="width: 100%;" type="text" value="Select OC"/>		
<a href="#">What is This</a>		<a href="#">What is this</a>	<a href="#">What is this</a>		
<b>DISCREPANCY</b>	<input style="width: 100%;" type="text"/>				
<b>CORRECTIVE ACTIONS</b>	<input style="width: 100%;" type="text"/>				
<b>COMMENTS</b>	<input style="width: 100%;" type="text"/>				
<input type="checkbox"/> WCCR		<input type="checkbox"/> PFCR			
<input type="button" value="Submit"/>	<input type="button" value="Cancel"/>	<input type="button" value="Save and Add another Activity"/>			

Figure 16. WorkCard Data screen – First Iteration

*Hello Steve Johnson!* [Help](#)

Surveillance Data	Surveillance Details	Reports
<a href="#">Start New Surveillance</a>	<a href="#">Work Cards</a>	<a href="#">Vendor Assessment</a>
<a href="#">View Surveillance Data</a>	<a href="#">ADs</a>	<a href="#">Productivity Report</a>
<a href="#">Activity Distribution</a>	<a href="#">Vendor NR</a>	
<a href="#">Information</a>	<a href="#">NR Info</a>	

[Start New Surveillance](#) > [Work Order Details](#) > [Surveillance Schedule](#) > **WorkCard Data**

**WorkCard Data**

**SITE** Indianapolis  **WORKORDER #** 4578 **ACN** 9608

**WORKCARD** 5597-55-5412 **WORKCARD TITLE** Grease doors frame

**NON ROUTINE NUMBER**

**STATUS**  ACCEPT  REJECT  OTHER

**MX TASK**  **PROCESS MEASURE**

**MX SOURCE**

**AIRCRAFT LEVEL IMPACT**  **ORGANIZATIONAL CATEGORIES**   
[What is This](#) [What is this](#)

Select One  
 Safety  
 Regulatory Compliance  
 Procedures and Paperwork Inadequacy  
 House-keeping  
 Operational

**DISCREPANCY**

**CORRECTIVE ACTIONS**

**COMMENTS**

WCCR  PFCR

Figure 17. Drop down indicating Aircraft Level Impact categories – First Iteration

A category is selected from the drop down associated with aircraft level impact. The drop down associated with organizational categories does not exist in surveillance. There is an explanation for this.

The prototyping of the surveillance module started two months after the technical and internal audit modules were completed. By this time the research associated with

‘organizational categories’ was over. The stakeholders wanted a risk matrix to pop up (Figure 18) each time a quality assurance representative wanted to make a documentation associated with organizational categories. The risk matrix is associated with severity at four levels and probability of an event occurring at four levels. This provides a four by four grid, which in turn is associated with risk at three levels: low, medium, and high.

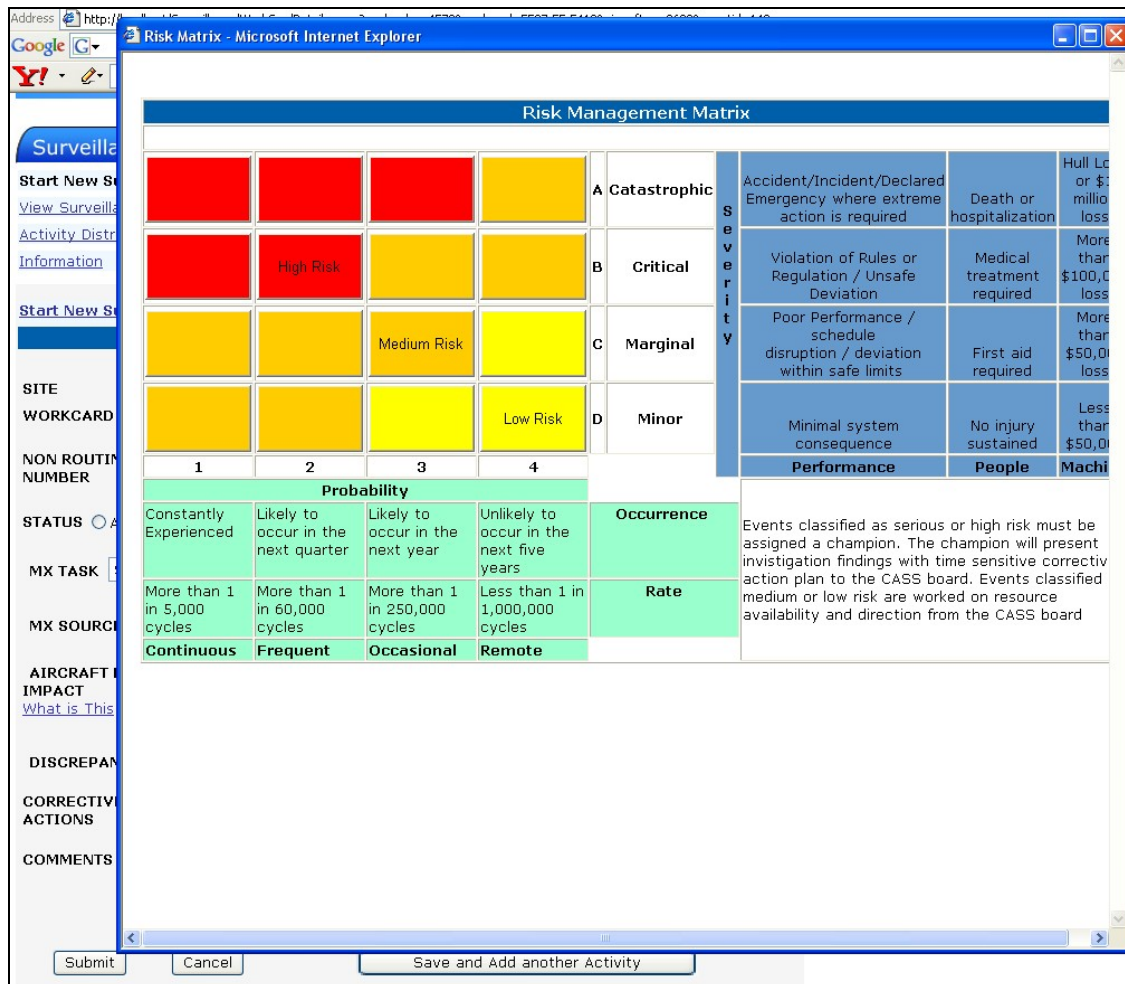


Figure 18. Risk Matrix for Organizational Categories – First Iteration

### 8.11 Results – Iteration 1

The results from Iteration 1 are indicated in below. The results of the technical audits group are indicated in Table 6. The results of the internal audits group are

indicated in Table 7. The results of the surveillance group are indicated in Table 8.

Table 6. Results of the Technical Audits group

	ASQ 1	ASQ 2	ASQ 3	Mean ASQ	Time ALI	Time OC
	(seconds) (seconds)					
Auditor 1	3	2	2	2.33	91.75	91.75
Auditor 2	1	1	n/a	1	43.43	43.43
Auditor 3	1	1	1	1	120.75	120.75
Auditor 4	1	1	1	1	60.46	60.46
TA Mgr	1	1	1	1	75.96	75.96
<b>NOTE</b>						
ASQ is an After Scenario Questionnaire						
TA Mgr is Technical Audits manager						
ALI is Aircraft Level Impact						
OC is Organizational Category						

Table 7. Results of the Internal Audits group

	ASQ 1	ASQ 2	ASQ 3	Mean ASQ	Time ALI	Time OC
	(seconds) (seconds)					
Auditor 1	1	1	n/a	1	55.28	55.28
Auditor 2	2	2	n/a	2	26.58	26.58
Auditor 3	4	3	3	3.33	50.62	50.62
Auditor 4	1	1	1	1	41.65	41.65
IA Mgr	1	1	n/a	1	40	40
<b>NOTE</b>						
ASQ is an After Scenario Questionnaire						
IA Mgr is Internal Audits manager						
ALI is Aircraft Level Impact						
OC is Organizational Category						



Table 8. Results of the Surveillance group

	ASQ 1	ASQ 2	ASQ 3	Mean ASQ	Time ALI	Time OC
					(seconds)	(seconds)
QAR 1	1	1	1	1	90.21	90.21
QAR 2	3	3	2	2.67	75.67	75.67
QAR 3	2	2	2	2	80.47	80.47
QAR 4	3	3	3	3	45.46	45.46
QAR 5	3	2	2	2.33	35.45	35.45
QAR 6	2	1	1	1.33	43.23	43.23
QAR 7	5	5	4	4.67	45.32	45.32
Mgr 1	2	1	3	2	33.25	33.25
Mgr 2	3	1	1	1.67	30.34	30.34
Mgr 3	1	1	1	1	25.45	25.45
<b>NOTE</b>						
ASQ is an After Scenario Questionnaire						
Mgr is Surveillance Manager						
ALI is Aircraft Level Impact						
OC is Organizational Category						
QAR is a Quality Assurance Representative						

Each result table consists of six columns (Table 6, Table 7, and Table 8). The first three columns are referred to as ASQ 1, ASQ 2, and ASQ 3, respectively. These three columns indicate participant ratings associated with questions in an After Scenario Questionnaire (ASQ) (Appendix P). The three ASQ based questions are: 1. Overall, I am satisfied with the ease of completing the tasks in this scenario, 2. Overall, I am satisfied with the amount of time it took to complete the tasks in this scenario, and 3. Overall, I am satisfied with the support information (online-line help, messages, documentation) when completing the tasks. The responses had a range from 1 to 7, where 1 indicates a strong agreement with the question, and 7 indicates a strong disagreement with the question. There was an option 'NA' which should be used if the participants do not wish to respond to a question based on the scenario. None of the twenty participants referred to the available 'help', yet only four responded to question ASQ 3 with a response of 'NA'.



Others associated a rating to the question. The product development team did not want to force a response from the participants, and hence did not interrupt them.

The range of time required to complete the task by the technical audits group was 43.43 seconds to 120.75 seconds. The mean time required to complete the task was 78.47 seconds.

The range of time required to complete the task by the internal audits group was 41.65 seconds to 55.28 seconds. The mean time required to complete the task was 42.83 seconds.

The range of time required by the surveillance group to complete the task was 25.45 seconds to 90.21 seconds for the surveillance group. The mean time required to complete the task was 50.49 seconds.

The overall range required to complete the task by the users was 25.45 seconds to 120.75 seconds. The mean time required to complete the task was 57.26 seconds.

The mean ASQ rating accounting for all the three questions asked was 1.82. This is extremely promising since a value of 1 indicates that the user is extremely satisfied with all aspects of the software, and 7 indicates that the user is not at all satisfied with the software. An ASQ rating of 1.82 to perform the task to categorize maintenance findings in terms of performance measures reflects the fact that the stakeholders were very satisfied with interface issues associated with categorization of maintenance findings.

The managers commented that the performance measures for aircraft level impact and organizational categories would remove subjectivity from the minds of quality assurance representatives and auditors. During user testing at the industry partner headquarters, the managers commended the design team for this aspect of the product.

Each participant was given a Software Usability Measurement Inventory (SUMI) form to fill out after the entire user testing session. SUMI is a method for assessing the quality of use of a software product or prototype. There are fifty questions on the SUMI form. Each question has three choices: Agree, Undecided, Disagree. SUMI scales above 50 are considered to be consistent with state of the art technology. The higher the SUMI scale scores the better the product is. The average response scores across the twenty participants was 60.

It is thus concluded that WebSAT is a competent web application that allows its users to do their tasks effectively.


#### 8.12 Second Iteration

The product went through a second iteration based on user feedback from the first iteration. None of the users had any problem in completing the scenario. None of the user feedback affected the work flow of the users to categorize audit and surveillance findings in terms of ALI and OC.

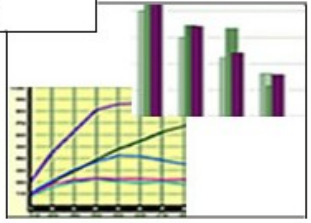

The changes in iteration two were not re-tested with users. The managers in every department were shown the changes made and an approval was asked for.

#### Internal Audits

The login page is shown in Figure 19.

**WebSAT**  **Web-based Surveillance & Auditing Tool**

**Safer Skies**



**Technical Audits**

Welcome to Login Screen

Username

Password

[Change Password](#)

[Forgot Password?](#)

**Analyze Aircraft Maintenance Data**  
**...Improve Airline Safety**

---

Developed by  
Clemson WebSAT Team @ Human Computer Systems Laboratory  
Department of Industrial Engineering, Clemson University, Clemson, SC 29634  
Research supported by a contract from FAA

Figure 19. Login page – Iteration Two

**WebSAT**  
Internal Audits

LOGOUT

Hello Robin Steven! [Help](#)

**Audit Tasks**   **Checklists**   **Reports**

[Start New Audit](#)   [View Checklist](#)   [Audit Report](#)

**Resume Audit**   [Modify Checklist](#)   [Department Assessment Report](#)

[Corrective Actions](#)   [New Department Checklist](#)

[Search Audits](#)

[Delete Audits](#)

**Resume Audit**

**Checklist Data Entry**   **Audit Details**

You are currently working on the following Audits.  
(Click on the AuditID to view Audit detail)

<a href="#">Audit ID</a>	<a href="#">Department Name</a>	<a href="#">Audit Start Date</a>	<a href="#">Status Name</a>
<a href="#">38</a>	Avionics	7/5/2006	Corrective Action
<a href="#">106</a>	Crew resource and Scheduling	10/30/2006	Opened
<a href="#">126</a>	Warehouse	10/30/2006	Findings

Figure 20. Resume Audit for Internal Audits – Second Iteration

The resume audit page (Figure 20) is different to that in iteration one. The links provided under the tab ‘Audit Tasks’ have changed compared to iteration one. A ‘Delete Audits’ link was added to the tab. This has no implications on the scenarios associated with metrics 1 and 2.

**Resume Audit > Checklist Data Entry**

**Crew resource and Scheduling Checklist (Questions and Answers)**

Audit ID	Auditor Name	Questions Answered	Department	Start Date	End Date
106	Robin Steven	0/10	Crew resource and Scheduling-memphis-TN	10/30/2006	

[Show All Findings](#)

**You can enter audit data using the fields below**

*Administration*

1 Is there someone in the Air Carrier that has been identified as the responsible person for this functional area?

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

*Administration*

2 Is this responsibility written in the Crew Resource and Scheduling (CRS) Policy and Procedures Manual and does this person know they have this responsibility?

Ref: (FAR 121.135)

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

*Records*

3 Does the responsible person have adequate written authority for this functional area?

Ref: (FAR 121.135 (b)(2))

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

*Records*

4 Does this person know they have this authority?

Figure 21. Checklist Data Entry screen for Internal Audits – Second Iteration

The checklist data entry page (Figure 21) is different from the one in the first iteration (Figure 5). The user has the ability to upload images and documentation

associated with a checklist question. The buttons 'Browse' and 'Upload' allow the user to select the appropriate files from their work station (Figure 21).

[Resume Audit](#) > Checklist Data Entry

### Crew resource and Scheduling Checklist (Questions and Answers)

Audit ID	Auditor Name	Questions Answered	Department	Start Date	End Date
106	Robin Steven	0/10	Crew resource and Scheduling-memphis-TN	10/30/2006	

[Show All Findings](#)

**You can enter audit data using the fields below**

*Administration*

1 Is there someone in the Air Carrier that has been identified as the responsible person for this functional area?

YES
  NO
  N/A

**ALI**

(What is this)

(What is this)

[Hide Findings, Comments and Concerns](#)

**Audit Findings**

**Concerns**

**Comments**

*Administration*

2 Is this responsibility written in the Crew Resource and Scheduling (CRS) Policy and Procedures Manual and does this person know they have this responsibility?

Ref: (FAR 121.135)

YES
  NO
  N/A

[Add Findings, Comments and Concerns](#)

Figure 22. A 'No' documented against a checklist question – Second Iteration

It is evident from Figure 22 that the drop down associated with organizational categories is gone. There is a link which states 'Select OC'. As the user clicks on the link, a risk matrix is displayed (Figure 24). The user clicks on the cell associated with the appropriate risk index, which will populate the label field next to the 'Select OC' (Figure 23).

**Resume Audit > Checklist Data Entry**

**Crew resource and Scheduling Checklist (Questions and Answers)**

Audit ID	Auditor Name	Questions Answered	Department	Start Date	End Date
106	Robin Steven	0/10	Crew resource and Scheduling-memphis-TN	10/30/2006	

[Show All Findings](#)

**You can enter audit data using the fields below**

---

*Administration*

1 Is there someone in the Air Carrier that has been identified as the responsible person for this functional area?

YES  NO  N/A

<b>ALI</b> (What is this)	<div style="border: 1px solid black; padding: 2px;">           Select One           <ul style="list-style-type: none"> <li style="background-color: #e0e0e0;">Select One</li> <li>Safety</li> <li>Regulatory Compliance</li> <li>Procedures and Paperwork Inadequacy</li> <li>House-keeping</li> <li>Operational</li> </ul> </div>	<a href="#">Select OC</a> <input type="text"/> (What is this)
------------------------------	--	--

[Hide Findings, Comments and Concerns](#)

**Audit Findings**

**Concerns**

**Comments**

*Administration*

Figure 23. Drop down indicating Aircraft Level Impact categories – Second Iteration

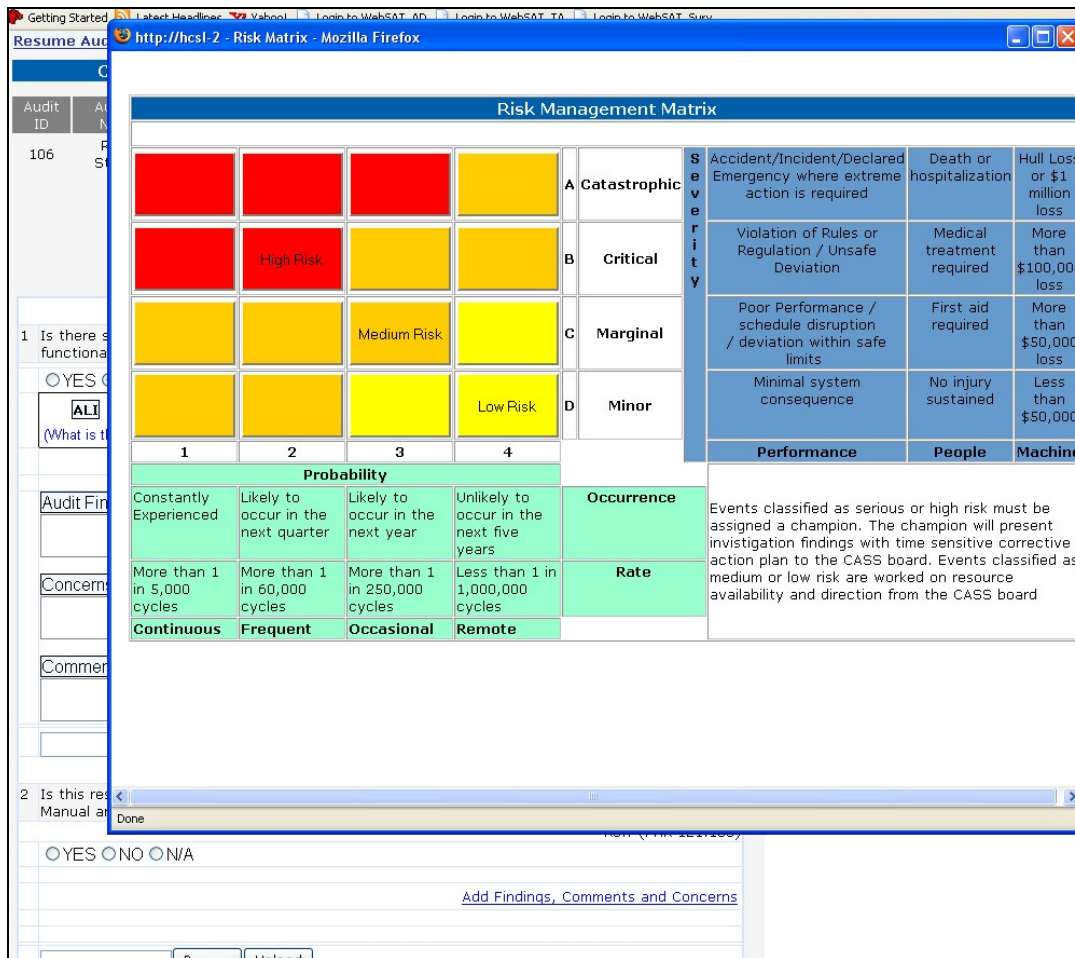


Figure 24. Risk matrix to document Organizational Categories

### Technical Audits

There were not any conceptual changes made to the technical audits module in the second iteration. There were changes which did not involve the screens associated with the scenarios presented to the users in the first iteration.

A new link known as ‘Delete Audits’ was added to the tab ‘Audit Tasks’ (Figure 25).



**WebSAT**  
Technical Audits

LOGOUT

Hello Pallavi Dharwada! [Help](#)

**Audit Tasks**   **Checklists**   **Reports**

[Start New Audit](#)   [View Checklist](#)   [Audit Report](#)

**Resume Audit**   [Modify Checklist](#)   [Vendor Assessment Report](#)

[Corrective Actions](#)   [New Audit Type Checklist](#)

[Search Audits](#)

[Delete Audits](#)

---

**Resume Audit**

**Checklist Data Entry**   [Audit Details](#)

You are currently working on the following Audits  
(Click on the Audit ID to perform checklist data entry)

<a href="#">Audit ID</a>	<a href="#">Vendor Name</a>	<a href="#">Audit Type</a>	<a href="#">Audit Start Date</a>	<a href="#">Status Name</a>
<a href="#">408</a>	Norfolk-VA-United States	Line_Mx	7/12/2006	Findings
<a href="#">430</a>	BSE-WA-United States	Suppliers	7/14/2006	Findings
<a href="#">438</a>	GEE-LO-United States	Fuel	7/14/2006	Findings
<a href="#">561</a>	TIMAE-AL-United States	Fuel	10/31/2006	Findings

Figure 25. Resume Audit screen for Technical Audits – Second Iteration

The user was provided with the ability to upload documentation and images associated with checklist questions (Figure 26).

12 A workplace chemical inventory of all chemicals, by label identity, is compiled and properly maintained.	
	Ref: HACP Intro.
<input type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A	
<a href="#">Add Findings, Comments and Concerns</a>	
<input type="text"/>	<input type="button" value="Browse..."/> <input type="button" value="Upload"/>
13 Material Safety Data Sheets (MSDS), for all chemicals, are compiled and properly maintained. Note- All MSDSs must be readily available and in accessible order. Orange labels, with assigned numbers to both the chemical and the MSDS is an original, and still acceptable, option. Other acceptable options include placing MSDSs in alphabetical order, and in alphabetical order and by category (i.e., solvents, lubricants, paints, office chemicals, manufacturer, etc.).	
	Ref: HACP MSDS Chap.
<input type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A	
<a href="#">Add Findings, Comments and Concerns</a>	
<input type="text"/>	<input type="button" value="Browse..."/> <input type="button" value="Upload"/>
14 All controlled technical and policy and procedures manuals on the aircraft contain the latest Information. Note- Refer to GMM references for list of required manuals and forms. List the title and publication number of all manuals that are not current. Report discrepancies to the AMT's as soon as possible.	
	Ref: (GMM 6-1-900, 6-1-902, 6-1-903, 6-1-904)
<input type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A	
<a href="#">Add Findings, Comments and Concerns</a>	
<input type="text"/>	<input type="button" value="Browse..."/> <input type="button" value="Upload"/>
<b>Paperwork Control</b>	
<i>Compliance/Documentation</i>	
15 The Line Maintenance Self-Audit Form (FedEx M-3310) is completed by the responsible manager or designee every 6-months. Note:- An equivalent form may be used.	
	Ref: GMM 6-1-2700
<input type="radio"/> YES <input type="radio"/> NO <input type="radio"/> N/A <input type="radio"/> N/O	
<a href="#">Add Findings, Comments and Concerns</a>	

Figure 26. Checklist Data Entry screen for Technical Audits – Second Iteration

[Resume Audit](#) > Checklist Data Entry

**Line\_Mx Checklist (Questions and Answers)**

Audit ID	Auditor Name	Questions Answered	Facility Name	Start Date	End Date
408	Pallavi Dharwada	10/137	Norfolk-Arlington-VA	7/12/2006	

[Show All Findings](#)

You can enter audit data using the fields below

Questions 1 - 10

**Manuals and Forms Control** *Compliance/Documentation*

1 The manual holder or manager responsible for the manual signed the Manual Accountability Statement and the signed sheet is maintained by the signer's manager. Note:- Utilize this policy at locations where management is stationed, Ref: GMM 2-1-100

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

2 Controlled manuals, CD-ROM's, checklists, placards, and microfilm cassettes are available for the type of aircraft assigned to the station. Ref: GMM 1-0-50

YES  NO  N/A

**ALI**   Medium Risk

(What is this) (What is this)

[Hide Findings, Comments and Concerns](#)

**Audit Findings**

Manuals have not been updates. Maintenance of the CD-ROMS and microfilm cassettes is very poor.

**Concerns**

Figure 27. A 'No' selected for a checklist answer in Technical Audits – Second Iteration

The drop down associated with organizational categories is absent. The user can click on the link 'Select OC' (refer to question 2 in Figure 27); a risk matrix selection is displayed as a label (Figure 28).

[Resume Audit](#) > Checklist Data Entry

**Line\_Mx Checklist (Questions and Answers)**

Audit ID	Auditor Name	Questions Answered	Facility Name	Start Date	End Date
408	Pallavi Dharwada	10/137	Norfolk-Arlington-VA	7/12/2006	

[Show All Findings](#)

You can enter audit data using the fields below

Save and Return to Audit Details Next >

Questions 1 - 10 Generate Report

Go >

**Manuals and Forms Control** *Compliance/Documentation*

1 The manual holder or manager responsible for the manual signed the Manual Accountability Statement and the signed sheet is maintained by the signer's manager. Note:- Utilize this policy at locations where management is stationed, Ref: GMM 2-1-100

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

2 Controlled manuals, CD-ROM's, checklists, placards, and microfilm cassettes are available for the type of aircraft assigned to the station. Ref: GMM 1-0-50

YES  NO  N/A

**ALI**   Medium Risk

(What is this)  (What is this)

Safety  
Regulatory Compliance  
Procedures and Paperwork Inadequacy  
House-keeping  
Operational

[Add Findings, Comments and Concerns](#)

**Audit Findings**  
Manuals have not been updates. Maintenance of the CD-ROMS and microfilm cassettes is very poor.

**Concerns**

Figure 28. Drop down indicating Aircraft Level Impact categories for Technical Audits –  
Second Iteration

12A workplace chemical inventory of all chemicals, by label identity, is compiled and properly maintained. Ref: HACP Intro.

YES  NO  N/A

**ALI** Select One Select OC Medium Risk  
(What is this) (What is this)

[Hide Findings, Comments and Concerns](#)

**Audit Findings**

**Concerns**

**Comments**

Browse... Upload

13 Material Safety Data Sheets (MSDS), for all chemicals, are maintained. Note- All MSDSs must be readily available and in labels, with assigned numbers to both the chemical and the still acceptable, option. Other acceptable options include plac order, and in alphabetical order and by category (i.e., solvent chemicals, manufacturer, etc.). Ref: HACP MSDS Chap.

YES  NO  N/A

[Add Findings, Comments and Concerns](#)

Browse... Upload

14 All controlled technical and policy and procedures manuals on the aircraft contain the latest Information. Note- Refer to GMM references for list of required manuals and forms. List the title and publication number of all manuals that are not current. Report discrepancies to the AMT's as soon as possible. Ref: (GMM 6-1-900, 6-1-902, 6-1-903, 6-1-904)

YES  NO  N/A

Done

http://hcs1-2 - AliHelp - Mozill...  
Each time a No is documented during an audit, an appropriate aircraft level impact (ALI) will be associated with each open-ended response indicating a possible risk to the aircraft.

Figure 29. Explanation for Aircraft Level Impact categories – Second Iteration

Clicking on the ‘What is this’ link next to the ‘ALI’ label under question 12 (Figure 29) displays a pop up to indicate to the user what ‘ALI’ is. The risk matrix is shown in Figure 30.



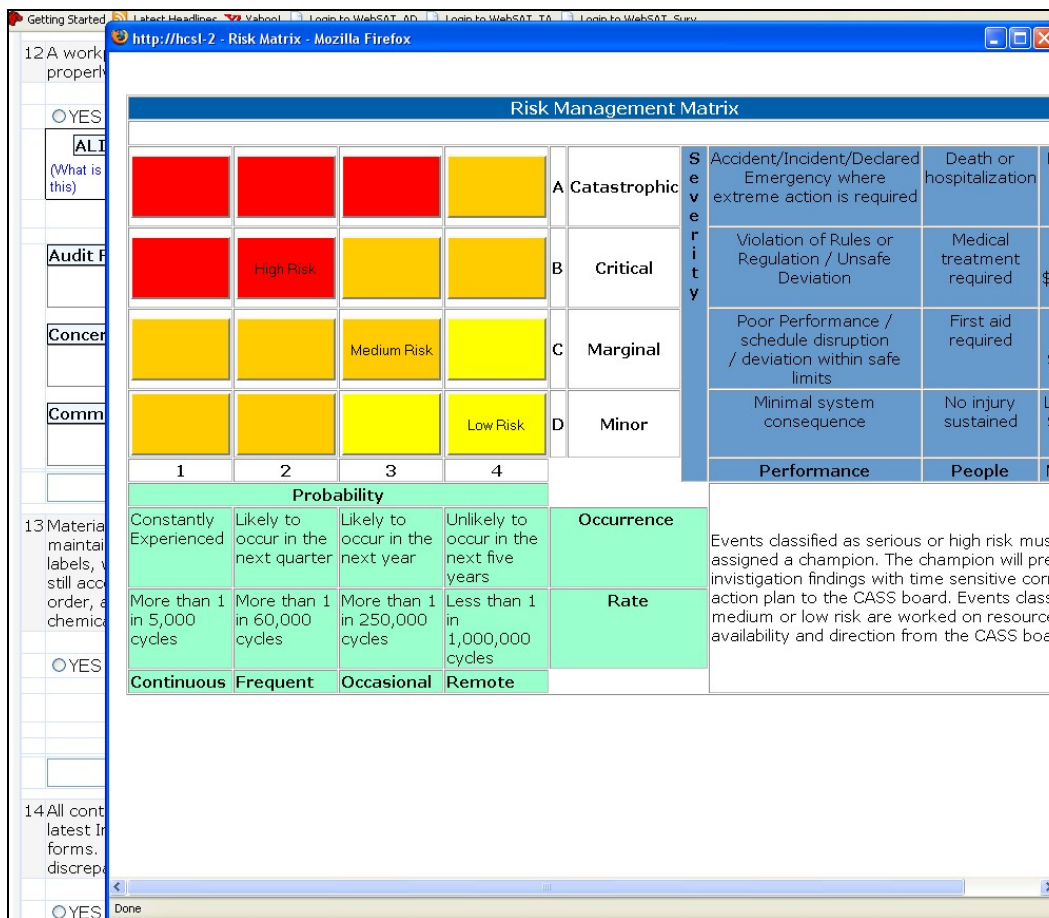



Figure 30. Risk matrix for Organizational Categories for Technical Audits – Second

Iteration

Surveillance

There were minor changes incorporated into the second iteration of the surveillance module. The changes were communicated to the quality assurance representatives and shown to the manager, but no formal user testing was performed on the second iteration.

A ‘Work Order Number’ field was added to the start new surveillance activity screen (Figure 13). The page was now referred to as ‘Surveillance Schedule’ (Figure 31).

**WebSAT Surveillance**  **LOGOUT**

*Hello Steve Johnson!* [Help](#)

**Enter Data** **View Data** **Reports**

**Surveillance Schedule** [Search Surveillance Activities](#) [Risk Evaluation](#)  
[Enter New Surveillance](#) [View Surveillance Data](#) [Productivity Report](#)  
[Enter New NR](#) [View NR Information](#)  
[View My Activity](#)  
[Distribution](#)


**Surveillance Schedule**

Enter at least one field

Aircraft Tail Number

Work Order Number

Figure 31. Surveillance Schedule screen – Second Iteration

**WebSAT Surveillance**  **LOGOUT**

*Hello Steve Johnson!* [Help](#)

**Enter Data** **View Data** **Reports**

**Surveillance Schedule** [Search Surveillance Activities](#) [Risk Evaluation](#)  
[Enter New Surveillance](#) [View Surveillance Data](#) [Productivity Report](#)  
[Enter New NR](#) [View NR Information](#)  
[View My Activity](#)  
[Distribution](#)

[Surveillance Schedule](#) > **Work Order Details**

**Work Order Details**

**Work Orders generated for the surveillance event**

WorkOrder #	Description	Site	Planned Date	Check Type	Visit #	WRI
<a href="#">4579</a>	Test work order	MAE	8/25/2006	B	2	true
<a href="#">4580</a>	Detailed Work Order	MAE	8/25/2006	A	4	true
<a href="#">4581</a>	Test	MAE	8/25/2006	C	2	true

Figure 32. Work Order Details screen – Second Iteration

**WebSAT Surveillance**  **LOGOUT**

*Hello Steve Johnson!* [Help](#)

**Enter Data** **View Data** **Reports**

**Surveillance Schedule** [Search Surveillance Activities](#) [Risk Evaluation](#)  
[Enter New Surveillance](#) [View Surveillance Data](#) [Productivity Report](#)  
[Enter New NR](#) [View NR Information](#)  
[View My Activity Distribution](#)

[Surveillance Schedule](#) > [Work Order Details](#) > [Surveillance Schedule Details](#)

**Surveillance Schedule Details**

**Work Order Number** 4579 **Aircraft Tail Number** 7824  
**Work Order Description** Test work order

**\* MANDATORY ITEMS MARKED IN BOLD**

Type	Number	Title	Last Performed	Completion Status	Belongs To
Work Card	<a href="#">180</a>	Remove Panels - Major Zone 322	9/17/2006	Completed	Steve Johnson
Work Card	<a href="#">181</a>	Remove Panels - Major Zone 323	10/16/2006	Completed	Steve Johnson
Work Card	<a href="#">182</a>	Remove Panels - Major Zone 324	8/28/2006	Completed	Steve Johnson
Work Card	<a href="#">183</a>	Remove Panels - Major Zone 325	10/18/2006	NR	Steve Johnson
Work Card	<a href="#">184</a>	Remove Panels - Major Zone 326	9/19/2006	Completed	Steve Johnson
Work Card	<a href="#">5597-55-5422</a>	Panel Lubrication	9/20/2006	Completed	Steve Johnson
Work Card	<a href="#">5597-58-5422</a>	Wire connectors	9/21/2006	NR	Steve Johnson
Work Card	<a href="#">000466</a>	Fuselage- Repair to cover Access hole	10/3/2006	Completed	Steve Johnson
Work Card	<a href="#">000472</a>	Smoke Detection and Fire support placards removal	Never	Not Worked on	Steve Johnson
Other	<a href="#">SG92</a>		9/29/2006	NR	Steve Johnson
Other	<a href="#">SG93</a>	This workcard belongs to other category	10/3/2006	NR	Steve Johnson

Figure 33. Surveillance Schedule Details screen – Second Iteration

The tab names on ‘Work Order Details’ page (Figure 14) were changed. Surveillance data was now referred to as ‘Enter Data’, Activity Types was now referred to as ‘View data’, and most of the links within each tab were changed to names



recommended by the managers and the quality assurance representatives during the first iteration (Figure 32). On the ‘Surveillance Schedule’ page a message indicating ‘Mandatory Items Marked In Bold’ was added (Figure 33).

**Surveillance** Hello Steve Johnson! [Help](#)

**Enter Data** | **View Data** | **Reports**

**Surveillance Schedule** | [Search Surveillance Activities](#) | [Risk Evaluation](#)  
[Enter New Surveillance](#) | [View Surveillance Data](#) | [Productivity Report](#)  
[Enter New NR](#) | [View NR Information](#)  
[View My Activity Distribution](#)

[Surveillance Schedule](#) > [Work Order Details](#) > [Surveillance Schedule Details](#) > **Activity Data**

**Activity Data**

**SITE** MAE  **WORKORDER #** 4580 **Aircraft Tail Number** 7824  
**AD Number** 882 **AD TITLE** Remove Panels - Major Zone 680

**NON ROUTINE NUMBER**

\* **STATUS**  ACCEPT  REJECT

\* **PROCESS MEASURE** [What is this](#)  Documentation Surveillance \* **MX TASK**  Restore(RS)

\* **MX SOURCE**  Engineering Order Air Worthiness Directive(EO(AD))

\* **AIRCRAFT LEVEL IMPACT**  Procedures and Paperwork Inadequacy \* **ORGANIZATIONAL CATEGORIES**  Low Risk [What is this](#)

\* **DISCREPANCY**

\* **CORRECTIVE ACTIONS**

**COMMENTS**

Non Routine generated for this AD : **NR45656**

\* Required Field

Figure 34. Activity Data – Second Iteration

In the 'Activity data' page (Figure 34) the following fields were referred to as 'Required Fields': 'status', 'process measure', 'MX (Maintenance) Source', 'MX (Maintenance) Task', 'Aircraft level Impact', 'Organizational Categories', 'Discrepancy', and 'Corrective Actions'. This was done on the recommendation of the surveillance manager.

The screenshot shows a web application interface for 'Activity Data'. At the top, there are three tabs: 'Enter Data', 'View Data', and 'Reports'. Below the tabs is a navigation breadcrumb: 'Surveillance Schedule > Work Order Details > Surveillance Schedule Details > Activity Data'. The main form contains several fields: 'SITE' (MAE), 'WORKORDER #' (4580), 'Aircraft Tail Number' (7824), 'AD Number' (882), and 'AD TITLE' (Remove Panels - Major Zone 680). There are also radio buttons for 'STATUS' (ACCEPT, REJECT), dropdowns for 'PROCESS MEASURE' (Documentation Surveillance), 'MX TASK' (Restore(RS)), 'MX SOURCE' (Engineering Order Air Worthiness Directive(EO(AD))), 'AIRCRAFT LEVEL IMPACT' (Procedures and Paperwork Inadequacy), and 'ORGANIZATIONAL CATEGORIES' (Low Risk). A dropdown menu for 'AIRCRAFT LEVEL IMPACT' is open, showing options: 'Select One', 'Safety', 'Regulatory Compliance', 'Procedures and Paperwork Inadequacy', 'House-keeping', and 'Operational'. There are also fields for 'DISCREPANCY', 'CORRECTIVE ACTIONS', and 'COMMENTS' (testing). At the bottom, there is a note: 'Non Routine generated for this AD : NR45656' and a legend for '\* Required Field'. Buttons for 'Submit', 'Cancel', and 'Save and Add another Activity' are at the bottom.

Figure 35. Drop down indicating Aircraft Level Impact categories – Second Iteration

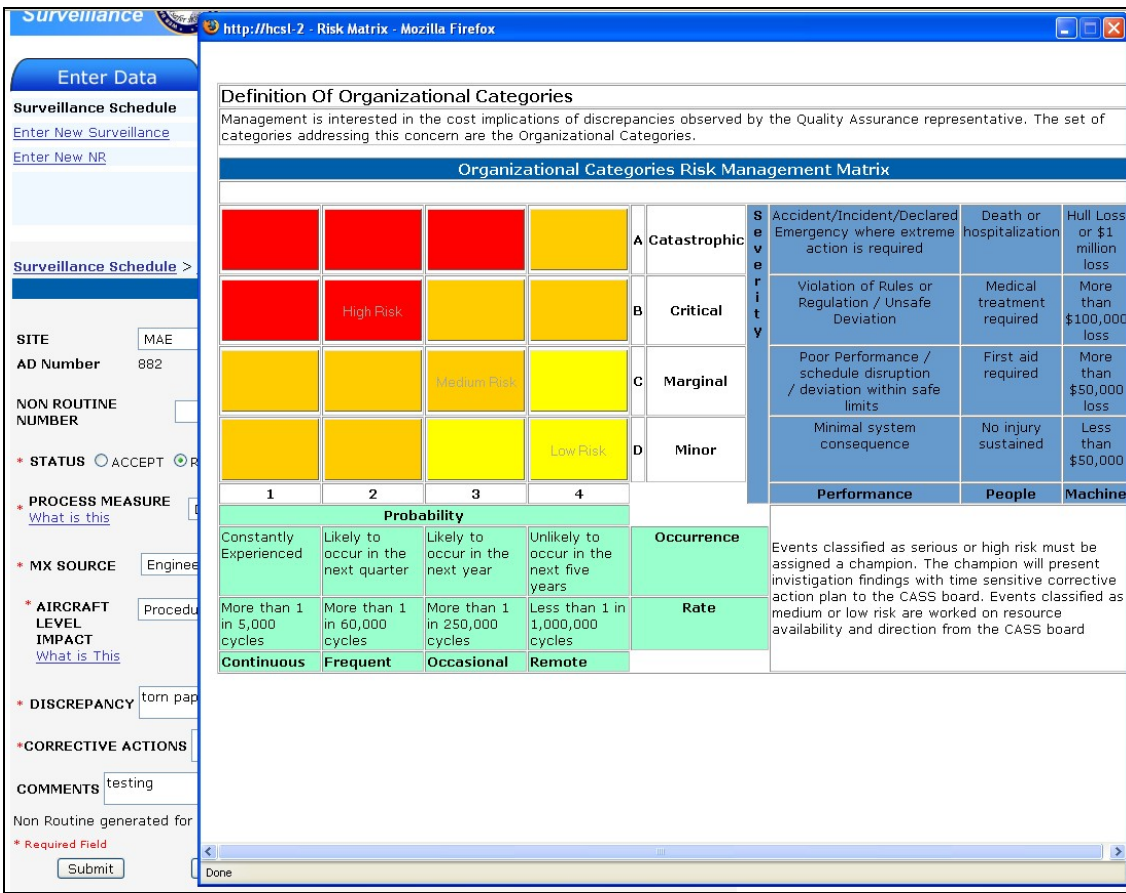


Figure 36. Risk matrix for Organizational Categories – Second Iteration

The team provided a link known as ‘What is this’ below the Organizational Categories text (Figure 35). This allows the user to look at the risk matrix to make an appropriate selection (Figure 36). Based on the manager’s recommendation, a drop down was provided to make an appropriate selection for the risk level associated with a finding (Figure 37). The managers wanted a drop down so that the surveillance personnel only referred to the risk matrix if they wanted to clarify information associated with their selection.

All of the auditors (eight) were accessible at Memphis, TN, but the product development team could meet only seven quality assurance representatives at Mobile,

AL, and Greensboro, NC, for user testing; the team could not meet with other quality assurance representatives because of logistical problems. Hence the acronyms ‘ALI’ and ‘OC’ were avoided on the surveillance modules to allow the quality assurance representatives to get used to the new terminology.

The screenshot shows a web application interface for 'Activity Data'. At the top, there is a breadcrumb trail: 'Surveillance Schedule > Work Order Details > Surveillance Schedule Details > Activity Data'. Below this is a blue header bar with the text 'Activity Data'. The form contains several fields and dropdown menus:

- SITE:** MAE (dropdown)
- WORKORDER #:** 4580
- Aircraft Tail Number:** 7824
- AD Number:** 882
- AD TITLE:** Remove Panels - Major Zone 680
- NON ROUTINE NUMBER:** (empty text box)
- \* STATUS:** Radio buttons for ACCEPT and REJECT (REJECT is selected).
- \* PROCESS MEASURE:** Documentation Surveillance (dropdown)
- \* MX TASK:** Restore(RS) (dropdown)
- \* MX SOURCE:** Engineering Order Air Worthiness Directive(EO(AD)) (dropdown)
- \* AIRCRAFT LEVEL IMPACT:** Procedures and Paperwork Inadequacy (dropdown)
- \* ORGANIZATIONAL CATEGORIES:** Low Risk (dropdown menu is open, showing options: Select One, High Risk, Medium Risk, Low Risk). 'Low Risk' is highlighted.
- \* DISCREPANCY:** torn papers (text box)
- \* CORRECTIVE ACTIONS:** (empty text box)
- COMMENTS:** testing (text box)

Below the form, there is a note: 'Non Routine generated for this AD : NR45656'. At the bottom, there are three buttons: 'Submit', 'Cancel', and 'Save and Add another Activity'. A legend indicates that an asterisk (\*) denotes a 'Required Field'.

Figure 37. Drop down indicating selected risk index for Organizational Categories-  
Second Iteration

### 8.13 Discussion

The marginally acceptable value to complete the classification task on WebSAT was < 2 minutes (< 120 seconds), and the ideal value was < 1 minute (< 60 seconds). The mean time required to complete the task was 57.26 seconds, which indicates that the users of WebSAT were able to use the web application very effectively.

Considering the fact that this was the first iteration, and the users were using the software for the first time, these are extremely promising results. Almost all users commented on the fact that the software was extremely easy to use, and that the tasks could be completed in a coherent sequence of steps. Taking into account the user feedback and the results from user testing, it is justified to conclude that the user will get used to the software quickly and that the time required to complete the tasks will decrease.

## CHAPTER 9

### CONCLUSIONS AND RECOMMENDATIONS

The research focus of this dissertation was the development of performance measures for aircraft level impact and organizational categories. Five phases formed the basis of this research. In the first phase audit and surveillance findings were presented to auditors and quality assurance representatives to uncover categories implying the 'effect' of maintenance findings on the safety of an aircraft. Five dimensions were uncovered. These dimensions are: Safety, Regulatory Compliance, Procedures and Paperwork Inadequacy, Operations, and House-keeping and storage.

In the second phase a linear regression approach was adopted to provide empirical evidence about the relevance of identified dimensions, and thus establish a final set of performance measures for aircraft level impact. Results from this stage established Safety, Procedures and Paperwork Inadequacy, Operations, and House-keeping and storage as relevant performance measures. The p-values for Regulatory Compliance were not conclusive. In the first phase of the research, dimension 2 (Regulatory Compliance) was better discriminated between items (open ended maintenance data) compared to dimension 3 (Paperwork and Procedures Inadequacy), dimension 4 (Operations), and dimension 5 (House-keeping and storage). Based on the loading values of the five dimensions and results from the second stage, it was concluded that the dimensions identified in the first phase of the research are interpreted as useful and meaningful by the quality assurance personnel.

In the third phase of the research the Participatory design approach was adopted to finalize a set of performance measures for Organizational Categories. Based on the insight provided by the Internal audits manager on the Risk Management Matrix, it was concluded that a 'risk' would be associated with each surveillance and audit finding. The 'risk' is determined based on the severity and the probability of occurrence of the finding

The fourth phase of the research then evaluated the utility of the categorization schemes. The first research hypothesis for this research was that the categorization schemes have an effect on prediction scores of the quality assurance representatives. The second research hypothesis stated that the reliability of allocation of responses within the cells of the Risk Management Matrix is higher for participants with information about the risk matrix, than for participants without information.

The dependent variable for the first research hypothesis was a prediction score. The independent variable is the availability of information on performance measures. A t-test was conducted on the prediction scores of participants with information and without information. It was concluded that the mean of prediction scores of the group with information on performance measures is higher.

The dependent variable for the second research hypothesis is the frequency of co-occurrence of a response within cells of the risk matrix. The frequency of co-occurrence was a measure of reliability. It was assumed that there is more agreement on allocation of responses between participants with information on performance measures for Organizational Categories. The independent variable was the availability of information on performance measures for Organizational Categories at two levels, available and not available.

There is a bias region for allocation of responses within the cells of the risk matrix for the participants without information on performance measures. In the absence of any information, the group without information made biased allocations. This bias region was eliminated and then analysis concluded that there is a higher degree of agreement between participants with information while allocating responses within cells of the risk matrix. The participants in the no information group took 2.22 more minutes than participants in the information group to make allocations for the task given to them. The time required to complete the task is 11.14 % is higher for the no information group.

The final phase of the research evaluated the interface on which the categorization schemes were used by auditors, quality assurance representatives, and managers. The marginally acceptable value of the time required categorizing surveillance or an audit finding in terms of Aircraft Level Impact and Organizational Categories in WebSAT was < 2 minutes (< 120 seconds). The ideal value to complete the task was < 1 minute (< 60 seconds). The mean time required to complete the task was 57.26 seconds. The time required to complete the task is lower than the ideal value. This indicates that the users of WebSAT were able to use WebSAT very effectively.

### 9.1 Relevance of this research

Previous research strategies (Helmreich, 2000, and Sarter, 2000) have depended on reacting to documented information once a maintenance incident is reported. Such a reactive strategy does not allow maintenance personnel to uncover or predict problematic trends to prevent a maintenance incident from occurring.



Organizations often have access to maintenance data, but seldom do maintenance managers receive information which is structured. It is important to process data to obtain useful insights on maintenance. Given the importance and availability of open-ended maintenance data in the quality assurance department, the data required interpretation to ensure their appropriate application in the maintenance and inspection process. It was important to associate this data with appropriate performance measures. The stakeholders required performance measures at two levels: the impact of maintenance findings on the safety of an aircraft, and the impact on the organization.

This research focused on transforming qualitative maintenance data into useful performance measures of aircraft safety and organizational cost. To accomplish such a transformation, it was important to assign an appropriate performance measure to qualitative maintenance data.

MDS was used to establish performance measures to classify the impact of maintenance findings on the safety of an aircraft. These categories are referred to as Aircraft Level Impact categories.

It was not possible to use a strategy such as MDS to establish organizational categories because there were only three managers the researcher had access to. A statistical technique such as MDS would not be effective with such a small group of participants.

To identify performance measures to classify maintenance findings the expertise of managers was required. The method of Participatory Design (PD) was adopted for this purpose. The advantage of this design methodology revolves around the concept that users and designers have equal significance in the development of the product.

Some of the main strengths of the methodologies adopted for this research are noted below:

1. They utilized the expertise of auditors and quality assurance representatives to classify open ended maintenance data to establish performance measures to indicate the impact of maintenance findings on the safety of an aircraft.
2. They did not assume any structure of the qualitative maintenance data.
3. They utilized the expertise of quality assurance managers to establish performance measures for organizational impact of maintenance findings.
4. They involved the stakeholders indirectly (MDS) and directly (PD) to establish performance measures. The constant involvement of stakeholders at various stages of the research provided the researcher with deeper insight and understanding about the stakeholder needs.

Although the adopted research strategy has advantages, there is a precautionary note mentioned below:

There were three hundred and four open ended maintenance findings which were sorted into categories by auditors and quality assurance representatives to help establish performance measures for aircraft safety. The mean time required to complete the sorting task was 107.33 minutes. The auditors were at the headquarters in Memphis, TN. The quality assurance representatives the researcher had access to were at maintenance facilities in Greensboro, NC, and Mobile, AL. The geographical distance between the research laboratory in Clemson, SC, and the stakeholders made conducting these studies difficult.

This research is unique since it allows auditors, quality assurance representatives, and quality assurance managers to categorize qualitative maintenance data to indicate the impact on the safety of aircraft and to associate a risk with a maintenance finding during the course of an audit or surveillance.

One of the requirements of WebSAT was to reduce data. Open ended responses are a rich source of documented information. The current research utilized qualitative data to establish performance measures. The focus of the research was aircraft maintenance data. The researcher strongly recommends this strategy for work domains which have qualitative data sets, the resolution of which would allow insights into system performance. Once performance measures are established and validated, web applications can allow users to categorize information, as was the case for users of WebSAT.

It would be useful to involve stakeholders to validate performance measures.

### 9.2 Suggestions for Future Research

This research applied MDS and PD to aircraft maintenance data available with maintenance locations associated with our industry partner to establish performance measures. It would be useful if maintenance data was gathered from other organizations which have documented maintenance data. Further it would be useful to validate the established performance measures with quality assurance personnel from other aircraft maintenance organizations.

Because of logistical problems the research phase to validate the utility of classification schemes was done in a laboratory setting with undergraduate and graduate

students at Clemson University. It would be beneficial to involve stakeholders for this phase of the research.

## **APPENDICES**

## Appendix A

### **Information Concerning Participation in a Research Study Clemson University**

Development of the Technical Audits Module Prototype for the Standardized Web-Based Surveillance and Auditing Tool to Analyze Aircraft Maintenance Operations

#### **Description of the research and your participation**

You are invited to participate in a research study conducted by Dr. Joel S. Greenstein, Dr. Anand K. Gramopadhye, and Kunal Kapoor. The purpose of this study is to categorize open ended maintenance data into useful performance metrics that impact the safety of an aircraft and the cost of aircraft maintenance operations to the organization.

The study focuses on the open ended maintenance responses documented by auditors and quality assurance representatives during auditing and surveillance. You will be asked to sort these responses into categories. You will be asked to do two different categorizations, in two different sessions. In the first session, you will be asked to sort the open ended responses in terms of the impact these findings have on the safety of an aircraft. In the second session, you will be asked to categorize the same responses in terms of the impact they have on the cost to your organization. There will be at least twenty people involved from your organization in this study. The other participants will be auditors, quality assurance representatives, or managers from the Quality Assurance department of your organization.

The amount of time required for your participation will be approximately four hours. The study will be conducted in two two-hour sessions.

#### **Risks and discomforts**

There are no known risks associated with this research.

#### **Potential benefits**

This research may help us to understand the implications of open ended maintenance data on the safety of aircraft and the cost to your organization.

#### **Protection of confidentiality**

We will do everything we can to protect your privacy. Your identity will not be revealed in any publication that might result from this study. The results of each individual's participation will be strictly confidential. No names or individual identifying information will be maintained. With the exception of the researchers involved in running this study, nobody will be allowed to see or discuss any of the individual responses. Your responses

will be combined with many others and reported in group form in any professional articles that may result from this research.

**Voluntary participation**

Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

**Contact information**

If you have any questions or concerns about this study or if any problems arise, please contact Dr. Anand K. Gramopadhye at Clemson University at 864.656.5540. If you have any questions or concerns about your rights as a research participant, please contact the Clemson University Office of Research Compliance at 864.656.6460.

Appendix B

Response Loading for Four Dimensions

Response	Dimension			
	1	2	3	4
V1	-0.63574	0.49506682	-0.28979	0.268781
V2	-0.82798	0.62616966	-0.04307	-0.13763
V3	-0.6844	0.50375061	-0.46546	-0.01585
V4	-0.56418	0.54565424	-0.30971	0.125777
V5	-0.6469	0.54360387	-0.35057	0.194922
V6	-0.63413	0.49705178	-0.31508	0.245755
V7	-0.73061	0.34478991	-0.54943	-0.10493
V8	-0.61274	0.45388214	-0.36573	-0.20238
V9	-0.62466	0.52798033	-0.34136	-0.12077
V10	-0.81272	0.35637143	-0.36174	0.210871
V11	-0.84303	0.1505577	-0.36745	0.388959
V12	-0.81244	0.18501894	-0.39558	0.305068
V13	-0.78329	0.30684833	-0.46001	-0.15578
V14	-0.70834	0.4268039	-0.2566	0.143123
V15	-0.7679	0.27942611	-0.32025	-0.50394
V16	-0.83709	0.23646202	-0.38987	0.01963
V17	-0.66564	0.47211414	-0.24885	0.112426
V18	-0.68595	0.43530972	-0.23535	-0.12296
V19	-0.7477	0.40013116	-0.308	-0.16609
V20	-0.64914	0.49191497	-0.22231	-0.20252
V21	-0.66357	0.40529005	-0.2024	-0.20119
V22	-0.65336	0.54709652	-0.20973	0.161426
V23	-0.73219	0.41263214	-0.23026	-0.14732
V24	-0.81522	0.38375945	-0.34631	-0.08952
V25	-0.82169	0.22615407	-0.23208	-0.29834
V26	-0.74215	0.24390947	-0.30945	-0.41697
V27	-0.84493	0.3076089	-0.0922	-0.24523
V28	-0.99734	-0.0574711	0.026307	-0.04272
V29	-0.82518	0.21725834	-0.02003	-0.31026
V30	-0.90288	0.15087623	0.476427	-0.11813
V31	-0.62169	0.52602184	-0.03002	0.011147
V32	-0.50919	0.64022703	-0.01806	-0.10881
V33	-0.65195	0.44326447	-0.00598	0.092195
V34	-0.65395	0.46395135	0.006854	0.05047
V35	-0.63037	0.48805732	-0.05076	0.150135
V36	-0.65986	0.43500028	-0.04741	0.165492
V37	-0.87072	0.27295378	0.046482	0.102402
V38	-0.79916	0.29890758	0.047148	0.099538
V39	-0.70821	0.37330399	0.079403	-0.17163



V40	-0.76941	0.33513025	0.06633	-0.12025
V41	-0.67303	0.48837046	0.098869	-0.18766
V42	-0.70272	0.47362832	0.034152	0.167336
V43	-0.78491	0.25901667	0.124722	0.133597
V44	-0.8134	0.27134328	0.030502	0.167636
V45	-0.814	0.27089197	0.031274	0.165195
V46	-0.71104	0.33088108	0.087818	0.146652
V47	-0.91736	-0.0730976	0.11337	0.134028
V48	-0.89735	-0.0874961	0.046999	0.380318
V49	-0.73592	0.20531303	0.238401	0.126791
V50	-0.85713	-0.0225608	0.195359	0.292376
V51	-0.62259	0.33596391	0.206968	0.149076
V52	-0.58321	0.38830085	0.173762	0.227614
V53	-0.60185	0.38092931	0.141549	0.247092
V54	-0.70255	0.30904448	0.217788	-0.03017
V55	-0.62426	0.37912144	0.203562	0.169248
V56	-0.63097	0.25910287	0.267998	-0.07556
V57	-0.59409	0.26742777	0.270215	0.104831
V58	-0.59778	0.31832857	0.19121	0.215295
V59	-0.53446	0.30568256	0.250632	0.138313
V60	-0.60734	0.1381726	0.279185	-0.15088
V61	-0.50716	0.27382536	0.257564	-0.07389
V62	-0.48674	0.33114081	0.234327	-0.02976
V63	-0.47334	0.4510182	0.105519	0.274678
V64	-0.59279	0.32981671	0.119778	0.308449
V65	-0.55598	0.36269405	0.121245	0.294091
V66	-0.57772	0.33579519	0.259623	0.032775
V67	-0.69084	0.11076179	0.259909	0.225755
V68	-0.57114	0.25789117	0.251675	0.233616
V69	-0.52885	0.40827218	0.190399	0.018406
V70	-0.5505	0.3440312	0.105329	0.314392
V71	-0.5027	0.33180379	0.162774	0.23206
V72	-0.48409	0.47042989	0.169107	0.096504
V73	-0.53766	0.10566963	0.203077	-0.29689
V74	-0.52892	0.41241668	0.192639	0.075527
V75	-0.5686	0.03360908	0.319007	0.055841
V76	-0.43109	-0.0308791	0.219817	-0.28374
V77	-0.43256	-0.0919012	0.180102	-0.35337
V78	-0.44823	-0.0723741	0.195701	-0.32933
V79	-0.41698	-0.0160924	0.212223	-0.22997
V80	-0.50549	-0.0206323	0.217446	-0.29487
V81	-0.40844	0.15775864	0.134118	-0.34008
V82	-0.55466	-0.1577466	0.073037	-0.31758
V83	-0.41892	0.06485719	0.134831	-0.34794
V84	-0.3748	-0.0964489	0.094453	-0.35436
V85	-0.48406	-0.1873737	0.112799	-0.35632
V86	-0.38457	0.0529438	0.122191	-0.35988

V87	-0.37622	-0.0588895	0.163844	-0.29929
V88	-0.43907	0.13145901	0.183496	0.025985
V89	-0.52177	-0.2005873	0.322816	-0.13106
V90	-0.49993	0.00263065	-0.17693	0.250004
V91	-0.50561	-0.1773366	0.37725	0.092993
V92	-0.41804	-0.2913399	0.141459	-0.31755
V93	-0.43831	-0.0080586	-0.02985	-0.18108
V94	-0.48198	-0.0271659	0.111963	0.333479
V95	-0.54589	-0.3043959	0.0382	-0.15769
V96	-0.55434	-0.2936422	-0.05198	-0.19495
V97	-0.45182	-0.293134	-0.06696	-0.27876
V98	-0.44388	-0.28537	0.06757	-0.27653
V99	-0.46453	-0.3155434	-0.08066	-0.26797
V100	-0.48271	-0.2775003	0.308999	0.230097
V101	-0.50663	-0.3837624	-0.05944	-0.18108
V102	-0.56294	-0.3898998	0.193822	0.232589
V103	-0.37358	-0.3470884	-0.02424	-0.32222
V104	-0.36515	-0.3276875	0.229326	-0.19866
V105	-0.40948	-0.2997295	0.165825	-0.21115
V106	-0.35502	-0.252071	0.342304	-0.00935
V107	-0.32392	-0.3478209	-0.00203	-0.33078
V108	-0.38599	-0.3034822	-0.08994	-0.31235
V109	-0.42955	-0.3527579	0.292957	0.146278
V110	-0.40957	-0.3211068	-0.18231	-0.21002
V111	-0.4196	-0.3422691	-0.11447	-0.15581
V112	-0.29292	-0.389175	-0.01416	-0.30874
V113	-0.28876	-0.2719076	-0.0675	-0.28304
V114	-0.39868	-0.4504904	-0.16326	-0.08503
V115	-0.34623	-0.4125295	0.244859	-0.04433
V116	-0.37758	-0.4488546	-0.1427	-0.09025
V117	-0.29752	-0.3855717	0.205604	-0.18354
V118	-0.32409	-0.4362685	-0.15621	-0.20866
V119	-0.29032	-0.4038442	-0.14076	-0.20288
V120	-0.33672	-0.450168	0.20126	0.034604
V121	-0.36749	-0.4924486	-0.16688	-0.03153
V122	-0.41463	-0.5296336	0.014285	0.132321
V123	-0.33965	-0.5024401	0.133639	-0.01051
V124	-0.29857	-0.4862583	-0.16904	-0.09946
V125	-0.39157	-0.5510528	0.086131	0.285616
V126	-0.36625	-0.5451602	0.109006	0.23
V127	-0.38298	-0.5493795	0.097578	0.2671
V128	-0.20055	-0.4806983	-0.01541	-0.19213
V129	-0.32069	-0.5048217	0.172155	0.246574
V130	-0.28133	-0.5226764	0.159303	0.043194
V131	-0.22902	-0.531457	-0.00354	-0.07986
V132	-0.42936	-0.582561	-0.13323	0.217841
V133	-0.25678	-0.5483606	-0.11925	0.06896

V134	-0.24266	-0.4645783	0.119553	0.289564
V135	-0.25011	-0.4897864	-0.1112	0.220448
V136	-0.28134	-0.5830103	0.085034	0.289049
V137	-0.20139	-0.602634	-0.02805	-0.0054
V138	-0.14016	-0.4821112	0.156242	0.057658
V139	-0.17439	-0.4875558	0.193745	0.25825
V140	-0.17276	-0.5767755	0.022816	0.062348
V141	-0.16718	-0.5366963	-0.03016	0.166538
V142	-0.21398	-0.6002165	0.121738	0.277234
V143	-0.23213	-0.6116273	0.093768	0.307812
V144	-0.08282	-0.5851894	0.097081	-0.04677
V145	-0.06433	-0.51129	0.222045	0.038373
V146	-0.11333	-0.5996151	0.135691	0.088652
V147	-0.02032	-0.5285927	0.139162	-0.01567
V148	-0.03972	-0.5669015	0.099198	-0.00412
V149	-0.03903	-0.5038801	0.133574	0.13914
V150	-0.06	-0.6148597	0.085816	-0.03041
V151	-0.05506	-0.6237285	0.04746	-0.02596
V152	0.012771	-0.5381668	0.1244	-0.08957
V153	-0.08816	-0.6248807	0.157156	0.203609
V154	0.027748	-0.4669237	0.242732	0.080486
V155	0.116976	-0.2699694	0.275417	0.206866
V156	0.128477	-0.3984584	0.136957	-0.12075
V157	0.127628	-0.4019786	0.194909	-0.00417
V158	0.169229	-0.3316322	0.177866	-0.06464
V159	0.134565	-0.4013921	0.191563	-0.08757
V160	0.201448	-0.3025354	0.159635	-0.07286
V161	0.154604	-0.2881687	0.165998	0.236963
V162	0.233873	-0.1780301	0.179882	0.186758
V163	0.133706	-0.484834	0.100922	-0.15037
V164	0.2197	-0.2445571	0.223874	0.088797
V165	0.231733	-0.2323823	0.2645	-0.01706
V166	0.205845	-0.2034377	0.074839	0.320195
V167	0.238482	-0.266979	0.10395	-0.13862
V168	0.107095	-0.4923585	-0.18399	0.103082
V169	0.199038	-0.2247858	0.006755	0.340997
V170	0.230134	-0.3189755	0.000617	-0.19052
V171	0.212943	-0.2533836	0.119077	0.317328
V172	0.202287	-0.429131	-0.0337	0.093946
V173	0.292187	-0.2375508	0.063887	-0.06296
V174	0.224271	-0.372898	-0.06264	-0.2068
V175	0.208444	-0.2468439	-0.21548	0.221661
V176	0.296489	-0.0696272	0.163419	0.30572
V177	0.256988	-0.3871779	-0.00889	-0.19608
V178	0.235198	-0.3328963	-0.09924	0.210285
V179	0.282834	-0.1254408	0.023681	0.347772
V180	0.319036	-0.1048526	0.168404	0.090676

V181	0.295966	-0.1644598	0.029989	0.294154
V182	0.311199	-0.1941918	-0.05578	-0.15708
V183	0.256738	-0.2545931	-0.15226	0.261927
V184	0.212092	-0.3791651	-0.30183	0.126917
V185	0.313789	-0.1281129	-0.04174	0.322151
V186	0.32016	-0.3572445	-0.10682	0.088823
V187	0.268313	-0.2166214	-0.29902	-0.09318
V188	0.244769	-0.2551568	-0.35325	-0.07205
V189	0.255167	-0.4005199	-0.30268	0.048597
V190	0.264422	-0.3699048	-0.32761	0.071894
V191	0.295352	-0.2555768	-0.23088	0.288618
V192	0.300476	-0.1358332	-0.35289	0.081053
V193	0.334244	-0.1310121	-0.2075	-0.22362
V194	0.271805	-0.2470538	-0.38692	0.125835
V195	0.33763	-0.1381588	-0.27559	0.211581
V196	0.320317	-0.3127465	-0.29798	-0.15539
V197	0.313561	-0.3499414	-0.34131	-0.02315
V198	0.30876	-0.3329188	-0.35706	-0.14881
V199	0.338251	-0.2610022	-0.28774	-0.21323
V200	0.30679	-0.3228138	-0.40414	-0.01745
V201	0.350472	-0.3042381	-0.33836	-0.11638
V202	0.326312	-0.3414065	-0.39504	-0.05165
V203	0.394676	-0.1497085	-0.27883	-0.18032
V204	0.40518	-0.1102954	-0.26129	-0.21552
V205	0.38852	-0.3869553	-0.30047	-0.07936
V206	0.411386	-0.1660226	-0.27711	-0.17898
V207	0.412432	-0.3480207	-0.26367	-0.16003
V208	0.431687	-0.2505497	-0.21873	-0.25874
V209	0.469284	-0.006438	-0.20839	-0.179
V210	0.477876	-0.1830421	-0.20323	-0.12584
V211	0.503321	0.10031442	-0.16656	-0.05067
V212	0.504193	0.04006627	-0.17927	-0.06543
V213	0.510272	0.14272768	-0.15941	-0.02516
V214	0.486712	-0.0771277	-0.27463	0.057796
V215	0.507625	0.07014661	-0.22747	0.082425
V216	0.527447	-0.1109312	-0.13758	0.124696
V217	0.474938	0.04995142	-0.30165	-0.12372
V218	0.535745	0.06020025	-0.14435	-0.01132
V219	0.523079	0.17098316	-0.14069	-0.00773
V220	0.553274	-0.0715878	-0.1127	0.066077
V221	0.526153	0.16426589	-0.17461	0.09718
V222	0.52562	0.15816752	-0.1614	0.062055
V223	0.526853	0.14437464	-0.20016	0.096976
V224	0.534	0.17951755	-0.14984	0.093935
V225	0.532274	0.19519535	-0.13344	0.147098
V226	0.539367	0.15916569	-0.14345	0.137619
V227	0.533787	0.16274874	-0.18224	0.123485

V228	0.540711	0.0898997	-0.14321	0.212617
V229	0.512849	0.10564881	-0.33817	0.092479
V230	0.538483	0.0898457	-0.30323	-0.05237
V231	0.584962	0.00776818	-0.12674	-0.22751
V232	0.550828	0.20064476	-0.13352	0.20385
V233	0.597401	-0.0113559	-0.23244	-0.15244
V234	0.573485	0.07752208	-0.26344	0.121835
V235	0.582742	0.16608077	-0.18783	0.002469
V236	0.555894	0.13034259	-0.32162	-0.00144
V237	0.578549	0.15650278	-0.20554	0.185506
V238	0.586712	0.22048389	-0.09706	0.062402
V239	0.583016	0.19581375	-0.1376	0.198879
V240	0.56516	0.24073226	-0.26847	-0.02749
V241	0.583768	0.22819855	-0.18212	0.140332
V242	0.588945	0.21085054	-0.20102	0.17901
V243	0.582213	0.19382132	-0.28822	0.080816
V244	0.597122	0.14135899	-0.32067	-0.08502
V245	0.609929	0.19828387	-0.19771	-0.13989
V246	0.62494	0.18084602	-0.2367	0.063605
V247	0.622262	0.17800301	-0.26592	0.058798
V248	0.646773	0.14888956	-0.18216	-0.17796
V249	0.668939	0.09712799	-0.22755	-0.12934
V250	0.662554	0.12313321	-0.13292	-0.20341
V251	0.630851	0.25605731	-0.21971	-0.07835
V252	0.637105	0.30553099	-0.14371	0.061881
V253	0.642749	0.29763127	-0.1463	0.058018
V254	0.641082	0.31458478	-0.12633	0.022121
V255	0.676981	0.23471045	-0.11913	0.126726
V256	0.727849	-0.0092643	-0.03667	0.260996
V257	0.725768	0.01793395	0.023196	0.220861
V258	0.651475	0.27885712	-0.03711	0.232243
V259	0.666448	0.29490949	0.00463	0.141048
V260	0.733197	0.12004104	-0.06096	0.182081
V261	0.720536	0.23693775	-0.06227	-0.03739
V262	0.678443	0.29694995	0.001871	0.177093
V263	0.739261	0.17823091	-0.011	-0.09405
V264	0.695276	0.26404148	0.019472	0.192511
V265	0.70249	0.24876795	0.032841	0.196676
V266	0.773191	0.1475951	0.004455	0.087302
V267	0.746131	0.13239572	0.107986	0.193052
V268	0.756273	0.20683273	0.037777	-0.06091
V269	0.7534	0.09843199	0.151522	0.229059
V270	0.737621	0.18303107	0.139095	0.186242
V271	0.800841	0.10938479	0.067461	-0.07639
V272	0.784739	0.13612579	0.129394	-0.031
V273	0.787612	0.13669902	0.101531	-0.11322
V274	0.784423	0.07872446	0.223714	0.068394

V275	0.811419	0.04905009	0.173432	-0.05528
V276	0.765808	0.18580816	0.224922	0.002295
V277	0.76135	0.18554681	0.250255	-0.01086
V278	0.763871	0.15567964	0.28036	0.031951
V279	0.785835	0.09681587	0.259892	-0.1305
V280	0.76579	0.15110662	0.30471	-0.02871
V281	0.754805	0.18681208	0.332542	-0.00976
V282	0.748303	0.22922345	0.32408	0.033142
V283	0.747884	0.2313643	0.32522	0.036295
V284	0.738384	0.32375452	0.276054	-0.0284
V285	0.741183	0.3230733	0.270392	-0.05088
V286	0.739549	0.32329869	0.289509	0.003555
V287	0.733891	0.31540152	0.32359	0.016082
V288	0.733413	0.31998539	0.326886	-0.00912
V289	0.743969	0.23742739	0.399867	-0.02831
V290	0.736896	0.33532565	0.30919	-0.11419
V291	0.73178	0.36101562	0.30345	-0.11784
V292	0.726861	0.37807798	0.316268	-0.07332
V293	0.725993	0.37598481	0.326214	-0.07611
V294	0.724686	0.39722751	0.306041	-0.10736
V295	0.731579	0.3909919	0.284505	-0.16896
V296	0.723849	0.38582283	0.333783	-0.15036
V297	0.730491	0.40048974	0.280773	-0.19944
V298	0.731752	0.35783139	0.337981	-0.21572
V299	0.733727	0.38208541	0.289992	-0.26431
V300	0.735583	0.36896138	0.29715	-0.28018
V301	0.73193	0.38498797	0.294762	-0.28188
V302	0.730566	0.36473663	0.333334	-0.28812
V303	0.728524	0.3841328	0.312882	-0.30515
V304	0.728781	0.3870354	0.307636	-0.31781

## Appendix C

### Response Loading for Five Dimensions

<b>Response</b>	<b>Dimension</b>				
	1	2	3	4	5
V1	-0.6471	0.475679	0.2659954	0.165569	-0.25508
V2	-0.82571	0.623898	-0.005516	-0.12372	0.065698
V3	-0.69702	0.477887	0.4683325	-0.04467	0.021434
V4	-0.5749	0.51849	0.1868693	0.033158	-0.31661
V5	-0.66009	0.518216	0.3665888	0.121351	-0.13902
V6	-0.64453	0.481975	0.280511	0.138043	-0.25807
V7	-0.73627	0.338468	0.5121956	-0.06141	0.197625
V8	-0.61809	0.458817	0.2245352	-0.27448	-0.20169
V9	-0.63319	0.51866	0.2825177	-0.18402	-0.12984
V10	-0.8193	0.338864	0.3697852	0.131348	-0.14657
V11	-0.83206	0.226085	-0.092957	0.00622	-0.52139
V12	-0.79974	0.227419	0.1095488	0.095269	-0.48515
V13	-0.78401	0.31053	0.407309	-0.22018	-0.12564
V14	-0.70442	0.424497	0.130926	0.057944	-0.28285
V15	-0.77012	0.295841	0.135639	-0.56109	-0.08076
V16	-0.81826	0.279852	0.1433416	-0.12012	-0.35886
V17	-0.66659	0.458572	0.1361743	0.037686	-0.27206
V18	-0.69051	0.430078	0.1156958	-0.16684	-0.18503
V19	-0.75095	0.396187	0.2385988	-0.21873	-0.12711
V20	-0.65631	0.488331	0.1466854	-0.23768	-0.08579
V21	-0.66948	0.405856	0.075004	-0.22472	-0.15346
V22	-0.66235	0.523787	0.2558156	0.089359	-0.08228
V23	-0.73576	0.407281	0.1565176	-0.1856	-0.13013
V24	-0.79527	0.379704	0.3665524	-0.0953	0.105221
V25	-0.80988	0.233801	0.2082789	-0.32488	0.065738
V26	-0.73351	0.244095	0.2999192	-0.41269	0.131926
V27	-0.81115	0.30113	0.1457308	-0.20961	0.229205
V28	-0.85158	-0.01757	0.1794365	0.042918	0.452806
V29	-0.8146	0.225102	-0.013289	-0.28805	0.149491
V30	-0.85823	0.140032	-0.263518	0.023917	0.480791
V31	-0.62806	0.513254	-0.020473	0.018534	-0.09872
V32	-0.52362	0.581987	0.1565361	-0.04034	0.203006
V33	-0.65813	0.431097	-0.024017	0.094917	-0.09199
V34	-0.65893	0.456728	-0.009577	0.062617	-0.02413
V35	-0.63712	0.470414	0.1136881	0.142886	0.014694
V36	-0.66701	0.424207	0.0732803	0.155694	-0.0538
V37	-0.83501	0.261276	0.0752252	0.142175	0.203267
V38	-0.79274	0.282712	0.0246877	0.139387	0.092943
V39	-0.70131	0.36132	-0.038095	-0.10908	0.192022

V40	-0.75107	0.31779	0.0170782	-0.05584	0.217729
V41	-0.66822	0.415352	0.0997524	-0.04694	0.311915
V42	-0.68367	0.425264	0.125661	0.166411	0.205337
V43	-0.77079	0.246868	-0.04145	0.178513	0.148889
V44	-0.79097	0.259408	0.0864022	0.188024	0.144486
V45	-0.7913	0.259006	0.0854834	0.186184	0.146043
V46	-0.70405	0.319559	-0.011261	0.181987	0.102389
V47	-0.8712	-0.07377	0.032011	0.173213	0.260009
V48	-0.85384	-0.08175	0.1550766	0.360887	0.233049
V49	-0.7351	0.202377	-0.185709	0.17003	0.095834
V50	-0.83689	-0.03131	-0.066184	0.329016	0.18716
V51	-0.62624	0.331959	-0.161658	0.188543	0.042021
V52	-0.58979	0.376704	-0.113486	0.260811	0.035415
V53	-0.60737	0.367321	-0.06964	0.277453	0.03923
V54	-0.68051	0.279931	-0.072782	0.071188	0.273625
V55	-0.62613	0.360336	-0.124039	0.224575	0.105988
V56	-0.63953	0.26197	-0.257049	-0.01269	0.026057
V57	-0.60402	0.26919	-0.230921	0.141602	-0.01508
V58	-0.60598	0.31974	-0.159461	0.219152	-0.05203
V59	-0.54363	0.309325	-0.214422	0.162947	-0.03999
V60	-0.61276	0.144197	-0.287509	-0.09034	0.052783
V61	-0.51728	0.274606	-0.25724	-0.01963	-0.03589
V62	-0.49671	0.330427	-0.229669	0.022618	-0.00272
V63	-0.48315	0.439536	-0.039192	0.294765	-0.00884
V64	-0.60135	0.320957	-0.07437	0.314195	-0.06042
V65	-0.56659	0.352849	-0.100143	0.285197	-0.10237
V66	-0.57469	0.308826	-0.177326	0.117937	0.210803
V67	-0.70118	0.111276	-0.239508	0.22591	-0.03535
V68	-0.58171	0.258498	-0.22267	0.242129	-0.04847
V69	-0.53627	0.383215	-0.105804	0.093707	0.167749
V70	-0.56113	0.329454	-0.030316	0.330092	0.013323
V71	-0.51175	0.330321	-0.137432	0.240832	-0.04714
V72	-0.49779	0.428844	-0.044237	0.159164	0.187864
V73	-0.53444	0.083678	-0.171266	-0.20188	0.253978
V74	-0.54735	0.301616	-0.002568	0.139982	0.31185
V75	-0.57518	0.042802	-0.306393	0.076535	-0.06214
V76	-0.4352	-0.02581	-0.251806	-0.23891	0.069363
V77	-0.43658	-0.08804	-0.226064	-0.30878	0.075816
V78	-0.45151	-0.0593	-0.253522	-0.28277	-0.02519
V79	-0.42092	-0.00762	-0.246067	-0.19712	-0.03604
V80	-0.50505	-0.0224	-0.233376	-0.243	0.138853
V81	-0.41336	0.148764	-0.145675	-0.28337	0.177516
V82	-0.5472	-0.16466	-0.07469	-0.28516	0.146446
V83	-0.42287	0.054826	-0.161936	-0.29436	0.159397
V84	-0.37547	-0.08772	-0.172257	-0.32899	-0.02148
V85	-0.48044	-0.19254	-0.105957	-0.30185	0.180809
V86	-0.38928	0.041664	-0.147668	-0.30852	0.163199



V87	-0.37774	-0.05211	-0.221062	-0.26627	0.023533
V88	-0.43211	0.140394	-0.255616	0.003226	-0.20102
V89	-0.52289	-0.19463	-0.338156	-0.08603	0.038094
V90	-0.48434	0.016773	0.0576673	0.114952	-0.34838
V91	-0.50584	-0.17199	-0.376863	0.119558	0.001534
V92	-0.41889	-0.28861	-0.148974	-0.28586	0.113086
V93	-0.40057	0.004377	-0.186453	-0.14538	-0.28597
V94	-0.47638	-0.01824	-0.167595	0.255379	-0.23895
V95	-0.53989	-0.29838	-0.069897	-0.17829	-0.0407
V96	-0.54708	-0.29004	0.0073782	-0.22493	-0.0308
V97	-0.4425	-0.28608	0.0043564	-0.30344	-0.05442
V98	-0.43606	-0.26836	-0.129914	-0.27707	-0.07317
V99	-0.45554	-0.30709	0.0280844	-0.29487	-0.04571
V100	-0.48046	-0.27876	-0.306478	0.243176	-0.01156
V101	-0.49573	-0.37291	0.050097	-0.19947	0.076692
V102	-0.56075	-0.39062	-0.186579	0.242146	-0.02513
V103	-0.37465	-0.33996	0.0123926	-0.29199	0.123678
V104	-0.36538	-0.32622	-0.240801	-0.17061	0.066537
V105	-0.38531	-0.25097	-0.215151	-0.17318	-0.22755
V106	-0.35048	-0.24805	-0.353126	0.010716	-0.03652
V107	-0.31963	-0.33546	-0.06029	-0.3358	-0.04896
V108	-0.37156	-0.28749	-0.055649	-0.31829	-0.16994
V109	-0.42249	-0.34968	-0.304386	0.145478	-0.07718
V110	-0.36343	-0.27959	-0.123571	-0.20321	-0.31792
V111	-0.35787	-0.27923	-0.152243	-0.17287	-0.31392
V112	-0.2921	-0.37698	-0.023465	-0.31789	0.010721
V113	-0.27152	-0.25072	-0.112301	-0.2293	-0.25408
V114	-0.39748	-0.44697	0.130683	-0.13492	-0.02262
V115	-0.34242	-0.4129	-0.251634	-0.0243	0.006133
V116	-0.37603	-0.44493	0.1108868	-0.13856	-0.00644
V117	-0.2975	-0.38109	-0.205876	-0.14905	0.115207
V118	-0.32048	-0.42398	0.101396	-0.25573	-0.04174
V119	-0.28281	-0.38836	0.0556382	-0.24307	-0.14265
V120	-0.32037	-0.43863	-0.208516	0.013877	-0.15513
V121	-0.36736	-0.48974	0.1428696	-0.08194	-0.05153
V122	-0.40999	-0.52919	-0.024815	0.109477	-0.09706
V123	-0.33107	-0.49839	-0.153706	-0.01346	-0.06085
V124	-0.29881	-0.47871	0.1418689	-0.1481	-0.03516
V125	-0.39062	-0.55398	-0.04834	0.282803	-0.0196
V126	-0.36293	-0.54666	-0.09335	0.23063	-0.03501
V127	-0.38126	-0.55161	-0.066991	0.26676	-0.02456
V128	-0.18689	-0.44992	-0.050717	-0.20145	-0.17235
V129	-0.31753	-0.50757	-0.143184	0.25744	0.018418
V130	-0.27139	-0.51947	-0.174806	0.042307	-0.05999
V131	-0.21136	-0.50205	-0.050106	-0.09261	-0.19005
V132	-0.43079	-0.58267	0.1554487	0.183133	-0.04759
V133	-0.26055	-0.54534	0.1234005	0.04403	0.011402

V134	-0.23396	-0.47326	-0.137043	0.228861	-0.17925
V135	-0.24047	-0.49017	0.0724905	0.145779	-0.21141
V136	-0.28069	-0.5868	-0.051329	0.282849	-0.02573
V137	-0.20634	-0.59311	0.0410748	-0.01639	0.051913
V138	-0.12113	-0.46175	-0.149976	0.012788	-0.21007
V139	-0.16838	-0.49643	-0.185863	0.232912	-0.10778
V140	-0.17071	-0.57772	-0.018027	0.036899	-0.0387
V141	-0.16245	-0.54014	0.0228356	0.129567	-0.105
V142	-0.21666	-0.6003	-0.071774	0.281674	0.024413
V143	-0.23626	-0.61177	-0.034012	0.306542	0.020956
V144	-0.08355	-0.58426	-0.077442	-0.04412	0.040009
V145	-0.06683	-0.5145	-0.181582	0.065237	0.085244
V146	-0.11503	-0.59899	-0.109413	0.09487	0.03775
V147	-0.02235	-0.52955	-0.112454	-0.00526	0.060305
V148	-0.0393	-0.56776	-0.082286	-0.01022	0.005864
V149	-0.03631	-0.50954	-0.119343	0.131285	-0.02543
V150	-0.06846	-0.60513	-0.051005	-0.01743	0.099529
V151	-0.06446	-0.61271	-0.013809	-0.0165	0.095919
V152	0.017759	-0.53512	-0.118214	-0.08883	-0.03258
V153	-0.09758	-0.61777	-0.088987	0.220316	0.098893
V154	0.032137	-0.47491	-0.220049	0.08488	0.005264
V155	0.121285	-0.27776	-0.246573	0.228662	0.002776
V156	0.131808	-0.40517	-0.114617	-0.10141	0.046479
V157	0.124592	-0.40534	-0.148141	0.029132	0.119934
V158	0.17456	-0.34102	-0.150312	-0.04849	-0.03184
V159	0.129275	-0.40154	-0.138735	-0.05154	0.155855
V160	0.197803	-0.30654	-0.117239	-0.03241	0.14005
V161	0.158129	-0.29368	-0.136335	0.243209	-0.05038
V162	0.237611	-0.18511	-0.148122	0.176994	-0.10878
V163	0.121656	-0.47694	-0.045785	-0.1111	0.163584
V164	0.220822	-0.25156	-0.183215	0.129937	0.067859
V165	0.213362	-0.22391	-0.119812	0.087877	0.288129
V166	0.208375	-0.20685	-0.035317	0.321628	-0.07006
V167	0.211628	-0.2478	0.0015793	-0.00024	0.290129
V168	0.089296	-0.43754	0.1864719	0.112169	0.231697
V169	0.200116	-0.22791	0.0391234	0.339377	-0.04335
V170	0.230347	-0.32469	0.0193113	-0.18408	0.019456
V171	0.216313	-0.2564	-0.087356	0.304622	-0.10933
V172	0.182845	-0.40526	0.0978611	0.114147	0.141492
V173	0.292662	-0.24779	-0.033399	-0.05461	-0.04357
V174	0.21432	-0.36311	0.0969337	-0.18599	0.124718
V175	0.209288	-0.23586	0.2086332	0.212573	0.180458
V176	0.295714	-0.07718	-0.087679	0.342297	0.067901
V177	0.235522	-0.36384	0.071317	-0.13518	0.208127
V178	0.21751	-0.29844	0.1471636	0.193315	0.180499
V179	0.28156	-0.13156	0.0468973	0.354558	0.023113
V180	0.305084	-0.10355	-0.026482	0.166154	0.273631

V181	0.293689	-0.16374	0.0283554	0.307024	-0.02848
V182	0.310331	-0.19727	0.0785533	-0.15751	-0.09212
V183	0.256724	-0.2522	0.1789021	0.228762	-0.1166
V184	0.216367	-0.37211	0.2838709	0.047794	-0.17097
V185	0.317195	-0.13078	0.0466626	0.253742	-0.20328
V186	0.296179	-0.3045	0.1196728	-0.01915	-0.23946
V187	0.264233	-0.21256	0.3124955	-0.09801	0.015762
V188	0.239857	-0.25164	0.3639415	-0.06701	0.019806
V189	0.24888	-0.38711	0.3172976	0.013141	-0.07931
V190	0.256581	-0.35753	0.3450082	0.045763	-0.05998
V191	0.299115	-0.24071	0.1675008	0.112153	-0.31338
V192	0.3017	-0.13265	0.3533241	0.082025	-0.07852
V193	0.326043	-0.12797	0.2318559	-0.13688	0.200745
V194	0.268635	-0.24031	0.395044	0.117989	-0.04216
V195	0.344355	-0.13234	0.2134364	0.089209	-0.26036
V196	0.318186	-0.29953	0.2942141	-0.16754	-0.09594
V197	0.307634	-0.32967	0.3400102	-0.07443	-0.11312
V198	0.294115	-0.30971	0.3832647	-0.1171	0.099258
V199	0.333825	-0.25108	0.2914166	-0.22447	-0.02484
V200	0.301914	-0.31115	0.4081756	-0.04885	-0.06301
V201	0.327714	-0.269	0.3665215	-0.06809	0.143991
V202	0.310411	-0.31625	0.4213601	-0.03591	0.048152
V203	0.387959	-0.13907	0.2942923	-0.17401	0.056466
V204	0.396183	-0.10439	0.2838627	-0.14147	0.164724
V205	0.354348	-0.334	0.361203	-0.02888	0.150124
V206	0.403806	-0.15155	0.285934	-0.19136	0.013639
V207	0.387651	-0.31207	0.3180945	-0.11914	0.13929
V208	0.424103	-0.23889	0.2325837	-0.26401	-0.0032
V209	0.465389	0.00197	0.2199236	-0.16555	0.084682
V210	0.468673	-0.16983	0.2344623	-0.11623	0.06181
V211	0.504116	0.10654	0.183786	-0.056	-0.02774
V212	0.501916	0.049002	0.19473	-0.08247	-0.05408
V213	0.512969	0.146598	0.1765576	-0.02428	-0.03377
V214	0.478691	-0.05421	0.240308	-0.02214	-0.18006
V215	0.508797	0.07881	0.2257035	0.041763	-0.12095
V216	0.515922	-0.08671	0.1529073	0.057947	-0.16769
V217	0.475259	0.051258	0.3046619	-0.06723	0.123133
V218	0.534478	0.068124	0.1757088	-0.01246	-0.034
V219	0.525893	0.166996	0.1630158	0.012673	0.073518
V220	0.525606	-0.03007	0.1669595	0.09881	0.169621
V221	0.533387	0.15467	0.1748588	0.0827	-0.10294
V222	0.529946	0.156471	0.1861232	0.075466	0.002994
V223	0.534424	0.131627	0.1730571	0.053783	-0.15136
V224	0.540339	0.172083	0.1649417	0.097698	-0.0544
V225	0.539655	0.185344	0.1667016	0.150162	0.023708
V226	0.543544	0.157717	0.1769885	0.136182	0.017802
V227	0.540479	0.157138	0.1799894	0.102464	-0.09965

V228	0.539157	0.09802	0.1850426	0.173	0.116353
V229	0.517798	0.101805	0.2970572	0.092442	0.157096
V230	0.539528	0.099898	0.303219	-0.04375	0.039643
V231	0.574753	0.023588	0.1408453	-0.18138	0.17351
V232	0.560455	0.184629	0.1728397	0.154841	0.123199
V233	0.586023	0.009267	0.238142	-0.12613	0.134509
V234	0.564355	0.101155	0.2539381	0.1139	0.107194
V235	0.580202	0.166603	0.2005409	0.034056	0.074865
V236	0.558259	0.13153	0.2991651	0.032912	0.108064
V237	0.578697	0.163656	0.1704879	0.10587	-0.17114
V238	0.586609	0.197965	0.1260042	0.07004	0.151883
V239	0.586743	0.196746	0.1624067	0.177915	0.030768
V240	0.57689	0.186782	0.2208931	0.061694	0.195353
V241	0.589949	0.222214	0.18876	0.124941	0.005867
V242	0.59354	0.209202	0.1904663	0.146384	-0.08933
V243	0.588399	0.191715	0.2735508	0.052235	-0.07132
V244	0.593626	0.145761	0.2776752	-0.13029	-0.10604
V245	0.609108	0.192071	0.1770165	-0.09563	0.148553
V246	0.612277	0.180385	0.1737846	-0.01751	-0.17771
V247	0.61197	0.180545	0.206209	-0.01952	-0.1736
V248	0.641482	0.15602	0.1639271	-0.19073	0.035144
V249	0.65527	0.106325	0.1885668	-0.17712	-0.07878
V250	0.656256	0.130265	0.1199772	-0.20838	0.060723
V251	0.632892	0.249268	0.2010922	-0.05236	0.105032
V252	0.637581	0.297208	0.1264565	0.018767	-0.07682
V253	0.642797	0.293176	0.131412	0.02315	-0.05512
V254	0.643742	0.306937	0.1185667	0.014168	0.034313
V255	0.654166	0.230986	0.0748959	0.034995	-0.19021
V256	0.730468	-0.00782	0.0567241	0.242233	0.006658
V257	0.716812	0.039179	0.0077334	0.209599	0.122865
V258	0.659112	0.2592	0.051763	0.185685	0.138676
V259	0.6683	0.274315	0.0050311	0.116828	0.129701
V260	0.733772	0.121732	0.053964	0.145583	-0.05543
V261	0.692257	0.219775	0.020923	0.008122	0.210277
V262	0.682133	0.283408	0.0044291	0.157363	0.083829
V263	0.700975	0.195386	-0.0187	-0.0025	0.230775
V264	0.690084	0.271261	-0.017756	0.168637	-0.05942
V265	0.694153	0.257375	-0.031399	0.161128	-0.10208
V266	0.758921	0.15344	-0.01941	0.028025	-0.1121
V267	0.742057	0.128167	-0.101265	0.163393	-0.10914
V268	0.743732	0.214793	-0.048643	-0.08365	0.047173
V269	0.755611	0.090477	-0.137608	0.220203	-0.02799
V270	0.737538	0.180863	-0.130185	0.178102	-0.01458
V271	0.776892	0.12392	-0.081163	-0.13699	-0.06973
V272	0.769024	0.146113	-0.12629	-0.0824	-0.07979
V273	0.771721	0.149674	-0.112897	-0.12811	0.076483
V274	0.783511	0.072447	-0.215709	0.06257	0.02931

V275	0.798725	0.050938	-0.17709	-0.09704	-0.04663
V276	0.75764	0.185617	-0.216574	-0.02092	-0.09625
V277	0.761003	0.184146	-0.241808	-0.00998	-0.01322
V278	0.764592	0.148734	-0.272375	0.035928	0.01279
V279	0.777414	0.094084	-0.260754	-0.13394	-0.07017
V280	0.765678	0.14134	-0.301578	-0.0185	-0.01306
V281	0.755217	0.178491	-0.327908	0.009974	0.032506
V282	0.748857	0.219342	-0.319546	0.044146	-0.02585
V283	0.748373	0.221223	-0.320632	0.046897	-0.03005
V284	0.736702	0.321609	-0.275515	-0.01778	0.017302
V285	0.738398	0.322328	-0.2716	-0.04071	-0.01371
V286	0.734801	0.306706	-0.2909	-0.0027	-0.10787
V287	0.734061	0.308492	-0.321825	0.037711	0.000535
V288	0.733832	0.314007	-0.324703	0.015981	0.027379
V289	0.745175	0.220275	-0.396003	0.00384	-0.07612
V290	0.73447	0.331296	-0.32047	-0.08956	-0.00571
V291	0.72949	0.354476	-0.315913	-0.09592	0.036602
V292	0.724956	0.366811	-0.332465	-0.04535	-0.01332
V293	0.724564	0.365073	-0.341684	-0.04432	0.006457
V294	0.722533	0.38479	-0.327194	-0.08202	0.024683
V295	0.727671	0.377733	-0.314123	-0.15008	0.012072
V296	0.722479	0.369638	-0.356326	-0.11913	0.061817
V297	0.725909	0.380528	-0.320615	-0.18239	0.028476
V298	0.728341	0.341153	-0.378089	-0.17491	0.017423
V299	0.729285	0.356318	-0.350372	-0.22718	-0.03147
V300	0.730826	0.343061	-0.360541	-0.23951	-0.02926
V301	0.727709	0.353437	-0.364096	-0.24046	-0.03783
V302	0.728664	0.331385	-0.401578	-0.23012	-0.04818
V303	0.72747	0.343958	-0.391026	-0.2417	-0.08098
V304	0.727136	0.344517	-0.392167	-0.25335	-0.0848

Appendix D

Response Loading for Six Dimensions

<b>Response</b>	<b>Dimension</b>					
	1	2	3	4	5	6
V1	0.638709	-0.49825	0.2823516	-0.14296	0.098886	-0.20026
V2	0.816101	-0.46696	-0.041136	0.068524	-0.32382	-0.29146
V3	0.667882	-0.55558	0.3645217	0.072858	0.129972	0.147013
V4	0.567411	-0.55459	0.1618686	-0.03255	0.166266	-0.21877
V5	0.640909	-0.56734	0.3309674	-0.10648	0.122452	-0.02219
V6	0.632753	-0.51388	0.2808358	-0.13867	0.161774	-0.14037
V7	0.691412	-0.45821	0.2595589	0.118193	0.290819	0.316493
V8	0.605134	-0.50796	0.154389	0.260222	0.185948	-0.05122
V9	0.618629	-0.56968	0.1987257	0.168131	0.143584	0.005292
V10	0.797084	-0.37433	0.3886945	-0.10811	0.12981	-0.0464
V11	0.801234	-0.27085	-0.121804	-0.00743	0.461762	-0.2631
V12	0.764892	-0.27418	0.0945497	-0.09189	0.484623	-0.15619
V13	0.753594	-0.36072	0.3633703	0.230527	0.218089	0.056594
V14	0.694037	-0.4454	0.1365798	-0.04139	0.157408	-0.22034
V15	0.752199	-0.31731	0.0807225	0.568947	0.130895	0.006359
V16	0.782144	-0.32197	0.1171761	0.114454	0.390484	-0.07797
V17	0.658853	-0.47872	0.1355322	-0.0384	0.184502	-0.16638
V18	0.681147	-0.45683	0.0880509	0.173657	0.098259	-0.12138
V19	0.731125	-0.4322	0.1880307	0.223984	0.168767	0.020981
V20	0.647121	-0.51307	0.0888239	0.219414	0.105806	0.032606
V21	0.660483	-0.42835	0.0355736	0.22071	0.12687	-0.05623
V22	0.651709	-0.5385	0.24794	-0.09872	0.060091	0.024246
V23	0.722125	-0.43403	0.1346568	0.202161	0.069023	-0.08673
V24	0.773845	-0.40401	0.3653159	0.103093	-0.02213	0.143738
V25	0.77821	-0.25044	0.1860076	0.316727	0.134398	0.183602
V26	0.715842	-0.26359	0.2682706	0.424184	0.039431	0.185519
V27	0.771617	-0.31229	0.1067502	0.168173	0.083993	0.338965
V28	0.829759	-0.04769	0.0124586	0.026525	-0.40338	-0.33807
V29	0.755646	-0.23805	-0.029246	0.237188	0.165216	0.299466
V30	0.818955	-0.19867	-0.246371	-0.01385	0.020229	0.517597
V31	0.619116	-0.48055	-0.020516	-0.07077	0.138931	0.160986
V32	0.517632	-0.57361	0.0740128	-0.02292	-0.00546	0.274634
V33	0.648724	-0.42499	-0.020163	-0.12153	0.092587	0.086085
V34	0.648235	-0.44261	-0.018676	-0.09108	0.057933	0.127753
V35	0.626316	-0.44626	0.0705688	-0.15756	0.067786	0.188176
V36	0.650032	-0.4072	0.0526921	-0.16473	0.105449	0.162937
V37	0.827538	-0.2654	0.1151916	-0.13292	-0.05458	0.194196
V38	0.79139	-0.28954	0.0666427	-0.11739	-0.04506	0.057638
V39	0.697618	-0.36027	-0.063112	0.111132	-0.08064	0.179331
V40	0.755942	-0.32187	0.0328446	0.089345	-0.18492	0.037992
V41	0.667455	-0.4144	0.0906251	0.061467	-0.24862	0.197749

V42	0.681379	-0.41423	0.1390532	-0.15718	-0.12378	0.192007
V43	0.779955	-0.25048	0.0014407	-0.15386	-0.08836	0.082375
V44	0.795648	-0.26152	0.1367522	-0.14252	-0.13294	0.017951
V45	0.796106	-0.26115	0.1354816	-0.14063	-0.13435	0.017502
V46	0.704705	-0.32316	0.0216796	-0.13215	-0.13457	-0.08404
V47	0.893477	0.067901	0.0847006	-0.11575	-0.09461	0.183738
V48	0.89334	0.095641	0.1276665	-0.27121	-0.24176	-0.01449
V49	0.734023	-0.20925	-0.155048	-0.16121	0.01113	0.125903
V50	0.863348	0.035281	-0.011875	-0.28575	-0.04897	0.144433
V51	0.6293	-0.32345	-0.127995	-0.20245	-0.0648	0.038638
V52	0.592744	-0.3645	-0.081608	-0.2708	-0.0543	0.052569
V53	0.61072	-0.3522	-0.022481	-0.28428	-0.08711	0.023902
V54	0.694461	-0.26989	-0.037907	-0.0494	-0.27651	0.010433
V55	0.631927	-0.34606	-0.085332	-0.22485	-0.15095	0.020009
V56	0.644008	-0.25515	-0.238767	0.00445	-0.07591	-0.05023
V57	0.605278	-0.26839	-0.217642	-0.15054	0.017079	0.008114
V58	0.608677	-0.31199	-0.131292	-0.23154	-0.02809	-0.0788
V59	0.547535	-0.30477	-0.198926	-0.17607	0.008237	-0.01768
V60	0.615028	-0.14341	-0.279463	0.094885	-0.02722	0.039116
V61	0.521892	-0.26721	-0.250545	0.005671	-0.02204	-0.05773
V62	0.502624	-0.31831	-0.219026	-0.04259	-0.0707	-0.04669
V63	0.487547	-0.42231	-0.007595	-0.30443	-0.08586	-0.00904
V64	0.605974	-0.30477	-0.001272	-0.3234	-0.0433	-0.07201
V65	0.572437	-0.33298	-0.037237	-0.29254	-0.04524	-0.14632
V66	0.584384	-0.2818	-0.110294	-0.13077	-0.22885	0.130095
V67	0.70888	-0.10572	-0.193042	-0.2445	0.018894	-0.01936
V68	0.585557	-0.25201	-0.191438	-0.26569	0.007306	-0.02993
V69	0.552489	-0.30454	-0.03806	-0.08772	-0.28527	-0.14785
V70	0.568039	-0.30371	0.0322395	-0.29896	-0.15708	-0.10355
V71	0.518473	-0.31008	-0.096695	-0.26112	-0.07745	-0.0814
V72	0.514087	-0.35796	-0.010074	-0.13712	-0.31324	-0.0901
V73	0.541294	-0.07637	-0.1604	0.183959	-0.28335	-0.0165
V74	0.562005	-0.25147	0.0394628	-0.10864	-0.36505	-0.07767
V75	0.578575	-0.04359	-0.293831	-0.09166	0.040315	-0.04555
V76	0.439576	0.028893	-0.248241	0.232838	-0.0948	-0.00144
V77	0.439758	0.090686	-0.22389	0.298008	-0.11582	-0.03053
V78	0.454949	0.060389	-0.244608	0.28413	0.006876	-0.02031
V79	0.42358	0.016559	-0.242163	0.178697	-0.05333	-0.11048
V80	0.509291	0.030054	-0.216268	0.223605	-0.19183	-0.03206
V81	0.417845	-0.12432	-0.131422	0.242089	-0.27019	-0.05628
V82	0.546669	0.159296	-0.040222	0.255306	-0.21526	-0.05021
V83	0.426654	-0.04308	-0.148599	0.275458	-0.21819	-0.00418
V84	0.382077	0.091991	-0.15644	0.330303	-0.008	-0.02319
V85	0.479304	0.191715	-0.10401	0.272192	-0.23709	-0.04682
V86	0.392965	-0.02549	-0.130299	0.272791	-0.24677	-0.04358
V87	0.38284	0.06184	-0.210849	0.251139	-0.09958	-0.06373
V88	0.438302	-0.09479	-0.149106	-0.06837	-0.13797	-0.29482

V89	0.529081	0.186318	-0.31868	0.086782	0.03133	0.083591
V90	0.494309	0.002434	0.2089536	-0.11058	0.009252	-0.28441
V91	0.515001	0.163987	-0.338414	-0.13822	0.079352	0.081968
V92	0.425653	0.277497	-0.129936	0.291143	-0.05345	0.111616
V93	0.419482	0.013825	-0.081691	0.148915	0.178991	-0.23041
V94	0.489428	0.03375	-0.060289	-0.31225	0.12943	-0.11845
V95	0.532725	0.292539	-0.05942	0.155906	-0.0973	-0.12437
V96	0.545336	0.283088	0.0449195	0.200803	-0.0799	-0.10083
V97	0.446903	0.282237	0.0527353	0.290967	-0.02553	-0.07282
V98	0.443251	0.269321	-0.100466	0.280335	0.007187	-0.05765
V99	0.460002	0.30163	0.0776751	0.281641	-0.02028	-0.05256
V100	0.492143	0.273228	-0.251898	-0.25281	0.092275	0.084259
V101	0.49862	0.36176	0.0949834	0.189434	-0.04627	0.07117
V102	0.572253	0.389476	-0.129674	-0.23146	0.082208	0.062446
V103	0.383526	0.334349	0.0619654	0.272737	-0.10569	0.090217
V104	0.371325	0.320429	-0.24828	0.15421	-0.07912	0.026338
V105	0.395191	0.251532	-0.196027	0.172324	0.162145	-0.15729
V106	0.361408	0.236422	-0.335839	-0.03551	0.078765	0.038259
V107	0.331421	0.334665	-0.015389	0.331308	0.02796	-0.01957
V108	0.376628	0.292262	-0.015386	0.284589	-0.02728	-0.21605
V109	0.434418	0.340754	-0.266541	-0.15582	0.130345	0.0322
V110	0.372499	0.280345	-0.076511	0.200105	0.228422	-0.22671
V111	0.367067	0.279091	-0.110744	0.164543	0.229416	-0.22871
V112	0.297192	0.375752	-0.00896	0.309836	-0.0621	-0.03687
V113	0.278173	0.259939	-0.087817	0.216858	0.084643	-0.25493
V114	0.392954	0.443219	0.1328001	0.123759	-0.07662	-0.08117
V115	0.351408	0.404674	-0.252694	0.012603	0.004125	0.016196
V116	0.369344	0.438902	0.1008073	0.116818	-0.11114	-0.0987
V117	0.310654	0.377489	-0.196072	0.127234	-0.08779	0.097453
V118	0.328118	0.420668	0.1424333	0.22995	-0.001	-0.03128
V119	0.283879	0.390645	0.0640974	0.206746	-0.03338	-0.18842
V120	0.330839	0.430992	-0.202932	-0.01283	0.149054	-0.05501
V121	0.365992	0.486141	0.1594602	0.078321	-0.02276	-0.05454
V122	0.416092	0.532421	-0.014002	-0.09093	0.066914	-0.0379
V123	0.334043	0.494991	-0.164551	0.023518	0.013074	-0.05276
V124	0.291195	0.47377	0.1194659	0.1342	-0.10121	-0.11724
V125	0.398866	0.562509	-0.03684	-0.25491	0.047866	0.027454
V126	0.371602	0.5509	-0.077486	-0.20773	0.062599	0.022304
V127	0.389804	0.558648	-0.053336	-0.23877	0.058329	0.030729
V128	0.208061	0.44144	-0.000208	0.190526	0.183941	-0.01518
V129	0.326009	0.507757	-0.123321	-0.24816	0.038606	0.065133
V130	0.284203	0.510559	-0.157937	-0.03096	0.096678	0.035751
V131	0.214279	0.503834	-0.062455	0.112521	0.080429	-0.15095
V132	0.431685	0.591104	0.1576928	-0.15896	-0.01163	-0.04875
V133	0.254625	0.548664	0.1021962	-0.03358	-0.08082	-0.04278
V134	0.241182	0.471284	-0.135544	-0.23722	0.137815	-0.09088
V135	0.228373	0.492244	-0.001338	-0.11766	-0.07376	-0.24924



V136	0.287215	0.597125	-0.054045	-0.25719	0.036438	0.002465
V137	0.211169	0.583512	0.047319	0.042191	0.023355	0.093436
V138	0.126053	0.45989	-0.179122	-0.01324	0.095169	-0.16932
V139	0.17701	0.487834	-0.188702	-0.22549	0.141953	-0.00641
V140	0.170954	0.579698	-0.045196	-0.01267	-0.0004	-0.02671
V141	0.162052	0.543711	-0.005829	-0.12505	-0.00084	-0.10795
V142	0.221371	0.609409	-0.080598	-0.25729	0.027689	0.040983
V143	0.240523	0.625074	-0.044114	-0.27729	0.026169	0.037812
V144	0.090423	0.572196	-0.094318	0.057307	0.046526	0.086426
V145	0.069306	0.5068	-0.213678	-0.05442	-0.01417	0.071552
V146	0.118442	0.59411	-0.135378	-0.07771	0.031972	0.05581
V147	0.031937	0.509228	-0.12461	0.008113	0.072771	0.127381
V148	0.050955	0.547517	-0.089818	0.01117	0.102536	0.095757
V149	0.040867	0.503685	-0.143334	-0.13536	0.0266	-0.01303
V150	0.073986	0.593298	-0.071235	0.035721	0.032359	0.136617
V151	0.068694	0.605132	-0.035144	0.034434	0.021745	0.123877
V152	-0.00657	0.514111	-0.140663	0.095758	0.117048	0.052502
V153	0.101202	0.617912	-0.101755	-0.20151	0.036501	0.121877
V154	-0.02121	0.453231	-0.233923	-0.08178	0.101324	0.078469
V155	-0.11641	0.266112	-0.263532	-0.22709	0.043166	0.032351
V156	-0.12887	0.397975	-0.163548	0.096166	-0.0233	0.003777
V157	-0.12216	0.399664	-0.187633	-0.02919	-0.10887	-0.0352
V158	-0.16959	0.329628	-0.189531	0.053038	0.034427	-0.0282
V159	-0.12272	0.382701	-0.168159	0.050565	0.036789	0.177625
V160	-0.19543	0.300425	-0.149438	0.0513	-0.00731	0.129938
V161	-0.15519	0.285926	-0.15668	-0.24313	0.076871	-0.00137
V162	-0.23453	0.177033	-0.164969	-0.17132	0.125976	-0.02263
V163	-0.11016	0.437207	-0.081152	0.099762	0.091496	0.231972
V164	-0.21752	0.240877	-0.213095	-0.11068	0.030788	0.084014
V165	-0.21984	0.236206	-0.174396	-0.07344	-0.24634	0.058855
V166	-0.20698	0.20478	-0.045259	-0.32136	0.093399	-0.00793
V167	-0.22113	0.267907	-0.04948	0.038385	-0.23291	0.112446
V168	-0.11445	0.450786	0.051168	-0.06553	-0.27304	-0.07413
V169	-0.19865	0.226168	0.0310578	-0.3378	0.079471	0.022709
V170	-0.2326	0.325259	-0.036422	0.186257	-0.02015	-0.00853
V171	-0.2076	0.237284	-0.085997	-0.28481	0.18508	0.071908
V172	-0.19699	0.418847	0.0084448	-0.11926	-0.10706	0.021853
V173	-0.29272	0.248588	-0.062843	0.063668	0.066379	-0.01027
V174	-0.21862	0.366865	0.0427545	0.202345	-0.04202	0.106288
V175	-0.21208	0.258097	0.2121692	-0.1904	-0.15226	0.07803
V176	-0.29479	0.074437	-0.080765	-0.34637	0.004757	0.081869
V177	-0.24286	0.372939	0.0065843	0.125936	-0.08076	0.187434
V178	-0.22814	0.319194	0.0915679	-0.20161	-0.15627	0.049045
V179	-0.28099	0.135536	0.0568699	-0.35458	0.012185	0.041237
V180	-0.31003	0.120251	-0.046644	-0.15057	-0.2392	0.134923
V181	-0.29489	0.170273	0.0158396	-0.30937	0.027432	-0.01452
V182	-0.31381	0.211447	0.0581511	0.163999	0.051779	-0.06235

V183	-0.25886	0.262563	0.1676883	-0.23072	0.102836	-0.03533
V184	-0.22186	0.390815	0.2617592	-0.06442	0.120224	-0.0983
V185	-0.31361	0.128534	0.0690438	-0.24663	0.221221	-0.02028
V186	-0.28669	0.286351	0.1049199	-0.01419	0.277734	0.039674
V187	-0.26944	0.235894	0.3037131	0.074682	-0.04334	0.001465
V188	-0.25859	0.285355	0.2981088	0.058484	-0.13375	-0.09763
V189	-0.25231	0.3987	0.2909136	-0.0249	0.10589	0.022958
V190	-0.26253	0.377216	0.3195467	-0.05223	0.059435	0.000268
V191	-0.29795	0.242664	0.1620729	-0.14519	0.282561	-0.11365
V192	-0.30542	0.156246	0.3581869	-0.05949	0.021785	-0.01554
V193	-0.33983	0.169645	0.1865783	0.114552	-0.23201	-0.00371
V194	-0.2775	0.269041	0.3607617	-0.11597	-0.06016	-0.08764
V195	-0.34201	0.139112	0.2439457	-0.0838	0.238806	-0.02613
V196	-0.31896	0.309729	0.2758559	0.156755	0.129022	0.021992
V197	-0.31315	0.348407	0.3127431	0.057045	0.132798	-0.00942
V198	-0.30324	0.337641	0.3498895	0.120557	-0.07197	0.079658
V199	-0.33669	0.266658	0.2711603	0.222408	0.051846	0.039009
V200	-0.30872	0.336966	0.3838849	0.046391	0.05821	-0.01184
V201	-0.34215	0.309134	0.3209913	0.075793	-0.13027	0.065029
V202	-0.32497	0.357084	0.3751888	0.047633	-0.06008	0.000581
V203	-0.39056	0.155022	0.2774285	0.168907	0.015712	0.104218
V204	-0.40259	0.130475	0.2604954	0.15785	-0.13083	0.09384
V205	-0.37372	0.378101	0.3008634	0.037485	-0.08128	0.110479
V206	-0.40848	0.172285	0.2631268	0.196018	0.008628	0.045213
V207	-0.4009	0.343404	0.2655348	0.122048	-0.04116	0.133
V208	-0.43184	0.260479	0.1898393	0.262582	0.034281	0.029866
V209	-0.47229	0.025545	0.198365	0.176495	-0.0873	0.03077
V210	-0.48215	0.202163	0.1800331	0.111165	-0.02368	0.038507
V211	-0.51173	-0.08095	0.1890408	0.057883	0.021074	0.016919
V212	-0.50784	-0.03058	0.1907841	0.075673	0.075661	0.049553
V213	-0.52009	-0.12114	0.1942859	0.028887	0.025023	0.028254
V214	-0.47893	0.058643	0.2349721	0.03547	0.187637	-0.0034
V215	-0.51334	-0.06529	0.236595	-0.02908	0.114337	-0.00507
V216	-0.51002	0.073989	0.1287704	-0.04593	0.208623	0.040714
V217	-0.4818	-0.02175	0.3016142	0.074845	-0.1026	0.07544
V218	-0.52893	-0.06545	0.1728824	0.013705	0.113318	0.115748
V219	-0.5342	-0.13354	0.1872018	-0.00404	0.044668	0.133148
V220	-0.52508	0.030577	0.1458706	-0.08093	0.013254	0.204513
V221	-0.53931	-0.13541	0.2006228	-0.07272	0.086598	-0.0245
V222	-0.5375	-0.12993	0.2059109	-0.05644	0.036512	0.079561
V223	-0.53882	-0.10903	0.185562	-0.0516	0.086963	-0.11448
V224	-0.54673	-0.15189	0.1919244	-0.07976	0.056558	0.01813
V225	-0.54765	-0.16099	0.2009904	-0.09763	0.053482	0.105771
V226	-0.54909	-0.13747	0.1967323	-0.07604	0.068305	0.118152
V227	-0.54581	-0.13611	0.2025833	-0.09029	0.063478	-0.05279
V228	-0.5425	-0.08442	0.188764	-0.16445	-0.04195	0.124492
V229	-0.52688	-0.05073	0.2278696	-0.07805	-0.23863	-0.06431

V230	-0.54568	-0.05005	0.2529376	0.037292	-0.143	-0.09456
V231	-0.5899	0.015204	0.1037645	0.16829	-0.13276	0.096084
V232	-0.56335	-0.16878	0.198859	-0.13838	-0.06124	0.107787
V233	-0.59877	0.040887	0.1917933	0.08263	-0.16827	-0.03256
V234	-0.5649	-0.06703	0.1919554	-0.12489	-0.17268	-0.08164
V235	-0.58304	-0.1284	0.1773843	-0.05876	-0.12722	-0.02822
V236	-0.56304	-0.07784	0.2272991	-0.03695	-0.20412	-0.09979
V237	-0.5782	-0.13623	0.1700195	-0.10828	0.039404	-0.1816
V238	-0.59041	-0.18036	0.1424356	-0.06386	-0.07792	0.13362
V239	-0.58725	-0.17786	0.1793865	-0.16965	-0.04696	0.000989
V240	-0.57984	-0.15518	0.2285738	-0.06	-0.19076	0.075634
V241	-0.5899	-0.18001	0.1741328	-0.11813	-0.10304	-0.09093
V242	-0.59195	-0.18581	0.2030966	-0.13616	-0.00461	-0.1109
V243	-0.58796	-0.16012	0.2772468	-0.0405	-0.02581	-0.1043
V244	-0.59877	-0.09932	0.2666799	0.105907	-0.04299	-0.16034
V245	-0.61303	-0.15298	0.1634949	0.084652	-0.19274	0.004585
V246	-0.6117	-0.15411	0.1818165	0.009573	0.062415	-0.17939
V247	-0.61084	-0.15511	0.2171039	0.018455	0.054687	-0.17156
V248	-0.64683	-0.13191	0.1681854	0.187278	-0.03502	0.017703
V249	-0.66133	-0.08246	0.1858234	0.168829	0.029148	-0.07042
V250	-0.66241	-0.10985	0.1163349	0.201722	-0.02764	0.058271
V251	-0.63276	-0.22034	0.2213183	0.052914	-0.11559	0.035316
V252	-0.63571	-0.26095	0.140012	-0.02379	-0.06126	-0.13623
V253	-0.64073	-0.27589	0.1643115	-0.02016	-0.0073	-0.05915
V254	-0.64336	-0.28574	0.149107	-0.01619	-0.06767	-0.01106
V255	-0.65334	-0.22992	0.1134314	-0.03545	0.129402	-0.1107
V256	-0.73425	0.0152	0.0133305	-0.22463	-0.00733	-0.02034
V257	-0.72022	-0.03612	-0.017775	-0.20632	-0.04928	0.071917
V258	-0.65711	-0.21456	0.0374659	-0.15684	-0.20522	-0.088
V259	-0.66774	-0.26537	0.026371	-0.12796	-0.12558	0.04148
V260	-0.72049	-0.12254	0.0298549	-0.14714	-0.04871	-0.11241
V261	-0.69293	-0.2184	0.0357027	-0.01766	-0.16125	0.123992
V262	-0.67748	-0.28976	0.0416429	-0.15236	-0.06972	0.04446
V263	-0.70257	-0.19245	-0.017048	-0.009	-0.17715	0.137577
V264	-0.68524	-0.27806	0.0126736	-0.16393	0.004342	-0.06846
V265	-0.68913	-0.26711	-0.001811	-0.15946	0.042425	-0.09166
V266	-0.75055	-0.17185	-0.012209	-0.03231	0.086086	-0.08043
V267	-0.73488	-0.14578	-0.103316	-0.16004	0.103602	-0.04785
V268	-0.7403	-0.22462	-0.036056	0.069149	0.016058	0.055541
V269	-0.75077	-0.10236	-0.157705	-0.2019	0.043018	-0.01648
V270	-0.72926	-0.2008	-0.121543	-0.18046	0.038197	-0.00504
V271	-0.76912	-0.13516	-0.098304	0.133691	0.030688	-0.07483
V272	-0.76138	-0.16319	-0.13312	0.075949	0.065461	-0.05234
V273	-0.76663	-0.16057	-0.126722	0.123788	-0.05798	0.011289
V274	-0.77016	-0.10101	-0.238105	-0.04859	0.025641	0.027409
V275	-0.78212	-0.07836	-0.211971	0.10129	0.02567	-0.05221
V276	-0.74823	-0.21301	-0.211552	0.018304	0.093198	-0.03244

V277	-0.74197	-0.22827	-0.224239	0.003474	0.101078	0.064511
V278	-0.74872	-0.19029	-0.267246	-0.02545	0.069035	0.054706
V279	-0.76009	-0.13402	-0.275064	0.13004	0.099904	0.002601
V280	-0.74994	-0.18296	-0.301084	0.028052	0.062587	0.023507
V281	-0.74359	-0.20515	-0.329236	0.0154	-0.03629	-0.03491
V282	-0.73797	-0.23429	-0.313951	-0.00039	-0.05362	-0.09499
V283	-0.73749	-0.23547	-0.314524	-0.00057	-0.05588	-0.0994
V284	-0.73134	-0.33507	-0.26251	0.019357	-0.04877	-0.03737
V285	-0.732	-0.33413	-0.261507	0.043905	-0.03491	-0.05759
V286	-0.73064	-0.32528	-0.27585	0.002423	0.039478	-0.09932
V287	-0.7299	-0.32553	-0.307877	-0.03158	-0.02049	-0.02969
V288	-0.72938	-0.33787	-0.305614	-0.01759	-0.01659	0.003544
V289	-0.73329	-0.25953	-0.3881	0.018091	0.065251	-0.0304
V290	-0.72701	-0.36044	-0.302923	0.077874	0.008896	-0.00899
V291	-0.72342	-0.38432	-0.292892	0.08556	-0.02838	0.005494
V292	-0.7209	-0.40319	-0.29364	0.026603	0.023174	-0.00179
V293	-0.72009	-0.40397	-0.301548	0.024979	0.01592	0.014215
V294	-0.71803	-0.42335	-0.287808	0.060148	-0.01085	0.012105
V295	-0.72129	-0.41631	-0.281766	0.131688	-0.00543	0.002843
V296	-0.71509	-0.41838	-0.3194	0.096021	-0.02265	0.043766
V297	-0.71854	-0.42875	-0.282492	0.157252	-0.00467	0.022854
V298	-0.71795	-0.39702	-0.341851	0.154681	0.032064	0.038284
V299	-0.71824	-0.41916	-0.307241	0.197021	0.06756	0.021844
V300	-0.71823	-0.40954	-0.319016	0.208784	0.074957	0.027441
V301	-0.71571	-0.42405	-0.316045	0.205738	0.081835	0.027442
V302	-0.71442	-0.4113	-0.34715	0.195813	0.110052	0.038992
V303	-0.71378	-0.43013	-0.326482	0.199063	0.134953	0.03579
V304	-0.71335	-0.43512	-0.323087	0.205879	0.14352	0.041332

Appendix E

Response Loading for Seven Dimensions

<b>Response</b>	<b>Dimension</b>						
	1	2	3	4	5	6	7
V1	-0.63531	-0.5133	0.274676	-0.1370174	-0.03849	-0.05373	-0.19653
V2	-0.81903	-0.4511	-0.06455	0.0996594	0.161039	0.334708	-0.22826
V3	-0.66943	-0.54659	0.195949	-0.056629	-0.35526	0.096404	0.070289
V4	-0.56664	-0.56346	0.152077	-0.0179812	-0.07487	-0.10572	-0.2272
V5	-0.63446	-0.59354	0.280293	-0.1162261	-0.12722	-0.05866	-0.02406
V6	-0.62988	-0.52868	0.274449	-0.1241573	-0.04193	-0.13002	-0.14626
V7	-0.70881	-0.40225	0.162222	0.2412644	0.211122	-0.39976	0.079036
V8	-0.61821	-0.45979	0.139307	0.270694	0.071435	-0.23646	-0.11016
V9	-0.62457	-0.54448	0.185685	0.1929662	0.024552	-0.19057	-0.05357
V10	-0.78285	-0.41619	0.2936	-0.1584925	-0.23653	0.017936	-0.02536
V11	-0.7981	-0.26903	-0.13345	-0.0116824	-0.2354	-0.33854	-0.33529
V12	-0.75601	-0.2892	0.095047	-0.1531302	-0.32941	-0.31002	-0.20217
V13	-0.74649	-0.38046	0.336637	0.1647212	-0.27432	-0.09947	0.057187
V14	-0.68958	-0.4558	0.132854	-0.050653	-0.13816	-0.0485	-0.21406
V15	-0.7457	-0.32138	0.06204	0.4360073	-0.3803	0.081001	0.057554
V16	-0.77423	-0.33033	0.116024	0.0726906	-0.30094	-0.25688	-0.11675
V17	-0.65425	-0.49233	0.129743	-0.039245	-0.14057	-0.08695	-0.16017
V18	-0.68092	-0.45006	0.090884	0.1785827	-0.05395	-0.07482	-0.1401
V19	-0.72811	-0.42884	0.199339	0.2181403	-0.09135	-0.15939	-0.01305
V20	-0.646	-0.50803	0.089945	0.2250857	-0.07571	-0.10066	0.002965
V21	-0.66194	-0.41735	0.042066	0.2264168	-0.04361	-0.12266	-0.08613
V22	-0.64406	-0.55613	0.221834	-0.0841235	-0.06949	-0.03417	0.042629
V23	-0.72032	-0.42689	0.151797	0.1981086	-0.05071	-0.05891	-0.10342
V24	-0.76594	-0.42193	0.340458	0.0638225	-0.11686	0.040537	0.157892
V25	-0.77144	-0.26023	0.182819	0.2934245	-0.16723	-0.11553	0.171518
V26	-0.71614	-0.26573	0.25536	0.4239066	-0.07555	-0.07421	0.173174
V27	-0.76263	-0.32468	0.099363	0.1460638	-0.12912	-0.10006	0.327454
V28	-0.82023	-0.08442	-0.03668	0.2422193	0.435293	-0.12773	-0.15094
V29	-0.75461	-0.24403	-0.03214	0.228012	-0.12209	-0.18596	0.262829
V30	-0.81427	-0.20721	-0.25253	-0.0583723	-0.09077	-0.06244	0.500275
V31	-0.61568	-0.48401	-0.02295	-0.0695653	-0.10649	-0.09571	0.15303
V32	-0.51794	-0.57542	0.07483	-0.0019445	0.035522	-0.07852	0.255708
V33	-0.64639	-0.42754	-0.02091	-0.1117331	-0.02479	-0.09562	0.083485
V34	-0.64532	-0.44426	-0.02244	-0.0827239	-0.03128	-0.05557	0.130342
V35	-0.62401	-0.45025	0.075607	-0.1368269	0.01746	-0.11348	0.174259
V36	-0.64752	-0.40937	0.065142	-0.1448683	0.017626	-0.15165	0.140204
V37	-0.8145	-0.27676	0.114645	-0.1525528	-0.03119	0.044682	0.208383
V38	-0.78156	-0.29483	0.076682	-0.1264995	-0.01284	0.059244	0.080774
V39	-0.70272	-0.3512	-0.04098	0.1215159	0.122281	-0.04061	0.14579
V40	-0.75941	-0.31392	0.062151	0.0943912	0.133455	0.102209	0.048471
V41	-0.66857	-0.41111	0.10068	0.0802905	0.149579	0.155729	0.22307

V42	-0.67439	-0.42357	0.119259	-0.152234	0.008364	0.113839	0.211011
V43	-0.77061	-0.25566	0.010432	-0.1631068	0.013249	0.092628	0.104053
V44	-0.7876	-0.26631	0.149814	-0.1474918	0.047915	0.125158	0.046812
V45	-0.78809	-0.26586	0.148682	-0.1455717	0.048352	0.126619	0.046569
V46	-0.69593	-0.3233	0.026876	-0.1311709	0.022983	0.182872	-0.02223
V47	-0.8828	0.054485	0.095797	-0.1551863	-0.021	0.082433	0.198801
V48	-0.89181	0.085566	0.132165	-0.2638744	0.165175	0.193663	0.002224
V49	-0.72912	-0.21119	-0.1521	-0.1755863	-0.01514	-0.01689	0.121449
V50	-0.85734	0.02584	0.000911	-0.3024567	0.057009	-0.01462	0.134922
V51	-0.62698	-0.31981	-0.12686	-0.1986378	0.031314	0.078788	0.058714
V52	-0.59245	-0.36455	-0.08801	-0.2586337	0.066808	0.036762	0.059597
V53	-0.61095	-0.35166	-0.01935	-0.2663857	0.119923	0.043157	0.029241
V54	-0.7009	-0.25913	0.002113	-0.0357252	0.261908	0.091758	-0.00833
V55	-0.63167	-0.34214	-0.08024	-0.2100244	0.117826	0.126044	0.044978
V56	-0.64139	-0.246	-0.22587	-0.0093176	-0.01975	0.142144	-0.01345
V57	-0.60615	-0.26432	-0.2099	-0.1419373	0.065995	-0.04695	-0.01265
V58	-0.60809	-0.30919	-0.13372	-0.2293965	0.03309	0.049285	-0.065
V59	-0.5494	-0.29892	-0.20202	-0.1751634	0.00372	0.017657	-0.00978
V60	-0.61588	-0.13591	-0.27507	0.0864089	-0.01221	0.063603	0.047412
V61	-0.52371	-0.25639	-0.2465	0.0045891	-0.03443	0.09383	-0.02644
V62	-0.50572	-0.30803	-0.22094	-0.0300084	0.028646	0.103253	-0.0196
V63	-0.48774	-0.42474	-0.01886	-0.2808709	0.119448	0.055851	0.00149
V64	-0.60516	-0.30537	0.002356	-0.3132689	0.081567	0.037928	-0.06725
V65	-0.5706	-0.33598	-0.05186	-0.2888706	0.022324	0.099938	-0.10676
V66	-0.59325	-0.2576	-0.03689	-0.1000946	0.307155	-0.02941	0.024197
V67	-0.70693	-0.10463	-0.16762	-0.2285642	0.103891	-0.0767	-0.054
V68	-0.58755	-0.24693	-0.1657	-0.226177	0.145444	-0.07521	-0.0674
V69	-0.55831	-0.28847	-0.01478	-0.0534161	0.261975	0.179488	-0.12406
V70	-0.56897	-0.30159	0.037262	-0.2781342	0.157819	0.122519	-0.08625
V71	-0.52268	-0.30296	-0.09132	-0.230828	0.151319	0.029207	-0.08601
V72	-0.51889	-0.34494	-0.00745	-0.100855	0.245023	0.242962	-0.05367
V73	-0.54919	-0.0546	-0.11305	0.1886142	0.287611	0.048847	-0.03593
V74	-0.56929	-0.23638	0.06359	-0.0618513	0.326484	0.194641	-0.06316
V75	-0.58006	-0.03776	-0.28078	-0.082529	0.053127	-0.0663	-0.06775
V76	-0.44268	0.037633	-0.23273	0.2373623	0.033093	0.104851	0.011909
V77	-0.44449	0.100005	-0.2039	0.3050628	0.059507	0.091898	-0.01598
V78	-0.45811	0.069077	-0.23511	0.2812709	-0.03613	0.027693	-0.01971
V79	-0.42798	0.034219	-0.20423	0.1970466	0.101397	-0.00996	-0.11621
V80	-0.51656	0.050197	-0.1658	0.2353826	0.197853	0.035677	-0.04787
V81	-0.425	-0.09	-0.09447	0.2540968	0.284265	0.050692	-0.06021
V82	-0.54777	0.175207	0.003745	0.261	0.182818	0.067429	-0.06867
V83	-0.43358	-0.01686	-0.11536	0.2841726	0.221894	0.046145	-0.02054
V84	-0.38431	0.098961	-0.15372	0.3197251	-0.05412	0.061317	-0.00854
V85	-0.48684	0.206824	-0.06966	0.2897304	0.167291	0.111024	-0.04579
V86	-0.39911	-0.00281	-0.10681	0.2913383	0.220096	0.09365	-0.03641
V87	-0.38922	0.081759	-0.17529	0.2650769	0.116051	0.014721	-0.06608
V88	-0.44009	-0.08903	-0.16108	0.0051644	0.099541	0.208302	-0.24441

V89	-0.53044	0.198406	-0.27833	0.1110427	0.094967	-0.11456	0.029185
V90	-0.47979	-0.01534	0.116499	-0.1275045	-0.2332	0.233634	-0.12647
V91	-0.51303	0.172469	-0.3076	-0.0845807	0.127606	-0.17562	0.016074
V92	-0.42793	0.281405	-0.12027	0.2876049	-0.03068	0.059123	0.106161
V93	-0.41294	0.008294	-0.12395	0.1435843	-0.24491	0.097963	-0.13721
V94	-0.49188	0.037409	-0.06165	-0.3150921	-0.07418	-0.04084	-0.13417
V95	-0.53029	0.297683	-0.02424	0.1669566	0.071035	0.0669	-0.12495
V96	-0.53779	0.275228	0.042248	0.168381	-0.07229	0.180152	-0.06116
V97	-0.44144	0.276871	0.04885	0.2522319	-0.12296	0.138936	-0.0371
V98	-0.44461	0.271766	-0.08315	0.2661871	-0.07338	0.038402	-0.06944
V99	-0.45347	0.294332	0.078206	0.2343525	-0.13268	0.13991	-0.01945
V100	-0.48982	0.278587	-0.24904	-0.2207706	0.081823	-0.15992	0.031463
V101	-0.49398	0.355998	0.109211	0.1575008	-0.07245	0.108134	0.081013
V102	-0.57024	0.392092	-0.12294	-0.22661	0.037181	-0.1129	0.022346
V103	-0.38284	0.338604	0.062111	0.2763103	0.005377	0.087358	0.093529
V104	-0.37618	0.337922	-0.17751	0.189457	0.102974	-0.0344	-0.02207
V105	-0.3941	0.243408	-0.19076	0.114458	-0.24458	0.058085	-0.09664
V106	-0.36151	0.254353	-0.28522	0.0199678	0.110157	-0.15673	-0.02326
V107	-0.33108	0.335965	-0.01229	0.3073227	-0.11654	0.047568	-0.01222
V108	-0.37248	0.275223	-0.02971	0.1719351	-0.22576	0.233552	-0.05661
V109	-0.43232	0.348772	-0.26402	-0.1299091	0.026106	-0.15496	-0.01093
V110	-0.37029	0.264889	-0.07221	0.0705515	-0.34866	0.127051	-0.07901
V111	-0.36596	0.265882	-0.1135	0.0605036	-0.33396	0.103401	-0.09361
V112	-0.2967	0.376688	-0.0081	0.2921361	-0.05786	0.110784	-0.01026
V113	-0.27957	0.262822	-0.08834	0.2017893	-0.14728	0.045815	-0.2305
V114	-0.38869	0.442681	0.140293	0.1187327	-0.00507	0.110677	-0.06236
V115	-0.34956	0.419708	-0.19744	0.0505188	0.092926	-0.08291	-0.02763
V116	-0.36712	0.441847	0.106906	0.1261958	0.04374	0.106099	-0.07853
V117	-0.31039	0.382939	-0.19572	0.1366851	0.039364	0.057891	0.088552
V118	-0.32181	0.412933	0.144011	0.1877623	-0.13129	0.104587	-0.00212
V119	-0.2874	0.397813	0.051933	0.2189609	0.040199	0.00744	-0.16159
V120	-0.33117	0.433816	-0.206	-0.0187277	-0.09132	-0.08962	-0.06912
V121	-0.36228	0.486069	0.167734	0.0744998	-0.01432	0.046571	-0.04975
V122	-0.41357	0.531198	-0.00732	-0.1069084	-0.05633	-0.01803	-0.04407
V123	-0.33291	0.490563	-0.16388	0.0052829	-0.067	0.049295	-0.02906
V124	-0.29077	0.478325	0.114317	0.1531573	0.055129	0.073838	-0.09537
V125	-0.39597	0.560517	-0.02942	-0.263168	0.002952	-0.04732	0.00969
V126	-0.36883	0.551617	-0.07289	-0.213168	-0.003	-0.0594	0.003372
V127	-0.38716	0.554338	-0.04779	-0.2535202	-0.02226	-0.04328	0.01724
V128	-0.20477	0.437602	-0.00118	0.1695667	-0.19486	-0.08496	-0.03115
V129	-0.32322	0.513693	-0.12134	-0.2336122	0.052307	-0.08056	0.034731
V130	-0.28134	0.516928	-0.15581	-0.0287199	-0.02027	-0.08783	0.00585
V131	-0.21358	0.500963	-0.05817	0.0956509	-0.12692	0.012584	-0.13968
V132	-0.4255	0.57921	0.168771	-0.1844928	-0.04283	0.058842	-0.03573
V133	-0.25089	0.549635	0.107299	-0.0313153	0.033345	0.081568	-0.03418
V134	-0.24145	0.461137	-0.13026	-0.2614253	-0.12146	-0.05094	-0.07811
V135	-0.22532	0.463948	0.017259	-0.167803	-0.1681	0.195936	-0.09519

V136	-0.28548	0.584613	-0.0456	-0.2798355	-0.04994	-0.00333	0.007617
V137	-0.20389	0.557812	0.053281	-0.0097344	-0.14985	0.06521	0.111667
V138	-0.12763	0.44347	-0.17097	-0.0567192	-0.18343	0.051457	-0.11401
V139	-0.17786	0.478583	-0.18741	-0.2453637	-0.10223	-0.08623	-0.01149
V140	-0.16801	0.564082	-0.0383	-0.0461962	-0.10151	0.075899	0.002386
V141	-0.16074	0.545094	-0.00379	-0.1209028	0.011557	0.022031	-0.11044
V142	-0.22012	0.59907	-0.07175	-0.2776884	-0.03418	-0.01221	0.042128
V143	-0.2387	0.609735	-0.03319	-0.302848	-0.04853	-0.00077	0.041845
V144	-0.08757	0.553451	-0.0918	0.0161681	-0.14022	0.028519	0.106744
V145	-0.07149	0.515033	-0.19552	-0.0322534	0.056767	-0.0599	0.038689
V146	-0.11829	0.594456	-0.13176	-0.0787085	-0.01381	-0.04128	0.047852
V147	-0.0298	0.506197	-0.13111	-0.0055553	-0.0788	-0.05159	0.11862
V148	-0.04869	0.533317	-0.09062	-0.02078	-0.14397	-0.03569	0.103442
V149	-0.04	0.496746	-0.14401	-0.1453909	-0.06283	0.015087	0.010493
V150	-0.07077	0.566635	-0.06501	-0.0152728	-0.1511	0.037307	0.155111
V151	-0.06494	0.589241	-0.03176	-0.0003625	-0.11464	0.025965	0.140501
V152	0.008205	0.501399	-0.14082	0.0607502	-0.16529	-0.0322	0.063847
V153	-0.10024	0.602653	-0.09317	-0.2292805	-0.07315	-0.01484	0.124454
V154	0.019251	0.438437	-0.21477	-0.1139491	-0.14693	-0.01145	0.091852
V155	0.114194	0.259654	-0.20045	-0.2381816	-0.15082	0.065149	0.063766
V156	0.129686	0.398971	-0.17124	0.0851458	-0.00556	0.018005	0.01019
V157	0.122173	0.402327	-0.19943	-0.0147386	0.086085	0.044491	-0.0199
V158	0.17065	0.331112	-0.19648	0.0361029	-0.03174	-0.0147	-0.02576
V159	0.117833	0.39321	-0.16747	0.0573228	0.115012	-0.12916	0.061174
V160	0.187404	0.298874	-0.1412	0.0537027	0.156381	-0.12255	0.025356
V161	0.158064	0.288246	-0.1593	-0.2414196	-0.03439	-0.05671	-0.00629
V162	0.237695	0.184098	-0.16542	-0.1779444	-0.0635	-0.08631	-0.03307
V163	0.115032	0.439493	-0.10618	0.0976551	-0.06382	-0.10232	0.19969
V164	0.219658	0.245399	-0.21146	-0.1173251	-0.02672	-0.02277	0.075934
V165	0.224457	0.244978	-0.18335	-0.0504795	0.168691	0.163217	0.078704
V166	0.212001	0.214682	-0.04159	-0.3165227	-0.0118	-0.08014	-0.02011
V167	0.219589	0.263997	-0.06263	0.0572375	0.277665	-0.06088	0.00811
V168	0.119629	0.457661	0.03218	-0.0298847	0.198165	0.197466	-0.04567
V169	0.203503	0.236066	0.033675	-0.3232582	0.030085	-0.10286	-0.00378
V170	0.232571	0.330266	-0.05638	0.1622644	0.095033	-0.05059	-0.03454
V171	0.209684	0.240176	-0.05224	-0.2942549	-0.15149	-0.08029	0.059133
V172	0.192767	0.413871	-0.01919	-0.0575397	0.186281	-0.04317	-0.01416
V173	0.291	0.247349	-0.07486	0.0712716	0.098422	-0.1214	-0.05499
V174	0.219906	0.37131	0.007509	0.190357	0.128441	-0.07379	0.044611
V175	0.222225	0.256628	0.119855	-0.0497567	0.31076	-0.09307	-0.01629
V176	0.29932	0.091325	-0.07383	-0.341999	0.050849	-0.0371	0.068227
V177	0.248838	0.378246	-0.02112	0.1344388	0.067027	-6.7E-05	0.170662
V178	0.229586	0.313308	0.043808	-0.0920993	0.270436	-0.07299	-0.01341
V179	0.285959	0.150613	0.051861	-0.3159734	0.134959	-0.09806	0.002979
V180	0.318084	0.136498	-0.05781	-0.0822026	0.295326	0.046422	0.095927
V181	0.297208	0.179663	0.005596	-0.2459523	0.154913	-0.12888	-0.05505
V182	0.312481	0.208293	0.030985	0.1260274	0.168114	-0.13197	-0.09238



V183	0.261365	0.265562	0.136354	-0.1631415	0.117632	-0.18184	-0.08875
V184	0.227718	0.393097	0.265152	-0.0796646	-0.09436	-0.04414	-0.06225
V185	0.317853	0.142521	0.072407	-0.2337092	-0.03763	-0.21944	-0.06696
V186	0.290928	0.291137	0.101	-0.0276686	-0.14221	-0.23435	-0.00468
V187	0.284563	0.241523	0.195062	0.1079115	0.216894	-0.10708	-0.05454
V188	0.266043	0.296376	0.284539	0.0807752	0.09286	0.108061	-0.06947
V189	0.258023	0.399198	0.289432	-0.0263237	-0.06186	-0.06462	0.023684
V190	0.266184	0.378841	0.280686	0.015952	0.09366	-0.14226	-0.05092
V191	0.301098	0.248534	0.192468	-0.1753647	-0.22356	-0.09159	-0.06124
V192	0.312625	0.17141	0.335759	-0.0090389	0.103541	-0.07714	-0.03799
V193	0.349368	0.180689	0.167481	0.139472	0.154477	0.159487	0.024468
V194	0.283535	0.281451	0.355692	-0.0923982	0.078781	0.033297	-0.06712
V195	0.348128	0.154517	0.251392	-0.0863125	-0.13316	-0.162	-0.03538
V196	0.324555	0.314138	0.260475	0.1645848	-0.07356	-0.1083	0.003922
V197	0.316881	0.353045	0.3023	0.0703001	-0.03531	-0.12713	-0.03085
V198	0.310527	0.342755	0.317389	0.1644812	0.109533	-0.01806	0.05294
V199	0.343753	0.271967	0.251181	0.2287256	-0.04442	-0.03757	0.034764
V200	0.314846	0.342447	0.371454	0.0468624	-0.0511	-0.00971	0.018893
V201	0.348193	0.312884	0.303194	0.110856	0.105742	0.061118	0.073527
V202	0.329959	0.359497	0.354557	0.0941118	0.091817	-0.00829	-0.00552
V203	0.399541	0.161898	0.239195	0.201573	0.073945	-0.07519	0.054159
V204	0.413011	0.13605	0.22724	0.1917306	0.138134	0.034967	0.068786
V205	0.375281	0.366349	0.257497	0.1281879	0.178135	-0.06549	0.050803
V206	0.416445	0.175079	0.216221	0.2182301	0.093138	-0.06802	-0.00187
V207	0.405281	0.337574	0.230484	0.1809134	0.09978	-0.05301	0.090144
V208	0.43124	0.255396	0.181714	0.2385721	-0.11135	0.024578	0.053695
V209	0.481664	0.034312	0.186093	0.1841244	0.054256	0.057113	0.032066
V210	0.482022	0.183639	0.161796	0.1467482	0.096532	-0.03961	-0.00013
V211	0.52157	-0.06782	0.18097	0.0860564	0.019995	-0.0368	0.004096
V212	0.5161	-0.02377	0.177281	0.0990495	0.030118	-0.09433	0.005993
V213	0.530253	-0.10715	0.185301	0.0647296	0.038107	-0.05165	0.008644
V214	0.482333	0.055716	0.210491	0.0748959	0.029532	-0.19482	-0.07205
V215	0.518781	-0.05794	0.229808	0.0020501	-0.00786	-0.12529	-0.03592
V216	0.508992	0.061222	0.117094	0.0097793	0.058964	-0.23313	-0.04574
V217	0.492024	-0.01292	0.273768	0.1135028	0.134391	0.025113	0.048818
V218	0.5362	-0.06224	0.160699	0.0493801	0.073057	-0.14602	0.027139
V219	0.542945	-0.12286	0.174533	0.0356348	0.080521	-0.10147	0.078831
V220	0.529133	0.020963	0.139106	-0.0160884	0.150734	-0.1236	0.112957
V221	0.545093	-0.12776	0.200697	-0.0432244	0.008816	-0.09984	-0.04361
V222	0.545927	-0.11939	0.189251	-0.0079751	0.102071	-0.09407	0.01612
V223	0.542097	-0.10134	0.197699	-0.0532819	-0.06671	-0.04465	-0.08857
V224	0.553771	-0.14316	0.186728	-0.0389262	0.054681	-0.09361	-0.0118
V225	0.553798	-0.15312	0.192602	-0.0530087	0.082828	-0.11586	0.061414
V226	0.554777	-0.13176	0.188492	-0.0355505	0.071505	-0.12588	0.065212
V227	0.552807	-0.12844	0.197616	-0.0491992	0.045991	-0.08762	-0.07986
V228	0.547345	-0.08576	0.181291	-0.1022494	0.161035	-0.06493	0.070429
V229	0.531032	-0.04639	0.234098	-0.0532649	0.156856	0.183713	-0.03116

V230	0.545726	-0.04556	0.26212	0.0323619	0.034512	0.14905	-0.04558
V231	0.566625	0.004681	0.134695	0.0735208	-0.12221	0.172252	0.143056
V232	0.565829	-0.16368	0.201623	-0.1115595	0.095898	-0.00844	0.104149
V233	0.561103	0.014254	0.214126	-0.0100872	-0.13294	0.200197	0.067391
V234	0.559477	-0.06716	0.215587	-0.1318932	0.024739	0.165143	-0.01127
V235	0.585082	-0.12705	0.186667	-0.0449944	0.102614	0.080958	-0.01256
V236	0.56017	-0.07508	0.243163	-0.0476122	0.052595	0.201972	-0.0371
V237	0.577216	-0.13705	0.184946	-0.1140937	-0.04897	0.007939	-0.15717
V238	0.585217	-0.17164	0.156004	-0.0777644	-0.02679	0.057248	0.140728
V239	0.583994	-0.17522	0.196177	-0.1541431	-0.00262	0.036151	0.028571
V240	0.581242	-0.15146	0.233312	-0.0392209	0.130096	0.123779	0.094259
V241	0.589297	-0.17812	0.187811	-0.1126076	0.037755	0.101001	-0.05829
V242	0.592655	-0.18623	0.209068	-0.1169723	0.03369	0.000597	-0.1104
V243	0.590599	-0.1595	0.266273	-0.0149242	0.0659	0.011755	-0.11034
V244	0.588316	-0.09962	0.27984	0.044445	-0.11562	0.129741	-0.08239
V245	0.601527	-0.14786	0.174617	0.0189749	-0.06132	0.205061	0.071742
V246	0.605461	-0.15676	0.194247	-0.0260056	-0.12498	0.027237	-0.13289
V247	0.607744	-0.15806	0.224811	0.0025133	-0.07887	0.008228	-0.15436
V248	0.628463	-0.13387	0.177645	0.1014557	-0.15089	0.11039	0.067956
V249	0.64048	-0.09278	0.198768	0.0913338	-0.18072	0.078091	-0.01335
V250	0.642212	-0.1189	0.133169	0.1128479	-0.1595	0.106273	0.099907
V251	0.627508	-0.21839	0.224878	0.0385522	0.00125	0.113951	0.06883
V252	0.630642	-0.26181	0.144809	-0.0458722	-0.04696	0.105091	-0.08938
V253	0.6351	-0.2752	0.164978	-0.037032	-0.05261	0.037528	-0.03312
V254	0.638253	-0.28403	0.14985	-0.0325329	-0.02146	0.077252	0.020643
V255	0.643893	-0.23639	0.118048	-0.0678915	-0.13656	-0.04406	-0.08993
V256	0.728473	-0.00736	0.030242	-0.2328362	0.037825	-0.00378	-0.02727
V257	0.714863	-0.05663	-0.00026	-0.2125201	0.067562	0.011326	0.064914
V258	0.650723	-0.22394	0.049598	-0.1711688	0.071136	0.194807	-0.03754
V259	0.662231	-0.2732	0.031722	-0.1295165	0.063211	0.091584	0.0604
V260	0.692472	-0.15155	0.045233	-0.1964668	-0.08057	0.105905	-0.04922
V261	0.686312	-0.23022	0.041939	-0.0335286	0.071499	0.122503	0.140882
V262	0.671001	-0.29892	0.042443	-0.1481525	0.051543	0.036972	0.051486
V263	0.685686	-0.20952	-0.00372	-0.0637987	-0.01433	0.165449	0.173892
V264	0.675518	-0.29049	0.01377	-0.169652	-0.02374	0.015689	-0.05222
V265	0.680446	-0.28101	-2.1E-05	-0.1634314	-0.02765	-0.01751	-0.08669
V266	0.697916	-0.20709	-0.01032	-0.1238658	-0.2162	0.058701	-0.00466
V267	0.721572	-0.17188	-0.09131	-0.1887363	-0.0782	-0.06131	-0.05282
V268	0.698677	-0.24468	-0.04472	-0.042846	-0.18998	0.077178	0.080449
V269	0.739195	-0.12896	-0.14531	-0.2279923	-0.02891	-0.02821	-0.02017
V270	0.712593	-0.22385	-0.11572	-0.2026754	-0.05861	-0.01216	-0.0005
V271	0.715867	-0.18647	-0.09042	-0.0196887	-0.25593	0.115681	0.012426
V272	0.716894	-0.20925	-0.1305	-0.0370296	-0.22202	0.069828	0.010526
V273	0.712644	-0.2109	-0.11945	-0.0265509	-0.2181	0.142008	0.068255
V274	0.761604	-0.12548	-0.22457	-0.0853081	-0.07693	0.011539	0.036266
V275	0.770072	-0.10875	-0.19079	0.0459441	-0.15442	0.071694	-0.02095
V276	0.739578	-0.235	-0.20154	-0.0098582	-0.11733	-0.0267	-0.02507

V277	0.741699	-0.24038	-0.21418	-0.0019093	-0.06061	-0.08238	0.042275
V278	0.750604	-0.20137	-0.25451	-0.0261345	-0.03289	-0.06026	0.035113
V279	0.755613	-0.15241	-0.26195	0.0852659	-0.16076	-0.0099	0.012509
V280	0.749011	-0.19624	-0.28932	0.0109728	-0.07779	-0.02171	0.020945
V281	0.743992	-0.21466	-0.31637	0.0063801	-0.01368	0.065953	-0.02355
V282	0.735469	-0.24668	-0.30337	-0.0122193	-0.01715	0.093491	-0.07169
V283	0.735006	-0.24772	-0.304	-0.0122224	-0.01591	0.096281	-0.07571
V284	0.72727	-0.34492	-0.25614	0.022182	-0.00657	0.061705	-0.0197
V285	0.727096	-0.34517	-0.2553	0.0414502	-0.02742	0.061145	-0.03437
V286	0.727328	-0.3364	-0.26973	0.0036623	-0.04455	0.004615	-0.09068
V287	0.726039	-0.33698	-0.30139	-0.024826	-0.00525	0.033729	-0.02021
V288	0.727642	-0.34463	-0.29962	-0.0047916	0.010745	0.017621	0.003767
V289	0.736884	-0.25862	-0.38237	0.0241561	-0.0327	-0.03215	-0.0396
V290	0.729169	-0.35623	-0.29735	0.0925225	-0.00179	0.004041	-0.01158
V291	0.729306	-0.36849	-0.28754	0.1094777	0.048135	0.01203	-0.00335
V292	0.722748	-0.39604	-0.29143	0.0589316	0.017028	-0.02181	-0.00985
V293	0.723725	-0.39264	-0.29869	0.0600225	0.035841	-0.02798	-0.00092
V294	0.724264	-0.40082	-0.28629	0.09982	0.061611	-0.01375	-0.00268
V295	0.723423	-0.40226	-0.28521	0.1504952	0.00162	0.009297	0.007851
V296	0.728742	-0.37635	-0.30962	0.1469079	0.101937	-0.02664	0.007217
V297	0.726643	-0.39822	-0.28415	0.1893906	0.044184	-0.01001	0.008458
V298	0.730297	-0.36005	-0.33489	0.1931132	0.051928	-0.04878	0.008647
V299	0.725131	-0.38986	-0.31472	0.2227723	-0.02052	-0.05271	0.007588
V300	0.726758	-0.37701	-0.3249	0.2361182	-0.01615	-0.06019	0.009016
V301	0.723831	-0.38976	-0.32433	0.2360764	-0.01669	-0.06893	0.007728
V302	0.724554	-0.37249	-0.35351	0.2318668	-0.01331	-0.09961	0.01013
V303	0.721933	-0.39372	-0.33778	0.2339188	-0.03657	-0.11823	0.007019
V304	0.721136	-0.39886	-0.33548	0.2404189	-0.04458	-0.12537	0.01209

Appendix F

Loading for Responses for Rating Task

<b>Dimension</b>									
<b>1</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>3</b>	<b>3</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>5</b>
<b>V</b>	<b>LV</b>	<b>V</b>	<b>LV</b>	<b>V</b>	<b>LV</b>	<b>V</b>	<b>LV</b>	<b>V</b>	<b>LV</b>
28	-0.852	2	0.624	3	0.468	15	-0.561	11	-0.521
30	-0.858	5	0.518	7	0.512	26	-0.413	12	-0.485
47	-0.871	9	0.519	13	0.407	77	-0.309	16	-0.359
48	-0.854	22	0.524	200	0.408	84	-0.329	90	-0.348
50	-0.837	32	0.582	202	0.421	12	-0.318	110	-0.318
271	0.777	142	-0.6	89	-0.338	48	0.361	28	0.453
274	0.784	143	-0.612	106	-0.353	179	0.355	30	0.481
275	0.799	150	-0.605	302	-0.402	169	0.339	74	0.312
278	0.765	151	-0.613	303	-0.391	176	0.342	41	0.312
280	0.766	153	-0.618	304	-0.392	170	0.33	167	0.29

**NOTE**

V: Response Variable Number

LV: Loading Value

## Appendix G

### Appendix G-I

#### Survey for Regulatory Compliance

<b>Number</b>	<b>Findings</b>	<b>Rating</b>
1	Pulled circuit breakers without "Lock Out Tags" in cockpit of N673FE.	
2	Found fire extinguisher #EE 4328 past due inspection on lift truck # 10165.	
3	Found several non-flammable compressed gas containers stacked improperly in different locations throughout the facility.	
4	Safety eyewash station in battery shop does not have the cleaning solution mounted on the wall, and the eyewash stations in several shop areas did not have safety covers installed.	
5	The FedEx Ramp Tower Control Center has only one emergency exit leading to the ramp. If a fire or some other catastrophic event should block this means of egress, the ramp tower personnel would not have an immediate source of egress.	
6	Found plastic bags of compressor blades with metal to metal contact.	
7	Many circuit breakers were pulled on the FedEx aircraft in work; none had the breakers collared to prevent inadvertent engagement.	
8	Door locks were not engaged in the fully closed latched position.	
9	Certain vendor employees that drove vehicles on the ramp did not turn of the engines while the vehicles were unoccupied.	
10	Generator used to provide aircraft power was mounted on a piece of plywood, stacked on cement blocks.	
11	Several AMT training records contained multiple and / or outdated copies of MOPs and several AMT had incomplete MOPs past the 60 day time limit for completion.	
12	Internal audits are not being conducted in accordance with the frequency outlined in the Base Maintenance Desktop Procedure Manual (DTPM).	
13	There are inadequate controls to ensure the previous owners' AD compliance record is accurate. Aircraft Conversions performs the primary review of the previous operator's records, and completes an AD Verification Report for the airframe, engines and components and life limited parts histories without verification processes.	
14	The Flight Safety DPM and the ASM state that all of the airports served by FedEx Express are assigned to Flight Safety Department Specialists for auditing. The airports in Asia and Latin America are currently unassigned.	
15	There was a localized issue revealed through the audit. A review of the Service Difficulty Report (SDR) log revealed numerous SDRs not closed.	
16	Motorized gas powered equipment within 25 ft of confined space perimeter.	
17	Plan does not match lay out for eye wash stations. First aid kits not stocked. Eye wash stations not cleaned. Trash cans full through out hanger. Work area very disorganized.	
18	Found wrong grease in tool crib grease gun.	
19	RT wing tip aft position light assembly is missing.	
20	Noted that upper deck area not lighted well for work in progress.	
21	Investigation revealed that stamp control per the Base Maintenance DTPM was not being followed consistently.	
22	Found engine received and released for service with incorrect or missing component airworthiness approval documentation.	
23	Non-aircraft sheet metal parts found in the mechanic's tool box.	

24	Incoming receiving inspections are not being accomplished in a timely fashion.	
25	Found squibs removed from the engine bottles, and the voids were not blocked.	
26	Ballast Pallet installed at cargo door area of main cargo deck with no cargo pallet locks secured.	
27	Found Auto Slat Extend Cont breaker not pulled IAW Predock card 53B0001.	
28	Aerosol cans were stored in a locker instead of in a flammable cabinet.	
29	ULDs, doors, and nets stored in some areas are not in compliance with the ULD Planning Policy.	
30	Roller Assembly marked as "condemned" was found stored on Discrepant Material rack 26 of 32.	
31	Several ball-mats were found without serviceability documentation in two separate locations.	
32	Found numerous main A/C batteries on pallets in the warehouse area without paperwork attached and serviceable and not identified.	
33	After Installation of Flap to wing fittings the attached bolt PRC protective sealant was not applied completely on attached hardware.	
34	Found container restraint collar STA 515 2nd seat track damaged/worn. Missed during incoming inspection.	
35	No security check takes place at this facility as has been outlined on the facility safety inspection checklist.	
36	Audit function completed per GMM 5-3-500 but found paperwork had not been completed.	
37	Found no certification for re-paint of repair.	
38	Found NDT not using T-619 form on a daily/first use basis per RSM.	
39	Flight Standards Line Check Airman/Designee Training for the specific fleets is not standardized. Each fleet type has different documentation and curriculums to qualify crewmembers.	
40	No environmental coordinator for the facility.	
41	No security check takes place at this facility.	
42	The FedEx Express FOM does not provide for a procedure to keep the flight crew members or other persons used in its operations informed of the provisions of its operations specifications when new operations specifications are received.	
43	Scrap trailers full and outside area overflowing.	
44	Found box with lose hardware at nose of aircraft.	
45	Step 3 for faxing should not have an associated N/A response.	
46	Company New Hire Pilot training information indicates FedEx Express does not utilize the provisions of FAR 121.523. The provisions of this FAR are referred to in the FOM and are part of the training syllabus in the FAA approved CRS Training Manual. It is not clear as to how the various provisions of FAR 121.523 can be discounted as not applicable to FedEx Express operations.	
47	SN and Performed Date were incorrectly entered on pages 1-3 of document SK-34-11-01.	

### Instructions

You have been presented with 47 different audit and surveillance findings. Please indicate the relationship of these responses to regulatory compliance.

Rate these responses on a scale of 1 to 7, where 7 indicates that the finding is highly associated with a Regulatory Compliance concern, and 1 indicates that the finding is not associated with a Regulatory Compliance concern.

Appendix G-II

Survey for Procedures and Paperwork Inadequacy

<b>Number</b>	<b>Findings</b>	<b>Rating</b>
1	Pulled circuit breakers without "Lock Out Tags" in cockpit of N673FE.	
2	Found fire extinguisher #EE 4328 past due inspection on lift truck # 10165.	
3	Found several non-flammable compressed gas containers stacked improperly in different locations throughout the facility.	
4	Safety eyewash station in battery shop does not have the cleaning solution mounted on the wall, and the eyewash stations in several shop areas did not have safety covers installed.	
5	The FedEx Ramp Tower Control Center has only one emergency exit leading to the ramp. If a fire or some other catastrophic event should block this means of egress, the ramp tower personnel would not have an immediate source of egress.	
6	Found plastic bags of compressor blades with metal to metal contact.	
7	Many circuit breakers were pulled on the FedEx aircraft in work; none had the breakers collared to prevent inadvertent engagement.	
8	Door locks were not engaged in the fully closed latched position.	
9	Certain vendor employees that drove vehicles on the ramp did not turn off the engines while the vehicles were unoccupied.	
10	Generator used to provide aircraft power was mounted on a piece of plywood, stacked on cement blocks.	
11	Several AMT training records contained multiple and / or outdated copies of MOPs and several AMT had incomplete MOPs past the 60 day time limit for completion.	
12	Internal audits are not being conducted in accordance with the frequency outlined in the Base Maintenance Desktop Procedure Manual (DTPM).	
13	There are inadequate controls to ensure the previous owners' AD compliance record is accurate. Aircraft Conversions performs the primary review of the previous operator's records, and completes an AD Verification Report for the airframe, engines and components and life limited parts histories without verification processes.	
14	The Flight Safety DPM and the ASM state that all of the airports served by FedEx Express are assigned to Flight Safety Department Specialists for auditing. The airports in Asia and Latin America are currently unassigned.	
15	There was a localized issue revealed through the audit. A review of the Service Difficulty Report (SDR) log revealed numerous SDRs not closed.	
16	Motorized gas powered equipment within 25 ft of confined space perimeter.	
17	Plan does not match lay out for eye wash stations. First aid kits not stocked. Eye wash stations not cleaned. Trash cans full through out hanger. Work area very disorganized.	
18	Found wrong grease in tool crib grease gun.	
19	RT wing tip aft position light assembly is missing.	
20	Noted that upper deck area not lighted well for work in progress.	
21	Investigation revealed that stamp control per the Base Maintenance DTPM was not being followed consistently.	
22	Found engine received and released for service with incorrect or missing component airworthiness approval documentation.	
23	Non-aircraft sheet metal parts found in the mechanic's tool box.	
24	Incoming receiving inspections are not being accomplished in a timely fashion.	

25	Found squibs removed from the engine bottles, and the voids were not blocked.	
26	Ballast Pallet installed at cargo door area of main cargo deck with no cargo pallet locks secured.	
27	Found Auto Slat Extend Cont breaker not pulled IAW Predock card 53B0001.	
28	Aerosol cans were stored in a locker instead of in a flammable cabinet.	
29	ULDs, doors, and nets stored in some areas are not in compliance with the ULD Planning Policy.	
30	Roller Assembly marked as "condemned" was found stored on Discrepant Material rack 26 of 32.	
31	Several ball-mats were found without serviceability documentation in two separate locations.	
32	Found numerous main A/C batteries on pallets in the warehouse area without paperwork attached and serviceable and not identified.	
33	After Installation of Flap to wing fittings the attached bolt PRC protective sealant was not applied completely on attached hardware.	
34	Found container restraint collar STA 515 2nd seat track damaged/worn. Missed during incoming inspection.	
35	No security check takes place at this facility as has been outlined on the facility safety inspection checklist.	
36	Audit function completed per GMM 5-3-500 but found paperwork had not been completed.	
37	Found no certification for re-paint of repair.	
38	Found NDT not using T-619 form on a daily/first use basis per RSM.	
39	Flight Standards Line Check Airman/Designee Training for the specific fleets is not standardized. Each fleet type has different documentation and curriculums to qualify crewmembers.	
40	No environmental coordinator for the facility.	
41	No security check takes place at this facility.	
42	The FedEx Express FOM does not provide for a procedure to keep the flight crew members or other persons used in its operations informed of the provisions of its operations specifications when new operations specifications are received.	
43	Scrap trailers full and outside area overflowing.	
44	Found box with loose hardware at nose of aircraft.	
45	Step 3 for faxing should not have an associated N/A response.	
46	Company New Hire Pilot training information indicates FedEx Express does not utilize the provisions of FAR 121.523. The provisions of this FAR are referred to in the FOM and are part of the training syllabus in the FAA approved CRS Training Manual. It is not clear as to how the various provisions of FAR 121.523 can be discounted as not applicable to FedEx Express operations.	
47	SN and Performed Date were incorrectly entered on pages 1-3 of document SK-34-11-01.	

### Instructions

You have been presented with 47 different audit and surveillance findings. Please indicate the relationship of these responses to procedures and paperwork inadequacy.

Rate these responses on a scale of 1 to 7, where 7 indicates that the finding is highly associated with procedures and paperwork inadequacy and 1 indicates that the finding is not associated with a procedures and paperwork inadequacy concern.



Appendix G-III

Survey for Operations

<b>Number</b>	<b>Findings</b>	<b>Rating</b>
1	Pulled circuit breakers without "Lock Out Tags" in cockpit of N673FE.	
2	Found fire extinguisher #EE 4328 past due inspection on lift truck # 10165.	
3	Found several non-flammable compressed gas containers stacked improperly in different locations throughout the facility.	
4	Safety eyewash station in battery shop does not have the cleaning solution mounted on the wall, and the eyewash stations in several shop areas did not have safety covers installed.	
5	The FedEx Ramp Tower Control Center has only one emergency exit leading to the ramp. If a fire or some other catastrophic event should block this means of egress, the ramp tower personnel would not have an immediate source of egress.	
6	Found plastic bags of compressor blades with metal to metal contact.	
7	Many circuit breakers were pulled on the FedEx aircraft in work; none had the breakers collared to prevent inadvertent engagement.	
8	Door locks were not engaged in the fully closed latched position.	
9	Certain vendor employees that drove vehicles on the ramp did not turn off the engines while the vehicles were unoccupied.	
10	Generator used to provide aircraft power was mounted on a piece of plywood, stacked on cement blocks.	
11	Several AMT training records contained multiple and / or outdated copies of MOPs and several AMT had incomplete MOPs past the 60 day time limit for completion.	
12	Internal audits are not being conducted in accordance with the frequency outlined in the Base Maintenance Desktop Procedure Manual (DTPM).	
13	There are inadequate controls to ensure the previous owners' AD compliance record is accurate. Aircraft Conversions performs the primary review of the previous operator's records, and completes an AD Verification Report for the airframe, engines and components and life limited parts histories without verification processes.	
14	The Flight Safety DPM and the ASM state that all of the airports served by FedEx Express are assigned to Flight Safety Department Specialists for auditing. The airports in Asia and Latin America are currently unassigned.	
15	There was a localized issue revealed through the audit. A review of the Service Difficulty Report (SDR) log revealed numerous SDRs not closed.	
16	Motorized gas powered equipment within 25 ft of confined space perimeter.	
17	Plan does not match lay out for eye wash stations. First aid kits not stocked. Eye wash stations not cleaned. Trash cans full through out hanger. Work area very disorganized.	
18	Found wrong grease in tool crib grease gun.	
19	RT wing tip aft position light assembly is missing.	
20	Noted that upper deck area not lighted well for work in progress.	
21	Investigation revealed that stamp control per the Base Maintenance DTPM was not being followed consistently.	
22	Found engine received and released for service with incorrect or missing component airworthiness approval documentation.	
23	Non-aircraft sheet metal parts found in the mechanic's tool box.	
24	Incoming receiving inspections are not being accomplished in a timely fashion.	

25	Found squibs removed from the engine bottles, and the voids were not blocked.	
26	Ballast Pallet installed at cargo door area of main cargo deck with no cargo pallet locks secured.	
27	Found Auto Slat Extend Cont breaker not pulled IAW Predock card 53B0001.	
28	Aerosol cans were stored in a locker instead of in a flammable cabinet.	
29	ULDs, doors, and nets stored in some areas are not in compliance with the ULD Planning Policy.	
30	Roller Assembly marked as "condemned" was found stored on Discrepant Material rack 26 of 32.	
31	Several ball-mats were found without serviceability documentation in two separate locations.	
32	Found numerous main A/C batteries on pallets in the warehouse area without paperwork attached and serviceable and not identified.	
33	After Installation of Flap to wing fittings the attached bolt PRC protective sealant was not applied completely on attached hardware.	
34	Found container restraint collar STA 515 2nd seat track damaged/worn. Missed during incoming inspection.	
35	No security check takes place at this facility as has been outlined on the facility safety inspection checklist.	
36	Audit function completed per GMM 5-3-500 but found paperwork had not been completed.	
37	Found no certification for re-paint of repair.	
38	Found NDT not using T-619 form on a daily/first use basis per RSM.	
39	Flight Standards Line Check Airman/Designee Training for the specific fleets is not standardized. Each fleet type has different documentation and curriculums to qualify crewmembers.	
40	No environmental coordinator for the facility.	
41	No security check takes place at this facility.	
42	The FedEx Express FOM does not provide for a procedure to keep the flight crew members or other persons used in its operations informed of the provisions of its operations specifications when new operations specifications are received.	
43	Scrap trailers full and outside area overflowing.	
44	Found box with lose hardware at nose of aircraft.	
45	Step 3 for faxing should not have an associated N/A response.	
46	Company New Hire Pilot training information indicates FedEx Express does not utilize the provisions of FAR 121.523. The provisions of this FAR are referred to in the FOM and are part of the training syllabus in the FAA approved CRS Training Manual. It is not clear as to how the various provisions of FAR 121.523 can be discounted as not applicable to FedEx Express operations.	
47	SN and Performed Date were incorrectly entered on pages 1-3 of document SK-34-11-01.	

### Instructions

You have been presented with 47 different audit and surveillance findings. Please indicate the relationship of these responses to operations.

Rate these responses on a scale of 1 to 7, where 7 indicates that the finding is highly associated with operations and 1 indicates that the finding is not associated with a operations inadequacy concern.

Appendix G-IV

Survey for House Keeping and Storage

<b>Number</b>	<b>Findings</b>	<b>Rating</b>
1	Pulled circuit breakers without "Lock Out Tags" in cockpit of N673FE.	
2	Found fire extinguisher #EE 4328 past due inspection on lift truck # 10165.	
3	Found several non-flammable compressed gas containers stacked improperly in different locations throughout the facility.	
4	Safety eyewash station in battery shop does not have the cleaning solution mounted on the wall, and the eyewash stations in several shop areas did not have safety covers installed.	
5	The FedEx Ramp Tower Control Center has only one emergency exit leading to the ramp. If a fire or some other catastrophic event should block this means of egress, the ramp tower personnel would not have an immediate source of egress.	
6	Found plastic bags of compressor blades with metal to metal contact.	
7	Many circuit breakers were pulled on the FedEx aircraft in work; none had the breakers collared to prevent inadvertent engagement.	
8	Door locks were not engaged in the fully closed latched position.	
9	Certain vendor employees that drove vehicles on the ramp did not turn off the engines while the vehicles were unoccupied.	
10	Generator used to provide aircraft power was mounted on a piece of plywood, stacked on cement blocks.	
11	Several AMT training records contained multiple and / or outdated copies of MOPs and several AMT had incomplete MOPs past the 60 day time limit for completion.	
12	Internal audits are not being conducted in accordance with the frequency outlined in the Base Maintenance Desktop Procedure Manual (DTPM).	
13	There are inadequate controls to ensure the previous owners' AD compliance record is accurate. Aircraft Conversions performs the primary review of the previous operator's records, and completes an AD Verification Report for the airframe, engines and components and life limited parts histories without verification processes.	
14	The Flight Safety DPM and the ASM state that all of the airports served by FedEx Express are assigned to Flight Safety Department Specialists for auditing. The airports in Asia and Latin America are currently unassigned.	
15	There was a localized issue revealed through the audit. A review of the Service Difficulty Report (SDR) log revealed numerous SDRs not closed.	
16	Motorized gas powered equipment within 25 ft of confined space perimeter.	
17	Plan does not match lay out for eye wash stations. First aid kits not stocked. Eye wash stations not cleaned. Trash cans full through out hanger. Work area very disorganized.	
18	Found wrong grease in tool crib grease gun.	
19	RT wing tip aft position light assembly is missing.	
20	Noted that upper deck area not lighted well for work in progress.	
21	Investigation revealed that stamp control per the Base Maintenance DTPM was not being followed consistently.	
22	Found engine received and released for service with incorrect or missing component airworthiness approval documentation.	
23	Non-aircraft sheet metal parts found in the mechanic's tool box.	
24	Incoming receiving inspections are not being accomplished in a timely fashion.	

25	Found squibs removed from the engine bottles, and the voids were not blocked.	
26	Ballast Pallet installed at cargo door area of main cargo deck with no cargo pallet locks secured.	
27	Found Auto Slat Extend Cont breaker not pulled IAW Predock card 53B0001.	
28	Aerosol cans were stored in a locker instead of in a flammable cabinet.	
29	ULDs, doors, and nets stored in some areas are not in compliance with the ULD Planning Policy.	
30	Roller Assembly marked as "condemned" was found stored on Discrepant Material rack 26 of 32.	
31	Several ball-mats were found without serviceability documentation in two separate locations.	
32	Found numerous main A/C batteries on pallets in the warehouse area without paperwork attached and serviceable and not identified.	
33	After Installation of Flap to wing fittings the attached bolt PRC protective sealant was not applied completely on attached hardware.	
34	Found container restraint collar STA 515 2nd seat track damaged/worn. Missed during incoming inspection.	
35	No security check takes place at this facility as has been outlined on the facility safety inspection checklist.	
36	Audit function completed per GMM 5-3-500 but found paperwork had not been completed.	
37	Found no certification for re-paint of repair.	
38	Found NDT not using T-619 form on a daily/first use basis per RSM.	
39	Flight Standards Line Check Airman/Designee Training for the specific fleets is not standardized. Each fleet type has different documentation and curriculums to qualify crewmembers.	
40	No environmental coordinator for the facility.	
41	No security check takes place at this facility.	
42	The FedEx Express FOM does not provide for a procedure to keep the flight crew members or other persons used in its operations informed of the provisions of its operations specifications when new operations specifications are received.	
43	Scrap trailers full and outside area overflowing.	
44	Found box with loose hardware at nose of aircraft.	
45	Step 3 for faxing should not have an associated N/A response.	
46	Company New Hire Pilot training information indicates FedEx Express does not utilize the provisions of FAR 121.523. The provisions of this FAR are referred to in the FOM and are part of the training syllabus in the FAA approved CRS Training Manual. It is not clear as to how the various provisions of FAR 121.523 can be discounted as not applicable to FedEx Express operations.	
47	SN and Performed Date were incorrectly entered on pages 1-3 of document SK-34-11-01.	

### Instructions

You have been presented with 47 different audit and surveillance findings. Please indicate the relationship of these responses to house keeping and storage.

Rate these responses on a scale of 1 to 7, where 7 indicates that the finding is highly associated with house keeping and storage and 1 indicates that the finding is not associated with a house keeping and storage concern.

Appendix G-V

Survey for Safety

<b>Number</b>	<b>Findings</b>	<b>Rating</b>
1	Pulled circuit breakers without "Lock Out Tags" in cockpit of N673FE.	
2	Found fire extinguisher #EE 4328 past due inspection on lift truck # 10165.	
3	Found several non-flammable compressed gas containers stacked improperly in different locations throughout the facility.	
4	Safety eyewash station in battery shop does not have the cleaning solution mounted on the wall, and the eyewash stations in several shop areas did not have safety covers installed.	
5	The FedEx Ramp Tower Control Center has only one emergency exit leading to the ramp. If a fire or some other catastrophic event should block this means of egress, the ramp tower personnel would not have an immediate source of egress.	
6	Found plastic bags of compressor blades with metal to metal contact.	
7	Many circuit breakers were pulled on the FedEx aircraft in work; none had the breakers collared to prevent inadvertent engagement.	
8	Door locks were not engaged in the fully closed latched position.	
9	Certain vendor employees that drove vehicles on the ramp did not turn off the engines while the vehicles were unoccupied.	
10	Generator used to provide aircraft power was mounted on a piece of plywood, stacked on cement blocks.	
11	Several AMT training records contained multiple and / or outdated copies of MOPs and several AMT had incomplete MOPs past the 60 day time limit for completion.	
12	Internal audits are not being conducted in accordance with the frequency outlined in the Base Maintenance Desktop Procedure Manual (DTPM).	
13	There are inadequate controls to ensure the previous owners' AD compliance record is accurate. Aircraft Conversions performs the primary review of the previous operator's records, and completes an AD Verification Report for the airframe, engines and components and life limited parts histories without verification processes.	
14	The Flight Safety DPM and the ASM state that all of the airports served by FedEx Express are assigned to Flight Safety Department Specialists for auditing. The airports in Asia and Latin America are currently unassigned.	
15	There was a localized issue revealed through the audit. A review of the Service Difficulty Report (SDR) log revealed numerous SDRs not closed.	
16	Motorized gas powered equipment within 25 ft of confined space perimeter.	
17	Plan does not match lay out for eye wash stations. First aid kits not stocked. Eye wash stations not cleaned. Trash cans full through out hanger. Work area very disorganized.	
18	Found wrong grease in tool crib grease gun.	
19	RT wing tip aft position light assembly is missing.	
20	Noted that upper deck area not lighted well for work in progress.	
21	Investigation revealed that stamp control per the Base Maintenance DTPM was not being followed consistently.	
22	Found engine received and released for service with incorrect or missing component airworthiness approval documentation.	
23	Non-aircraft sheet metal parts found in the mechanic's tool box.	
24	Incoming receiving inspections are not being accomplished in a timely fashion.	

25	Found squibs removed from the engine bottles, and the voids were not blocked.	
26	Ballast Pallet installed at cargo door area of main cargo deck with no cargo pallet locks secured.	
27	Found Auto Slat Extend Cont breaker not pulled IAW Predock card 53B0001.	
28	Aerosol cans were stored in a locker instead of in a flammable cabinet.	
29	ULDs, doors, and nets stored in some areas are not in compliance with the ULD Planning Policy.	
30	Roller Assembly marked as "condemned" was found stored on Discrepant Material rack 26 of 32.	
31	Several ball-mats were found without serviceability documentation in two separate locations.	
32	Found numerous main A/C batteries on pallets in the warehouse area without paperwork attached and serviceable and not identified.	
33	After Installation of Flap to wing fittings the attached bolt PRC protective sealant was not applied completely on attached hardware.	
34	Found container restraint collar STA 515 2nd seat track damaged/worn. Missed during incoming inspection.	
35	No security check takes place at this facility as has been outlined on the facility safety inspection checklist.	
36	Audit function completed per GMM 5-3-500 but found paperwork had not been completed.	
37	Found no certification for re-paint of repair.	
38	Found NDT not using T-619 form on a daily/first use basis per RSM.	
39	Flight Standards Line Check Airman/Designee Training for the specific fleets is not standardized. Each fleet type has different documentation and curriculums to qualify crewmembers.	
40	No environmental coordinator for the facility.	
41	No security check takes place at this facility.	
42	The FedEx Express FOM does not provide for a procedure to keep the flight crew members or other persons used in its operations informed of the provisions of its operations specifications when new operations specifications are received.	
43	Scrap trailers full and outside area overflowing.	
44	Found box with lose hardware at nose of aircraft.	
45	Step 3 for faxing should not have an associated N/A response.	
46	Company New Hire Pilot training information indicates FedEx Express does not utilize the provisions of FAR 121.523. The provisions of this FAR are referred to in the FOM and are part of the training syllabus in the FAA approved CRS Training Manual. It is not clear as to how the various provisions of FAR 121.523 can be discounted as not applicable to FedEx Express operations.	
47	SN and Performed Date were incorrectly entered on pages 1-3 of document SK-34-11-01.	

### Instructions

You have been presented with 47 different audit and surveillance findings. Please indicate the relationship of these responses to safety.

Rate these responses on a scale of 1 to 7, where 7 indicates that the finding is highly associated with safety, and 1 indicates that the finding is not associated with a safety concern.

## Appendix G-VI

### **Information Concerning Participation in a Research Study Clemson University**

Classification of audit and surveillance findings into performance metrics to evaluate impact on aircraft and impact on cost to organization

#### **Description of the research and your participation**

You are invited to participate in a research study conducted by Dr. Joel S. Greenstein, Dr. Anand K. Gramopadhye, and Kunal Kapoor. The purpose of this study is to evaluate the association of performance metrics that impact the safety of an aircraft and open ended maintenance data.

The study focuses on open ended maintenance responses documented by auditors and quality assurance representatives during auditing and surveillance. You will be asked to rate these responses on a scale of 1 to 7, indicating the association of the response with each of five performance metrics. There will be at least fifteen people from your organization involved in this study. The other participants will be auditors and quality assurance representatives from the Quality Assurance department of your organization.

The amount of time required for your participation will be approximately one hour.

#### **Risks and discomforts**

There are no known risks associated with this research.

#### **Potential benefits**

This research may help us to understand the implications of open ended maintenance data on the safety of aircraft.

#### **Protection of confidentiality**

We will do everything we can to protect your privacy. Your identity will not be revealed in any publication that might result from this study. The results of each individual's participation will be strictly confidential. No names or individual identifying information will be maintained. With the exception of the researchers involved in running this study, nobody will be allowed to see or discuss any of the individual responses. Your responses will be combined with many others and reported in group form in any professional articles that may result from this research.

#### **Voluntary participation**

Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

**Contact information**

If you have any questions or concerns about this study or if any problems arise, please contact Dr. Anand K. Gramopadhye at Clemson University at 864.656.5540. If you have any questions or concerns about your rights as a research participant, please contact the Clemson University Office of Research Compliance at 864.656.6460.



## Appendix G-VII

### **Information Concerning Participation in a Research Study Clemson University**

Classification of audit and surveillance findings into performance metrics to evaluate impact on aircraft and impact on cost to organization

#### **Description of the research and your participation**

You are invited to participate in a research study conducted by Dr. Joel S. Greenstein, Dr. Anand K. Gramopadhye, and Kunal Kapoor. The purpose of this study is to categorize maintenance data into useful performance metrics that impact the cost of aircraft maintenance operations to the organization.

The session will primarily be an interview session, and the researcher will take notes throughout the interview. These notes will be confidential and no one other than the researcher will have access to this information. There will be at least four quality assurance personnel involved in this study from your organization.

The amount of time required for your participation will be approximately one hour.

#### **Risks and discomforts**

There are no known risks associated with this research.

#### **Potential benefits**

This research may help us to understand the implications of open ended maintenance data on the cost to your organization.

#### **Protection of confidentiality**

We will do everything we can to protect your privacy. Your identity will not be revealed in any publication that might result from this study. The results of each individual's participation will be strictly confidential. No names or individual identifying information will be maintained. With the exception of the researchers involved in running this study, nobody will be allowed to see or discuss any of the individual responses.

#### **Voluntary participation**

Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

#### **Contact information**

If you have any questions or concerns about this study or if any problems arise, please contact Dr. Anand K. Gramopadhye at Clemson University at 864.656.5540. If you have any questions or concerns about your rights as a research participant, please contact the Clemson University Office of Research Compliance at 864.656.6460.

Appendix G-VIII

**Interview Script**

1. Indicate the outcome of the card-sorting study to generate categories of cost of aircraft maintenance operations to the organization.
2. Indicate that the previous study was conducted with auditors and quality assurance representatives.
3. Indicate the thought process of the auditors and the quality assurance representatives.
4. Inform the managers that it is the auditors and quality assurance representatives who will actually enter audit and surveillance data in the Web-based surveillance and auditing tool (WebSAT).
5. Remind the managers about the categories they had in mind.
6. Inform the managers that the work flow may need to be altered to suit the mental models of the auditors and quality assurance representatives.
7. Inform the manager about the two sets of categories which the design team has in mind.
8. Finalize the categories.
9. Talk to the managers about the inclusion of a training module in WebSAT, which will help the auditors and quality assurance representatives.
10. Remind the managers that design is an iterative process, and any further insights may be incorporated.

## Appendix H

### Data Set for Response Ratings for Regression Analysis

1. Pulled circuit breakers without "Lock out Tags" in cockpit of N673FE.
2. Found fire extinguisher #EE 4328 past due inspection on lift truck # 10165.
3. Found several non-flammable compressed gas containers stacked improperly in different locations throughout the facility.
4. Safety eyewash station in battery shop does not have the cleaning solution mounted on the wall, and the eyewash stations in several shop areas did not have safety covers installed.
5. The FedEx Ramp Tower Control Center has only one emergency exit leading to the ramp. If a fire or some other catastrophic event should block this means of egress, the ramp tower personnel would not have an immediate source of egress.
6. Found plastic bags of compressor blades with metal to metal contact.
7. Many circuit breakers were pulled on the FedEx aircraft in work; none had the breakers collared to prevent inadvertent engagement.
8. Door locks were not engaged in the fully closed latched position.
9. Certain vendor employees that drove vehicles on the ramp did not turn of the engines while the vehicles were unoccupied.
10. Generator used to provide aircraft power was mounted on a piece of plywood, stacked on cement blocks.
11. Several AMT training records contained multiple and / or outdated copies of MOPs and several AMT had incomplete MOPs past the 60 day time limit for completion.
12. Internal audits are not being conducted in accordance with the frequency outlined in the Base Maintenance Desktop Procedure Manual (DTPM).
13. There are inadequate controls to ensure the previous owners' AD compliance record is accurate. Aircraft Conversions performs the primary review of the previous operator's records, and completes an AD Verification Report for the airframe, engines and components and life limited parts histories without verification processes.
14. The Flight Safety DPM and the ASM state that all of the airports served by FedEx Express are assigned to Flight Safety Department Specialists for auditing. The airports in Asia and Latin America are currently unassigned.
15. There was a localized issue revealed through the audit. A review of the Service Difficulty Report (SDR) log revealed numerous SDRs not closed.
16. Motorized gas powered equipment within 25 ft of confined space perimeter.
17. Plan does not match lay out for eye wash stations. First aid kits not stocked. Eye wash stations not cleaned. Trash cans full through out hanger. Work area very disorganized.
18. Found wrong grease in tool crib grease gun.
19. RT wing tip aft position light assembly is missing.
20. Noted that upper deck area not lighted well for work in progress.
21. Investigation revealed that stamp control per the Base Maintenance DTPM was not being followed consistently.

22. Found engine received and released for service with incorrect or missing component airworthiness approval documentation.
23. Non-aircraft sheet metal parts found in the mechanic's tool box.
24. Incoming receiving inspections are not being accomplished in a timely fashion.
25. Found squibs removed from the engine bottles, and the voids were not blocked.
26. Ballast Pallet installed at cargo door area of main cargo deck with no cargo pallet locks secured.
27. Found Auto Slat Extend Cont breaker not pulled IAW Predock card 53B0001.
28. Aerosol cans were stored in a locker instead of in a flammable cabinet.
29. ULDs, doors, and nets stored in some areas are not in compliance with the ULD Planning Policy.
30. Roller Assembly marked as "condemned" was found stored on Discrepant Material rack 26 of 32.
31. Several ball-mats were found without serviceability documentation in two separate locations.
32. Found numerous main A/C batteries on pallets in the warehouse area without paperwork attached and serviceable and not identified.
33. After Installation of Flap to wing fittings the attached bolt PRC protective sealant was not applied completely on attached hardware.
34. Found container restraint collar STA 515 2nd seat track damaged/worn. Missed during incoming inspection.
35. No security check takes place at this facility as has been outlined on the facility safety inspection checklist.
36. Audit function completed per GMM 5-3-500 but found paperwork had not been completed.
37. Found no certification for re-paint of repair.
38. Found NDT not using T-619 form on a daily/first use basis per RSM.
39. Flight Standards Line Check Airman/Designee Training for the specific fleets is not standardized. Each fleet type has different documentation and curriculums to qualify crewmembers.
40. No environmental coordinator for the facility.
41. No security check takes place at this facility.
42. The FedEx Express FOM does not provide for a procedure to keep the flight crew members or other persons used in its operations informed of the provisions of its operations specifications when new operations specifications are received.
43. Scrap trailers full and outside area overflowing.
44. Found box with lose hardware at nose of aircraft.
45. Step 3 for faxing should not have an associated N/A response.
46. Company New Hire Pilot training information indicates FedEx Express does not utilize the provisions of FAR 121.523. The provisions of this FAR are referred to in the FOM and are part of the training syllabus in the FAA approved CRS Training Manual. It is not clear as to how the various provisions of FAR 121.523 can be discounted as not applicable to FedEx Express operations.
47. SN and Performed Date were incorrectly entered on pages 1-3 of document SK-34-11-01.

Appendix I

Appendix I-I

Ratings of Quality Assurance Personnel

<b>Response Number</b>	<b>Dimension 1</b>	<b>Dimension 2</b>	<b>Dimension 3</b>	<b>Dimension 4</b>	<b>Dimension 5</b>
1	7	5.6	4.667	3.333	1.067
2	6.533	4.933	4.2	2	3.333
3	6.733	4.067	4.4	1.867	5.733
4	6.4	4.6	3.667	2.733	4
5	6.533	4.8	3	3.8	2.2
6	3.667	3.333	2.933	2.133	5.933
7	6.933	5.6	4.133	3.733	1.533
8	5.867	3.533	4.2	5.067	1.4
9	6	3.467	4.467	4.333	2.467
10	5.4	2.267	2.733	2.733	3.667
11	2.467	6.267	6.533	2.6	2.733
12	1.867	6.333	6.4	2.667	1.6
13	3.2	6.067	5.4	3.267	1.467
14	2.733	5.733	5.133	4.133	1.067
15	2.4	6.467	6.133	2.8	1.267
16	6.133	6	4.6	3.933	2.533
17	5.733	4.733	3.667	2.467	5
18	4.067	5.6	4.667	3.867	3.333
19	3.533	3.867	2.733	4.467	1.733
20	5.733	3.2	2.467	3.733	3.733
21	2.733	5.333	6	3.267	2.2
22	4.2	6.333	6.933	3.333	2.333
23	3.6	3.467	3.8	2.267	5.333
24	1.8	3	3.4	3.6	2.733
25	3.933	4.333	4.467	3.067	4.4
26	6.33	4.067	4.267	4.867	2.267
27	6.133	5.8	4.733	3.733	1.267
28	4.867	5.733	3.6	2.133	6.467
29	2.067	4.733	3.867	3.067	5.867
30	2.067	3.933	3.133	1.933	6.067
31	2.467	4.933	6.333	2.533	5.733
32	2.533	5.8	6.4	2.4	4.867
33	3.2	5.267	4.067	4.133	1.267
34	3.4	3.4	2.933	4.333	1.8
35	4.4	4.467	3.733	4.533	2.4
36	2.133	4.6	6.6	2.933	1.2
37	2.467	4.6	5.8	3.733	1.733

38	2.733	5	5.4	2.667	1.267
39	2.8	3.133	4.067	4.4	1.133
40	4.267	3.467	2.933	3.067	2.933
41	5.267	4.8	3.867	4.333	2.2
42	2.933	5.2	4.6	5.667	1.067
43	2.8	2.867	3.4	2.467	6.733
44	2.267	3.067	3.333	2.4	5.667
45	1.267	2.133	3.8	1.8	1.067
46	2.8	5.467	4.667	5	1.067
47	1.667	4.8	5	2.2	1.267

## Appendix I-II

## Ratings of Internal Audit Personnel

Response Number	Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5
1	7	3.83333333	2	2.33333333	1
2	6	3.16666667	3.16666667	1	3.33333333
3	7	3.66666667	3.16666667	1.33333333	6.66666667
4	5.833	3.5	3	1.83333333	4.83333333
5	6	3	2.33333333	2.83333333	3
6	1.167	3.33333333	2.33333333	2.16666667	7
7	7	4	2	3.33333333	1.5
8	4.833	3.16666667	1.5	4.16666667	1.5
9	5.167	2.66666667	2.33333333	4	2.66666667
10	4.167	1.33333333	1.83333333	1.83333333	3.83333333
11	2.5	5.5	6	2.66666667	1.16666667
12	1.667	6.16666667	6	2	1.16666667
13	2.333	6.83333333	6.5	3	1.16666667
14	2.333	6	5.66666667	4.16666667	1
15	1.5	6.16666667	5.33333333	1.83333333	1.33333333
16	5.5	5.66666667	3	3.33333333	4.16666667
17	5.333	5.33333333	2.66666667	1.83333333	5
18	4	4.33333333	2.83333333	4	3.33333333
19	3.167	4.5	2	5.16666667	2.16666667
20	4.333	4.5	2	3.33333333	4.66666667
21	2	3.83333333	4.83333333	3	1.5
22	4.167	5.66666667	7	2.16666667	1.33333333
23	3.333	3.16666667	4.33333333	2.66666667	5.66666667
24	1.5	1.33333333	4.16666667	4.33333333	1.5
25	3.667	2.66666667	3.66666667	3.66666667	5.66666667
26	5.833	2.16666667	1.83333333	4.5	2.16666667
27	6.333	5	2.5	3.66666667	1
28	4.833	4.83333333	2.5	1.16666667	6.83333333
29	1.667	3	2.5	2.83333333	6.16666667
30	1.167	2.66666667	2.33333333	1.16666667	6.5
31	1.833	3.33333333	5.66666667	1.66666667	6.33333333
32	2	4.5	5.5	1.66666667	5.66666667
33	4.167	3.83333333	2.33333333	4.33333333	1.16666667
34	2.333	3	2.33333333	4.66666667	1.16666667
35	3.667	4	3.5	3	1.33333333
36	1.333	3.5	6.33333333	1.16666667	1
37	1.5	3.83333333	4.83333333	3.16666667	1.16666667
38	1.5	3.66666667	5.83333333	1.66666667	1.16666667
39	2	2.66666667	4.16666667	2.5	1.16666667
40	3.833	2.16666667	2.5	3.5	2.83333333



41	4.5	4	3.5	3.16666667	1.16666667
42	3	4.16666667	6	5.16666667	1
43	1.833	3.16666667	2.83333333	2.16666667	6.66666667
44	1.667	3.33333333	2.83333333	2	5.5
45	1.167	2.5	5	1.16666667	1
46	2.833	5.33333333	6	4.33333333	1
47	1.833	3.83333333	6.33333333	1.33333333	1.16666667

Appendix I-III

Ratings of Technical Audit Personnel

<b>Response Number</b>	<b>Dimension 1</b>	<b>Dimension 2</b>	<b>Dimension 3</b>	<b>Dimension 4</b>	<b>Dimension 5</b>
1	7	6.8	6.6	5	1.2
2	7	6.2	5.4	3.6	3.4
3	7	4.4	5.8	3.2	6.4
4	7	5.4	4.6	4.4	3.8
5	7	6	3.4	5.4	2.2
6	7	3.6	4	3	5.8
7	7	6.6	5.8	5.2	1.2
8	7	3.4	6.8	6.8	1.4
9	7	4.6	6.6	5.8	3
10	7	3	3.8	4.4	3.4
11	3	6.8	7	3.2	4.8
12	2.2	6.8	6.8	3.6	2.2
13	3.8	5.6	4.6	4.4	1.8
14	2.8	5.8	5.2	4.2	1.2
15	3	7	6.8	4.6	1.4
16	7	6.6	6.8	5.8	1.6
17	7	4.4	4.2	3.8	5.2
18	5	6.8	6.8	5	3.4
19	4.8	3.6	4.2	6	1.6
20	7	3	3	5.6	1.8
21	4	7	6.8	4.4	3
22	4.8	7	7	4.8	3.6
23	4.8	4.6	4	2.6	7
24	2.2	3.8	3	4	4.6
25	3	6	5.4	3.6	3.4
26	7	5.8	7	6.8	1.8
27	5.4	6.8	7	4.8	1.2
28	4.2	6.6	5	3.2	6.4
29	1.6	6.6	5.2	4.4	7
30	3.2	5.8	3.8	3.2	7
31	3.2	6.6	6.8	4	7
32	3.2	7	7	3.8	5.8
33	2.4	6.2	5.8	4.4	1.2
34	5	4.2	4.2	4.4	2.4
35	5.4	5.6	4.2	6.2	2.6
36	2.8	6.2	7	4	1.6
37	4	5.6	7	4.8	1.6
38	4.8	6.2	5.6	4.6	1.2
39	3.8	3.2	3.6	5.8	1.2

40	5.4	4.6	3	3.4	2.2
41	7	5.6	4.4	6.2	2.2
42	3	6.4	3.6	6	1.2
43	4.8	3	4.6	4	7
44	3.2	3.4	4.6	3.8	7
45	1.6	2.6	3.4	3.2	1.2
46	2.2	5.6	3.8	5.2	1.2
47	1.6	6	4.6	3.8	1.2

Appendix I-IV

Ratings of Surveillance Personnel

<b>Response Number</b>	<b>Dimension 1</b>	<b>Dimension 2</b>	<b>Dimension 3</b>	<b>Dimension 4</b>	<b>Dimension 5</b>
1	7	6.75	6.25	2.75	1
2	6.75	6	4.25	1.5	3.25
3	6	4.25	4.5	1	3.5
4	6.5	5.25	3.5	2	3
5	6.75	6	3.5	3.25	1
6	3.25	3	2.5	1	4.5
7	6.75	6.75	5.25	2.5	2
8	6	4.25	5	4.25	1.25
9	6	3.25	5	3	1.5
10	5.25	2.75	2.75	2	3.75
11	1.75	6.75	6.75	1.75	2.5
12	1.75	6	6.5	2.5	1.5
13	3.75	5.5	4.75	2.25	1.5
14	3.25	5.25	4.25	4	1
15	3	6.25	6.5	2	1
16	6	5.75	4.25	2.5	1.25
17	4.75	4.25	4.5	1.75	4.75
18	3	6	4.75	2.25	3.25
19	2.5	3.25	2	1.5	1.25
20	6.25	1.5	2.5	2	4.75
21	2.25	5.5	6.75	2.25	2.25
22	3.5	6.5	6.75	3.25	2.25
23	2.5	2.5	2.75	1.25	2.75
24	1.75	4.5	2.75	2	2.25
25	5.5	4.75	4.5	1.5	3.75
26	6.25	4.75	4.5	3	3
27	6.75	5.75	5.25	2.5	1.75
28	5.75	6	3.5	2.25	6
29	3.25	5	4.25	1.75	4
30	2	3.5	3.5	1.5	4.25
31	2.5	5.25	6.75	2	3.25
32	2.5	6.25	7	1.75	2.5
33	2.75	6.25	4.5	3.5	1.5
34	3	3	2.25	3.75	2
35	4.25	3.75	3.5	4.75	3.75
36	2.5	4.25	6.5	4.25	1
37	2	4.5	5.75	3.25	2.75
38	2	5.5	4.5	1.75	1.5
39	2.75	3.75	4.5	5.5	1

40	3.5	4	3.5	2	4
41	4.25	5	3.75	3.75	3.75
42	2.75	5.25	3.75	6	1
43	1.75	2.25	2.75	1	6.5
44	2	2.25	2.5	1.25	4.25
45	1	1	2.5	1	1
46	3.5	5.5	3.75	5.75	1
47	1.5	4.75	3.5	1.5	1.5

Appendix I-V

Loading values of responses used for regression analysis

<b>Response Number</b>	<b>Dimension 1</b>	<b>Dimension 2</b>	<b>Dimension 3</b>	<b>Dimension 4</b>	<b>Dimension 5</b>
1	-0.85158	-0.01757	0.1794365	0.042918	0.452806
2	-0.85823	0.140032	-0.263518	0.023917	0.480791
3	-0.8712	-0.07377	0.032011	0.173213	0.260009
4	-0.85384	-0.08175	0.1550766	0.360887	0.233049
5	-0.83689	-0.03131	-0.066184	0.329016	0.18716
6	0.776892	0.12392	-0.081163	-0.13699	-0.06973
7	0.783511	0.072447	-0.215709	0.06257	0.02931
8	0.798725	0.050938	-0.17709	-0.09704	-0.04663
9	0.764592	0.148734	-0.272375	0.035928	0.01279
10	0.765678	0.14134	-0.301578	-0.0185	-0.01306
11	-0.82571	0.623898	-0.005516	-0.12372	0.065698
12	-0.66009	0.518216	0.3665888	0.121351	-0.13902
13	-0.63319	0.51866	0.2825177	-0.18402	-0.12984
14	-0.66235	0.523787	0.2558156	0.089359	-0.08228
15	-0.52362	0.581987	0.1565361	-0.04034	0.203006
16	-0.21666	-0.6003	-0.071774	0.281674	0.024413
17	-0.23626	-0.61177	-0.034012	0.306542	0.020956
18	-0.06846	-0.60513	-0.051005	-0.01743	0.099529
19	-0.06446	-0.61271	-0.013809	-0.0165	0.095919
20	-0.09758	-0.61777	-0.088987	0.220316	0.098893
21	-0.69702	0.477887	0.4683325	-0.04467	0.021434
22	-0.73627	0.338468	0.5121956	-0.06141	0.197625
23	-0.78401	0.31053	0.407309	-0.22018	-0.12564
24	0.301914	-0.31115	0.4081756	-0.04885	-0.06301
25	0.310411	-0.31625	0.4213601	-0.03591	0.048152
26	-0.52289	-0.19463	-0.338156	-0.08603	0.038094
27	-0.35048	-0.24805	-0.353126	0.010716	-0.03652
28	0.728664	0.331385	-0.401578	-0.23012	-0.04818
29	0.72747	0.343958	-0.391026	-0.2417	-0.08098
30	0.727136	0.344517	-0.392167	-0.25335	-0.0848
31	-0.77012	0.295841	0.135639	-0.56109	-0.08076
32	-0.73351	0.244095	0.2999192	-0.41269	0.131926
33	-0.43658	-0.08804	-0.226064	-0.30878	0.075816
34	-0.37547	-0.08772	-0.172257	-0.32899	-0.02148
35	-0.79974	0.227419	0.1095488	0.095269	-0.48515
36	0.28156	-0.13156	0.0468973	0.354558	0.023113
37	0.200116	-0.22791	0.0391234	0.339377	-0.04335
38	0.295714	-0.07718	-0.087679	0.342297	0.067901
39	-0.56113	0.329454	-0.030316	0.330092	0.013323

40	-0.83206	0.226085	-0.092957	0.00622	-0.52139
41	-0.79974	0.227419	0.1095488	0.095269	-0.48515
42	-0.81826	0.279852	0.1433416	-0.12012	-0.35886
43	-0.48434	0.016773	0.0576673	0.114952	-0.34838
44	-0.36343	-0.27959	-0.123571	-0.20321	-0.31792
45	-0.54735	0.301616	-0.002568	0.139982	0.31185
46	-0.66822	0.415352	0.0997524	-0.04694	0.311915
47	0.211628	-0.2478	0.0015793	-0.00024	0.290129

## Appendix J

### **Consent Form for Participation in a Research Study Clemson University**

(Evaluation of categorization schemes for aircraft level impact and organizational categories)

#### **Description of the research and your participation**

You are invited to participate in a research study conducted by Dr. Joel S. Greenstein, Dr. Anand K. Gramopadhye, and Kunal Kapoor. The purpose of this research is to evaluate the two categorization schemes, each indicating the impact of aircraft maintenance data at two different levels. The first level referred to as the aircraft level impact, indicates the impact of aircraft maintenance findings on the safety of an aircraft. The second level referred to as organizational categories indicate the impact of the aircraft maintenance findings at an organizational level.

The current research study will evaluate the effectiveness of the two identified categorization schemes. Each time an open ended response is documented during aircraft maintenance, an impact is associated with the safety of the aircraft and the organization. This research study will help establish the appropriateness and reliability of the identified performance measures for aircraft safety and organizational categories.

The amount of time required for your participation will be approximately sixty minutes with a break of thirty minutes in between. You will be among forty participants involved in this study.

#### **Risks and discomforts**

There are no known risks associated with this research.

#### **Potential benefits**

This research may help us to evaluate the categorization schemes for aircraft level impact and organizational categories.

#### **Protection of confidentiality**

We will do everything we can to protect your privacy. Your identity will not be revealed in any publication that might result from this study. The results of each individual's participation will be strictly confidential. With the exception of the researcher involved in running this study, nobody will be allowed to see or discuss any of the individual



responses. Your responses will be combined with many others and reported in-group form in any professional articles that may result from this research.

In rare cases, a research study will be evaluated by an oversight agency, such as the Clemson University Institutional Review Board or the federal Office for Human Research Protections, that would require that we share the information we collect from you. If this happens, the information would only be used to determine if we conducted this study properly and adequately protected your rights as a participant.

### **Voluntary participation**

Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

### **Contact information**

If you have any questions or concerns about this study or if any problems arise, please contact Dr. Anand K. Gramopadhye at Clemson University at 864.656.5540. If you have any questions or concerns about your rights as a research participant, please contact the Clemson University Institutional Review Board at 864.656.6460.

### **Consent**

**I have read this consent form and have been given the opportunity to ask questions. I give my consent to participate in this study.**

Participant's signature: \_\_\_\_\_ Date: \_\_\_\_\_

A copy of this consent form should be given to you.

## Appendix K

### Research study participation request e-mail

You are invited to be a part of a research study to evaluate two different categorization schemes. The first categorization scheme is related to the association of audit and surveillance findings during aircraft maintenance to performance measures indicating the impact on aircraft safety. The second categorization scheme indicates the impact of the same surveillance and audit findings at an organizational level.

The study will be conducted in the Human-Computer Systems Laboratory (147, Freeman Hall). The study will consist of two segments which will require approximately thirty minutes each, with a break of thirty minutes after the first segment.

Please confirm your participation by replying back to this e-mail.

If you have any questions or concerns about this study or if any problems arise, please contact (Dr. Anand K. Gramopadhye, the Principal Investigator) at Clemson University (110-A Freeman Hall) at 864.656.5540.

Appendix L

Appendix L-I

Risk Matrix with Information

				<b>A</b>	<b>Catastrophic</b>	<b>Severity</b>	Accident / Incident / Declared Emergency	Death or Hospitalization	Hull Loss or \$ 1 million loss
		<b>High Risk</b>		<b>B</b>	<b>Critical</b>		Violations of Rules or Regulation / Unsafe Deviation	Medical treatment required	More than \$ 100,000 loss
				<b>C</b>	<b>Marginal</b>		Poor Performance / Schedule disruption / Deviation within safe limits	First aid required	More than \$ 50,000 loss
			<b>Low Risk</b>	<b>D</b>	<b>Minor</b>		Minimal System Consequence	No injury sustained	Less than \$ 50,000 loss
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>			<b>Performance</b>	<b>People</b>	<b>Machine</b>
	<b>Probability</b>								
	Constantly Experienced	Likely to occur in the next quarter	Likely to occur in the next year	Unlikely to occur in the next five years					<b>Occurrence</b>
	More than 1 in 5,000 cycles	More than 1 in 60,000 cycles	More than 1 in 250,000 cycles	Less than 1 in 1,000,000 cycles					<b>Rate</b>
	<b>Continuous</b>	<b>Frequent</b>	<b>Occasional</b>	<b>Remote</b>					

Appendix L-II

Risk Matrix without Information

				<b>A</b>	<b>Catastrophic</b>	<b>Severity</b>
	High Risk			<b>B</b>	<b>Critical</b>	
		Medium Risk		<b>C</b>	<b>Marginal</b>	
			Low Risk	<b>D</b>	<b>Minor</b>	
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>			
<b>Probability</b>						
<b>Continuous</b>	<b>Frequent</b>	<b>Occasional</b>	<b>Remote</b>			

Appendix L-IIIResponses for Aircraft Level Impact Categories

1. Pulled circuit breakers without "Lock Out Tags" in cockpit of N673FE.
2. Many circuit breakers were pulled on the FedEx aircraft in work; none had the breakers collared to prevent inadvertent engagement.
3. There was a localized issue revealed through the audit. A review of the Service Difficulty Report (SDR) log revealed numerous SDRs not closed.
4. Internal audits are not being conducted in accordance with the frequency outlined in the Base Maintenance Desktop Procedure Manual (DTPM).
5. Investigation revealed that stamp control per the Base Maintenance DTPM was not being followed consistently.
6. Found engine received and released for service with incorrect or missing component airworthiness approval documentation.
7. Found container restraint collar STA 515 2nd seat track damaged/worn. Missed during incoming inspection.
8. Flight Standards Line Check Airman/Designee Training for the specific fleets is not standardized. Each fleet type has different documentation and curriculums to qualify crewmembers.
9. Scrap trailers full and outside area overflowing.
10. Found box with loose hardware at nose of aircraft.

Appendix L-IVOrganizational Categories Data

1. Pulled circuit breakers without "Lock Out Tags" in cockpit of N673FE.
2. Found fire extinguisher #EE 4328 past due inspection on lift truck # 10165.
3. Found several non-flammable compressed gas containers stacked improperly in different locations throughout the facility.
4. Safety eyewash station in battery shop does not have the cleaning solution mounted on the wall, and the eyewash stations in several shop areas did not have safety covers installed.
5. The FedEx Ramp Tower Control Center has only one emergency exit leading to the ramp. If a fire or some other catastrophic event should block this means of egress, the ramp tower personnel would not have an immediate source of egress.
6. Found plastic bags of compressor blades with metal to metal contact.
7. Many circuit breakers were pulled on the FedEx aircraft in work; none had the breakers collared to prevent inadvertent engagement.
8. Door locks were not engaged in the fully closed latched position.
9. Certain vendor employees that drove vehicles on the ramp did not turn of the engines while the vehicles were unoccupied.
10. Generator used to provide aircraft power was mounted on a piece of plywood, stacked on cement blocks.
  
11. Several AMT training records contained multiple and / or outdated copies of MOPs and several AMT had incomplete MOPs past the 60 day time limit for completion.
12. Internal audits are not being conducted in accordance with the frequency outlined in the Base Maintenance Desktop Procedure Manual (DTPM).
13. There are inadequate controls to ensure the previous owners' AD compliance record is accurate. Aircraft Conversions performs the primary review of the previous operator's records, and completes an AD Verification Report for the airframe, engines and components and life limited parts histories without verification processes.
14. The Flight Safety DPM and the ASM state that all of the airports served by FedEx Express are assigned to Flight Safety Department Specialists for auditing. The airports in Asia and Latin America are currently unassigned.
15. There was a localized issue revealed through the audit. A review of the Service Difficulty Report (SDR) log revealed numerous SDRs not closed.
16. Motorized gas powered equipment within 25 ft of confined space perimeter.
17. Plan does not match lay out for eye wash stations. First aid kits not stocked. Eye wash stations not cleaned. Trash cans full through out hanger. Work area very disorganized.
18. Found wrong grease in tool crib grease gun.
19. RT wing tip aft position light assembly is missing.

20. Noted that upper deck area not lighted well for work in progress.
21. Investigation revealed that stamp control per the Base Maintenance DTPM was not being followed consistently.
22. Found engine received and released for service with incorrect or missing component airworthiness approval documentation.
23. Non-aircraft sheet metal parts found in the mechanic's tool box.
24. Incoming receiving inspections are not being accomplished in a timely fashion.
25. Found squibs removed from the engine bottles, and the voids were not blocked.
26. Ballast Pallet installed at cargo door area of main cargo deck with no cargo pallet locks secured.
27. Found Auto Slat Extend Cont breaker not pulled IAW Predock card 53B0001.
28. Aerosol cans were stored in a locker instead of in a flammable cabinet.
29. ULDs, doors, and nets stored in some areas are not in compliance with the ULD Planning Policy.
30. Roller Assembly marked as "condemned" was found stored on Discrepant Material rack 26 of 32.
31. Several ball-mats were found without serviceability documentation in two separate locations.
32. Found numerous main A/C batteries on pallets in the warehouse area without paperwork attached and serviceable and not identified.
33. After Installation of Flap to wing fittings the attached bolt PRC protective sealant was not applied completely on attached hardware.
34. Found container restraint collar STA 515 2nd seat track damaged/worn. Missed during incoming inspection.
35. No security check takes place at this facility as has been outlined on the facility safety inspection checklist.
36. Audit function completed per GMM 5-3-500 but found paperwork had not been completed.
37. Found no certification for re-paint of repair.
38. Found NDT not using T-619 form on a daily/first use basis per RSM.
- 39.** Flight Standards Line Check Airman/Designee Training for the specific fleets is not standardized. Each fleet type has different documentation and curriculums to qualify crewmembers.
40. No environmental coordinator for the facility.
41. No security check takes place at this facility.
42. The FedEx Express FOM does not provide for a procedure to keep the flight crew members or other persons used in its operations informed of the provisions of its operations specifications when new operations specifications are received.
43. Scrap trailers full and outside area overflowing.
44. Found box with lose hardware at nose of aircraft.
45. Step 3 for faxing should not have an associated N/A response.
46. Company New Hire Pilot training information indicates FedEx Express does not utilize the provisions of FAR 121.523. The provisions of this FAR are referred to in the FOM and are part of the training syllabus in the FAA approved CRS Training Manual. It is not clear as to how the various provisions of FAR 121.523 can be discounted as not applicable to FedEx Express operations.

47. SN and Performed Date were incorrectly entered on pages 1-3 of document SK-34-11-01.



Appendix M

Appendix M-I

Prediction scores for Research Hypothesis I – Stage 1

Test Scores I	
Group 1	Group 2
0.6	0.5
0.8	0.3
0.7	0.6
0.7	0.4
0.6	0.6
0.5	0.5
0.6	0.5
0.7	0.4
0.6	0.2
0.3	0.2
0.5	0.9
0.8	0.9
0.5	0.6
0.7	0.7
0.6	0.6
0.7	0.8
0.3	1
0.4	1
0.6	1
0.6	0.9

**Group 1:** without data reduction technique

**Group 2:** with data reduction technique

Appendix M-II

Results for Research Hypothesis – Stage 1

**Test I Analysis**

**Group Statistics**

	<b>N</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Std. Error Mean</b>
<b>Group 1</b>	20	0.59	0.14105	0.03154
<b>Group 2</b>	20	0.63	0.26178	0.05853

**Independent Samples Test**

	<b>Levene's Test for Equality of Variances</b>		<b>t-Test for Equality of Means</b>		
	<b>F</b>	<b>Sig.</b>	<b>t</b>	<b>df</b>	<b>Sig.(2-tailed)</b>
<b>Equal Variances Assumed</b>	8.984	0.005	-0.602	38	0.551
<b>Equal Variances Not Assumed</b>			-0.602	29.175	0.552

	<b>t-Test for Equality of Means</b>				
	<b>Mean Difference</b>	<b>Std. Error Diff.</b>	<b>95 % Confidence Interval of Diff.</b>		
			<b>Lower</b>		<b>Upper</b>
<b>Equal Variances Assumed</b>	-0.04	0.06649	-0.1746		0.0946
<b>Equal Variances Not Assumed</b>	-0.04	0.06649	-0.1746		0.0946

Appendix M-III

Prediction scores for Research Hypothesis I – Stage 2

<b>Test Scores II</b>	
<b>Group 1</b>	<b>Group 2</b>
0.6	0
0.4	0
0.2	0.2
0.4	0
0.2	0.2
0	0.2
0.2	0.4
0.4	0.2
0.2	0
0	0
0	0.6
0.2	0.2
0	0
0.2	0.4
0.2	0.2
0.2	0.4
0	1
0	1
0.2	1
0	0.6

**Group 1:** without data reduction technique

**Group 2:** with data reduction technique

Appendix M-IV

Results for Research Hypothesis – Stage 2

**Test II Analysis**

**Group Statistics**

	<b>N</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Std. Error Mean</b>
<b>Group 1</b>	20	0.18	0.17045	0.03811
<b>Group 2</b>	20	0.33	0.34504	0.07715

**Independent Samples Test**

	<b>Levene's Test for Equality of Variances</b>		<b>t-Test for Equality of Means</b>		
	<b>F</b>	<b>Sig.</b>	<b>t</b>	<b>df</b>	<b>Sig(2-tailed)</b>
<b>Equal Variances Assumed</b>	8.788	0.005	-1.743	38	0.089
<b>Equal Variances Not Assumed</b>			-1.743	27.752	0.092

	<b>t-Test for Equality of Means</b>				
	<b>Mean Diff.</b>	<b>Std. Error Diff.</b>	<b>95 % Confidence Interval of Diff.</b>		
			<b>Lower</b>		<b>Upper</b>
<b>Equal Variances Assumed</b>	-0.15	0.08605	-0.32634		0.02421
<b>Equal Variances Not Assumed</b>	-0.15	0.08605	-0.32634		0.02634

Appendix N

Appendix N-I

Co-Occurrence frequency distribution – Stage 1

**Without information on Organizational Categories**

1	1	25	15	A	Catastrophic	<b>Severity</b>
16	24	57	29	B	Critical	
19	60	92	37	C	Marginal	
10	35	45	33	D	Minor	
<b>Probability</b>						
1	2	3	4			
Continuous	Frequent	Occasional	Remote			

Appendix N-II

Co-Occurrence frequency distribution – Stage 1

**With information on Organizational Categories**

1	5	32	25	A	Catastrophic	<b>Severity</b>
12	39	69	38	B	Critical	
19	41	63	15	C	Marginal	
32	21	43	36	D	Minor	
<b>Probability</b>						
1	2	3	4			
Continuous	Frequent	Occasional	Remote			

Appendix N-III

Time taken to categorize findings – Research Hypothesis II

<b>Time Taken (in minutes:seconds)</b>	
<b>With Information</b>	<b>Without Information</b>
16:45	47:46:00
22:51	17:41
32:23:00	16
23:19	42:30:00
26:01:00	18:22
16:47	15:19
21:53	19:05
22:24	25:04:00
11:52	23:00
22:45	20:48
14:28	14:30
13:29	12:14
15:37	13:00
16:49	23:25
20:32	14:34
23:40	24:50:00
11:16	22:16
24:51:00	27:21:00
28:29:00	19:33
12:24	26:32:00

Appendix N-IV

Co-Occurrence frequency distribution – Stage 2

**Without information on Organizational Categories**

1	1		15	A	Catastrophic	<b>Severity</b>
16	24		29	B	Critical	
10	35		33	D	Minor	
<b>Probability</b>						
1	2		4			
Continuous	Frequent		Remote			



Appendix N-V

Co-Occurrence frequency distribution – Stage 2

**With information on Organizational Categories**

1	5		25	A	Catastrophic	<b>Severity</b>
12	39		38	B	Critical	
32	21		36	D	Minor	
<b>Probability</b>						
1	2		4			
Continuous	Frequent		Remote			

Appendix N-VI

Frequency distribution with the correction factor

**Without information on Organizational Categories**

1	1	25	15	A	Catastrophic	<b>Severity</b>
16	24	57	29	B	Critical	
19	60	92	37	C	Marginal	
10	35	45	33	D	Minor	
<b>Probability</b>						
1	2	3	4			
Continuous	Frequent	Occasional	Remote			

**With information on Organizational Categories**

1.02	5.08	32.52	25.41	A	Catastrophic	<b>Severity</b>
12.2	39.64	70.12	38.62	B	Critical	
19.31	41.67	64.03	15.24	C	Marginal	
32.52	21.34	43.71	36.59	D	Minor	
<b>Probability</b>						
1	2	3	4			
Continuous	Frequent	Occasional	Remote			

Appendix O

Appendix O-I

**CONSENT TO PARTICIPATE IN A RESEARCH STUDY**

**User Testing of an Intranet Application (Web-based Surveillance and Auditing Tool  
(WebSAT)) to Evaluate the Performance of the Interface**

<b>Study to be conducted at:</b>	<b>Memphis, TN, Mobile, AL, and Greensboro, NC</b>
<b>Principal Investigator:</b>	<b>Dr. Anand Gramopadhye 864-656-5540</b>
<b>Co-Investigator:</b>	<b>Dr. Joel Greenstein 864-656-5649</b>
<b>Research Assistant:</b>	<b>Kunal Kapoor 864-656-7891</b>
<b>Research Assistant:</b>	<b>Nikhil Iyengar 864-656-7891</b>
<b>Research Assistant:</b>	<b>Pallavi Dharwada 864-656-7891</b>

**INFORMATION:**

You are invited to participate in a research study. Before you choose to be a research participant, it is important that you read the following information and ask as many questions as necessary to be sure that you understand what your participation will involve. Your signature on this consent form will acknowledge that you received all of the following information and explanations from the investigators, and have been given an opportunity to discuss your questions and concerns with these investigators.

**PURPOSE:**

You are invited to participate in an experiment aimed to evaluate the performance of the WebSAT application. The purpose of this session is to investigate the performance of WebSAT interfaces with respect to their functionality, screen content and ease of use. If you participate, you will be required to perform certain scenarios representative of the functionality of the prototype as a part of reviewing the screens. You will work individually. Your participation will involve one session, which will last approximately one hour. If you participate, you will be one of approximately 24 people who will be participating in this session.

**POSSIBLE RISKS:**

There are no known risks associated with this research.

**POTENTIAL BENEFITS:**

The results obtained through your participation in this study will help us to evaluate the use of WebSAT application in your surveillance and auditing work domain.

**VOLUNTARY PARTICIPATION:**

Participation in this study is voluntary. You may refuse to participate or withdraw from the study at any time. If you refuse to participate or withdraw from the study at any time, you will not be penalized or lose any benefits and your decision will not affect your relationship with this organization.

**CONFIDENTIALITY:**

The records of your participation are confidential. The investigator will maintain your information, and this information may be kept on a computer. However, the data on your participation will be available only to the investigators. This study may be used to make presentations, but your identity will not be revealed.

**CONTACT INFORMATION:**

If you have any questions or concerns about this study or if any problems arise, please contact (Dr. Anand K. Gramopadhye, the Principal Investigator) at Clemson University at 864.656.5540. If you have any questions or concerns about your rights as a research participant, please contact the Clemson University Institutional Review Board at 864.656.6460.

**CONSENT**

I have been given an opportunity to ask questions about this study; answers to such questions (if any) have been satisfactory.

In consideration of all of the above, I give my consent to participate in this research study. I acknowledge receipt of a copy of this informed consent statement.

PARTICIPANT'S SIGNATURE: \_\_\_\_\_ DATE: \_\_\_\_\_

Appendix O-II

Greetings,

We are writing to request your participation in the user testing of “WebSAT”, a surveillance and auditing tool developed by the Human Computer Systems Laboratory at Clemson University.

We would like to gather data by conducting laboratory experiments to evaluate the WebSAT. We are testing the *ease of use* of the tool. The usability testing process will be carried out on site at FedEx in Memphis, TN, Mobile, AL, and Greensboro, NC. Data will be recorded in terms of the time taken to accomplish the tasks, errors committed and deviation from the optimal method of performing the tasks. The testing process will be conducted in one session, which will take around one hour. Please note that we are testing the interface, and not your performance as an individual.

Attached is a consent form which will explain the purpose of the study and detail on any potential risks or benefits associated with this study.

We would really appreciate your participation in this study

Sincerely,

Dr. Anand Gramopadhye

Principal Investigator

(864) 656 5540 or [agramop@ces.clemson.edu](mailto:agramop@ces.clemson.edu)

## Appendix O-III

### WebSAT Usability Study Test Session Introduction

As you know, the Web based Surveillance and Auditing tool (WebSAT) is being evaluated, which is why you are here. The results of the test will help to improve the tool which eventually will assist in performing your job-related tasks with more efficiency. This study is intended to assess how easy or difficult it is for end users such as auditors and surveillance representatives like you to use the tool and how easy or difficult it is for users to retrieve, store and analyze the information they need to work on. As a participant in this study you will be asked to complete a given set of tasks using this intranet application. You will be asked to “think-aloud,” describing what you are doing, why you are doing it, and what you expect to happen while you are doing it. If you are having trouble with this, your observer will help by prompting you with appropriate questions when necessary.

You will also be asked to complete a questionnaire after the study. You may decline answering any of the questions or completing the tasks if you choose so. I want you to remember that it is the tool that we are testing, and not you as the user. The tool should, by its interface, facilitate all of these tasks, and so an inability to complete a given task will be seen as a problem with the tool. Discovering problems with the tool is at the heart of what we are trying to do with this study.

Keep in mind: Your opinion matters! Information gathered during these tests will be used to enhance the usability and content of the website.

Do you have any questions before we begin?

Appendix P

After-Scenario Questionnaire

For each of the questions below, circle the answer of your choice.

1. Overall, I am satisfied with the ease of completing the tasks in this scenario.

strongly agree <=====> strongly disagree    not applicable  
1    2    3    4    5    6    7    N/A

Comments:

2. Overall, I am satisfied with the amount of time it took to complete the tasks in this scenario.

strongly agree <=====> strongly disagree    not applicable  
1    2    3    4    5    6    7    N/A

Comments:

3. Overall, I am satisfied with the support information (on-line help, messages, documentation) when completing the tasks?

strongly agree <=====> strongly disagree    not applicable  
1    2    3    4    5    6    7    N/A

Comments:

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