

Review & Analysis

Crew Resource Management (CRM) Anonymous Reporting System (ARS) Questionnaire Evaluation

Prepared for: AIR MOBILITY COMMAND

DIRECTORATE OF OPERATION AND TRAINING (AMC/DOT)

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February 26, 1996

DISTRIBUTION STATEMENT A

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19970212 010

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CSERIAC-RA-96-003

February 26, 1996



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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704 - 0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 02/26/96	3. REPORT TYPE AND DATES COVERED Final							
4. TITLE AND SUBTITLE Crew Resource Management (CRM) Anonymous Reporting System (ARS) Questionnaire Evaluation			5. FUNDING NUMBERS SPO900-94-D-0001							
6. AUTHORS <table style="width: 100%; border: none;"> <tr> <td style="width: 33%;">Aaron J. Gayman</td> <td style="width: 33%;">Aaron W. Schopper</td> <td style="width: 33%;">Frank C. Gentner</td> </tr> <tr> <td>Mark E. Neumeier</td> <td>W. Jeffrey Rankin</td> <td></td> </tr> </table>					Aaron J. Gayman	Aaron W. Schopper	Frank C. Gentner	Mark E. Neumeier	W. Jeffrey Rankin	
Aaron J. Gayman	Aaron W. Schopper	Frank C. Gentner								
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7. PERFORMING ORGANIZATIONS NAME(S) AND ADDRESS(ES) CSERIAC Program Office AL/CFH/CSERIAC Bldg 248 2255 H Street WPAFB, OH 45433-7022 Commercial: (513) 255-4842 DSN: 785-4842			8. PERFORMING ORGANIZATION REPORT NUMBER RA-96-003							
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Headquarters Air Mobility Command Directorate of Operations and Training (HQ AMC/DOTV) 402 Scott Drive, Unit 3A1 Scott AFB, IL 62225-5302			10. SPONSORING / MONITORING AGENCY REPORT NUMBER							
11. SUPPLEMENTARY NOTES										
12a. DISTRIBUTION / AVAILABILITY STATEMENT Distribution Statement A: Approved for public release; distribution is unlimited.			12b. DISTRIBUTION CODE							
13. ABSTRACT (Maximum 200 words) The purpose of this report is to furnish suggestions for improvement of the Air Mobility Command (AMC) Crew Resource Management (CRM) Anonymous Reporting System (ARS) reporting form based on current scientific literature. This report describes CRM dimensions and CRM evaluation techniques helpful in refining the AMC CRM ARS form. The AMC CRM ARS form is compared to research findings, and recommendations for revisions to the ARS form are provided. In summary, this report: reviews current literature regarding CRM; identifies concurrent CRM dimensions common to the Federal Aviation Administration (FAA), the US Air Force (USAF), and mainstream CRM literature; identifies applicable CRM rating methods; evaluates the current AMC CRM ARS reporting form using widely accepted CRM dimensions and rating methods; and presents recommendations for the improvement of the AMC CRM ARS reporting form.										
14. SUBJECT TERMS HUMAN FACTORS ENGINEERING, FLIGHT CREWS, PSYCHOMETRICS, CREW RESOURCE MANAGEMENT, CRM, CREW COORDINATION, HUMAN SYSTEMS INTEGRATION (HSI), AIRCREW TRAINING, SURVEYS, QUESTIONNAIRES, TEAM TRAINING			15. NUMBER OF PAGES 58							
			16. PRICE CODE							
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UNLIMITED							

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ACKNOWLEDGMENTS

The authors thank Mr. David F. Wourms, CSERIAC Human Factors Analyst, and Mr. Mark Detroit, CSERIAC Senior Design Engineer for their comments on the scope and content of this report.

ACRONYMS

AC	Advisory Circular
ACE	Aircrew Coordination Evaluation
ACT	Aircrew Coordination Training
ADM	Aeronautical Decision Making
AGL	Above Ground Level
AFI	Air Force Instruction
AMC	Air Mobility Command
AQP	Advanced Qualification Program
ARS	Anonymous Reporting System
ASRS	Aviation Safety Reporting System
ATC	Air Traffic Control
ATP	Airline Transport Pilot
CFI	Certified Flight Instructor
CMAQ	Cockpit Management Attitudes Questionnaire
CRM	Crew Resource Management
CSERIAC	Crew System Ergonomics Information Analysis Center
CTAF	Common Traffic Advisory Frequency
DOT	Directorate of Operations and Training
EFIS	Electronic Flight Instrument System
F/E	Flight Engineer
FAA	Federal Aviation Administration
FOA	Field Operations Agency
FSS	Flight Service Station
GAR	Go-Around
HQ	Headquarters
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
LLC	Line/LOS (LOFT) Checklist
LOFT	Line-Oriented Flight Training
LOS	Line Operational Simulation
MAJCOM	Major Command
MSL	Mean Sea Level

NAS	National Aviation System
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
RA	Radar Altitude
RVR	Runway Visual Range
SA	Situation Awareness
SID	Standard Instrument Departure
STAR	Standard Terminal Arrival Route
TA	True Altitude
TWA	Trans World Airlines
US	United States
USAF	United States Air Force
UT	University of Texas
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

EXECUTIVE SUMMARY

The purpose of this report is to furnish suggestions for improvement of the Air Mobility Command (AMC) Crew Resource Management (CRM) Anonymous Reporting System (ARS) reporting form based on current scientific literature. This report describes CRM dimensions and CRM evaluation techniques helpful in refining the AMC CRM ARS form. The AMC CRM ARS form is compared to research findings, and recommendations for revisions to the ARS form are provided. In summary, this report:

- reviews current literature regarding CRM
- identifies concurrent CRM dimensions common to the Federal Aviation Administration (FAA), the US Air Force (USAF), and mainstream CRM literature
- identifies applicable CRM rating methods
- evaluates the current AMC CRM ARS reporting form using widely accepted CRM dimensions and rating methods
- presents recommendations for the improvement of the AMC CRM ARS reporting form

To quantify CRM, the Crew System Ergonomics Information Analysis Center (CSERIAC) first defined the concept, and then decomposed CRM into individual dimensions. Since this report used current mainstream research literature, it was necessary to ensure that the mainstream and USAF CRM definitions and dimensions concurred with each other. CSERIAC compared and contrasted a variety of mainstream CRM dimensions with the USAF dimensions. Dimensions that appeared across taxonomies were identified as defensible CRM dimensions, while dimensions that had no concurrence with other taxonomies were identified for revision.

CSERIAC reviewed the Line/LOS Checklist (LLC), the Aircrew Coordination Evaluation (ACE) Checklist, and the AMC CRM Assessment Sheet to determine appropriate means of assessing CRM behaviors. From this review, it appears appropriate to use CRM behavioral marker ratings which are mapped back to distinct, well-defined CRM curriculum elements. A broad taxonomy of possible behavioral markers is provided in the present report. Ideally, the same behavioral markers that are used in aircrew CRM training should also be used in operational reporting.

The 12 factors appearing on the current AMC CRM ARS form address CRM-specific, general crew experience, and general event context information in the same section. CSERIAC recommends that the factors which actually address CRM on the ARS form be separated from those that do not directly address CRM dimensions of an event.

In conclusion, CSERIAC recommends the revision and reorganization of the current AMC CRM ARS reporting form. In its present state, the form does not appear to map well to Air Force Instruction (AFI) 36-2243 (including AMC Supplement 1), accepted taxonomies of CRM, or CRM behavioral markers. Additionally, the form presents individual factors that overlap heavily across several distinct CRM dimensions. CSERIAC recommends that the ARS form be extensively revised and divided into the following five sections:

- Contact information
- Crew background information
- Event context information
- CRM behavioral markers
- Narrative description

Contact information would simply include name, address, and telephone numbers. The crew experience section would include information on the crew's training, proficiency, and background. The event context section would provide weather, conflict, and equipment failure information (along with other context-related data) of the situation being reported. The CRM behavioral marker section would address the CRM-specific elements surrounding the situation being reported by allowing the reporter to rate (on Likert scale) specific, observable behaviors which can be readily traced back to USAF CRM dimensions. Finally, the narrative description section would allow AMC CRM ARS reporters to freely write an account of the reported situation from start to finish, providing suggested improvements where appropriate.

1. INTRODUCTION

1.1 Background

In 1972, a Lockheed L-1011 descended at night into the trees and swamps of the Florida Everglades, killing 99 passengers and crewmembers on board (NTSB, 1973). During the ensuing National Transportation Safety Board (NTSB) investigation, it was revealed that one small, burned-out landing gear indicator set in motion a sequence of events that ended in disaster. More accurately, the response of the cockpit crew to the inoperative bulb ultimately hardened the last links in this chain of catastrophe. While in flight, each crewmember (flight engineer, first officer, and captain) fixated on solving the same condition, an aberrant landing gear down and locked bulb, neglecting to notice that the autopilot had become disengaged. Quietly, while all crewmembers were attending to the same, non-emergency condition, the aircraft descended, under neither human nor automatic control, until it finally augured in to the mud and water below.

Twenty-four years later, we identify the Everglades L-1011 accident as a classic study in Crew Resource Management (CRM) deficiencies. Neither the United States (US) airlines nor the United States Air Force (USAF) were formally trained in CRM in the 1970's (indeed, the concept was not specifically developed until the late 1970's). CRM was first (arguably) implemented by United Air Lines in 1979 as noted in Keyes (1990). It is important to realize, however, that for some airlines, CRM is simply a new name for a crew concept that has always been trained. Consider this excerpt from Massey (1990):

Not every airline feels that CRM is really new. TWA [Trans World Airlines], which calls its current program Cockpit Resource Training, has long stressed the crew concept, according to a training department representative. "We've been doing CRM for years and years, although we haven't been calling it that," he said. "I've been with the company for 25 years, and I think the crew concept's been around longer than that." (p. 65)

Today, CRM is a widely accepted training concept and program in major airlines and the USAF. Current CRM initiatives involve the refinement and improvement of CRM training programs with the ultimate goals of improving safety, enhancing mission effectiveness, and augmenting training efficiency (USAF, 1994). These initiatives seek to operationally fulfill the USAF (1994) CRM definition: "the effective use of all available resources—people, weapon systems, facilities, and equipment, and environment—by individuals or crews to safely and efficiently accomplish an assigned mission or task" (p. 14).

1.2 Purpose of this Report

This report provides suggestions for possible changes to the Air Mobility Command (AMC) CRM Anonymous Reporting System (ARS) reporting form. The AMC CRM ARS is a program initiated by AMC to augment the CRM training process. The system consists of a questionnaire on which aircrew members supply information about a CRM incident and a database in which questionnaire data is stored. Headquarters Air Mobility Command,

Directorate of Operations and Training (HQ AMC/DOT) continuously requests that its aircrew members complete the questionnaire when they experience or observe a CRM event, be it positive or negative. AMC indicates that the information gained through this anonymous source will be used to improve operations and training programs. It is essential for aircrew members to report CRM events, and it is just as important to have a means of classifying incidents. Appropriate classification of CRM incidents can serve as a pointer to areas that might benefit from increased training emphasis or implementation of new training methods.

The purpose of this report is to evaluate the current AMC CRM ARS reporting form in light of the current literature and research on CRM. The objectives are:

- Review current literature regarding CRM.
- Identify concurrent CRM dimensions common to the Federal Aviation Administration (FAA), the US Air Force (USAF), and mainstream CRM literature..
- Identify applicable CRM rating methods.
- Evaluate the current AMC CRM ARS reporting form using widely accepted CRM dimensions and rating methods.
- Present recommendations for the improvement of the AMC CRM ARS reporting form.

1.3 Scope of this Report

Although the design recommendations presented within this report provide a basis upon which to improve the AMC CRM ARS reporting form, the present effort does not provide a finished product form.

2. METHOD

In order to provide defensible suggestions for the improvement of the AMC CRM ARS reporting form, the Crew System Ergonomics Information Analysis Center (CSERIAC) elected to systematically analyze elements believed to be important to an effective ARS form. Broadly, this analysis consisted of three parts, including an analysis of overall CRM dimensions, an analysis of observable behaviors constituting these dimensions, and an overall analysis of the current AMC CRM ARS form and structure. These three analysis components are described below, and each analysis component composes a major section (i.e., 3.1, 3.2, and 3.3) in the body of this report.

2.1 Analysis of CRM Dimensions

In order to quantify CRM, it was necessary to first define the concept, and then break CRM down into individual dimensions. Since this report used current mainstream research literature, it was necessary to compare and determine the extent to which mainstream (e.g., FAA, 1995) and USAF CRM (USAF, 1994; USAF, 1995) definitions and dimensions concurred with each other.

CSERIAC compared and contrasted a variety of mainstream CRM dimensions with the Air Force dimensions. USAF dimensions that appeared across mainstream CRM taxonomies were identified as defensible CRM dimensions, while USAF CRM dimensions that had no concurrence with mainstream dimensions were identified for revision. CSERIAC also considered the possibility that some mainstream dimensions might not appear among USAF dimensions. However, this was not the case.

2.2 Analysis of Crew Performance Evaluation Techniques

Although breaking CRM down into defensible dimensions was an important first step in developing an effective assessment of CRM, CSERIAC realized that crewmembers could find difficulty in distinguishing among CRM dimensions unless the dimensions were broken down into behavioral definitions. A behavioral definition for a dimension consists of a list of specific, observable behaviors that represent that dimension

CSERIAC identified two lists of behavioral markers (from FAA and the AMC) and compared these lists. A new list consisting of the sum of these lists was then formed. CSERIAC compared this new list of behavioral markers with the current ARS form, pointing out possible improvements to the form. CSERIAC also reorganized the behavioral markers to map back to the specific, defensible USAF CRM dimensions identified in the analysis of CRM dimensions (2.1, above).

2.3 Analysis of Present AMC CRM ARS Form and Format

Finally, CSERIAC reviewed the overall content and structure of the AMC CRM ARS form. CSERIAC compared the ARS form to the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) form and commented on possible structure and content changes resulting from this comparison. Specific to CRM

assessment of the ARS form, CSERIAC compared the 12 factors presently appearing on the AMC CRM ARS form to the CRM dimensions (2.1) and crew performance markers (2.2) previously identified.

3. RESULTS AND DISCUSSION

The purpose of this section is to review current research findings as they pertain to the present evaluation of the AMC CRM ARS reporting form. These research findings help emphasize and organize dimensions for describing CRM functions.

3.1 Analysis of CRM Dimensions

3.1.1 Purpose and Definition of CRM

The primary purpose of CRM is to enhance flight safety. A large number of accidents due to lack of crew coordination (e.g., Everglades L-1011 accident) raised concerns with several organizations, including the airlines, the FAA, the NTSB, and the USAF. Most CRM programs exist for the principal reason of enhancing safety. Air Force Instruction (AFI) 36-2243 (USAF, 1994) specifies a total of three objectives for the USAF CRM program. These objectives include maximizing operational effectiveness and combat capability, preventing incidents and accidents to preserve human and materiel resources, and improving efficiency of all training. Although safety is at the crux of the CRM program, it follows that increases in crew coordination will not only increase safety, but also enhance operational effectiveness and combat capability.

To enhance the utility of the CRM ARS improvement effort, it is important that ARS reporters and analysts share the same perceptions and definitions regarding CRM. Consider the opinion of Driskell and Adams (1992), which summarizes the generally accepted main themes of CRM:

Crew resource management represents an approach to improving aviation safety that was born of real life experiences of airline pilots. They realized that technical skill alone was not enough to manage safely a complex flight system. CRM emphasizes the effective utilization of **all** resources available to the flight crew, including equipment and people. In addition to respecting the importance of traditional stick and rudder skills, CRM focuses on those other skills required for effective crew performance. **The overall goal of CRM is the blending of technical skills and human skills so as to support safe and efficient operation of aircraft.** (p. 10, original emphasis)

CRM is broadly conceptualized as the proper utilization of all available resources--hardware, software, and liveware--to achieve safe, efficient flight operations (Lauber, 1987). For Lauber (1987), hardware includes the aircraft itself, the instruments, and ground equipment. Software (in contrast to its use in the computer domain) refers to procedures, planning, and general policies. Liveware refers to the people available in the system. Lauber's definition has been divided further into goals and objectives by researchers and organizations, including the FAA (FAA, 1995).

3.1.2 FAA Advisory Circular 120-51B Suggested CRM Dimensions

The FAA Advisory Circular (AC) 120-51B (FAA, 1995) is a landmark publication on CRM training, and suggests basic CRM skills appropriate for use in developing CRM training programs (Driskell and Adams, 1992). The FAA categorizes CRM into three main clusters, including (1) communication processes and decision behavior, (2) team building and maintenance, and (3) workload management and situation awareness. These clusters are further broken down into subtopics which can be more readily trained and assessed than the overall clusters (see Table 1).

TABLE 1
FAA AC 120-51B Suggested CRM Topics (FAA, 1995, pp. 10-A6)

Cluster	Subtopics
Communication Processes and Decision Behavior	<ol style="list-style-type: none">1. Briefings2. Inquiry/Advocacy/Assertion3. Crew Self-Critique4. Conflict Resolution5. Communications and Decision making
Team Building and Maintenance	<ol style="list-style-type: none">1. Leadership/Followership/Concern for Tasks2. Interpersonal Relationships/Group Climate
Workload Management and Situation Awareness	<ol style="list-style-type: none">1. Preparation/Planning/Vigilance2. Workload Distributed/Distractions Avoided3. Individual Factors/Stress Reduction

From this division into clusters and subtopics, FAA (1995) develops a list of behavioral crew performance markers. Essentially, this is a list of observable behaviors that may assist in developing CRM programs and aid in providing guidelines for evaluation and feedback. Each behavioral marker can be mapped back to a specific subtopic classification (e.g., preparation/planning/vigilance). Although not presented as a checklist for evaluating individual crewmembers, these behavioral performance markers could form the basis for an evaluation strategy adapted to the AMC CRM ARS form refinement purpose. The FAA's crew performance marker clusters are provided in Appendix A of this report.

3.1.3 Concurrent Lists of CRM Dimensions

Many researchers and organizations share common beliefs on the definition, purpose, and desired outcomes of CRM. Consider the CRM dimensions used by various authors and organizations (Table 2) and note the similarities among them. FAA AC 120-51B dimensions have been integrated into this list for easier comparison of common themes. Recurrent themes appear among the various dimensions, lending concurrent validity to the factors purported to compose the CRM construct.

TABLE 2
CRM Dimensions Used by Other Authors and Organizations

Dimensions	Reference
<ol style="list-style-type: none"> 1. Briefings 2. Inquiry/Advocacy/Assertion 3. Crew Self-Critique 4. Conflict Resolution 5. Communications and Decisionmaking 6. Leadership/Followership/Concern for Tasks 7. Interpersonal Relationships/Group Climate 8. Preparation/Planning/Vigilance 9. Workload Distributed/Distractions Avoided 10. Individual Factors/Stress Reduction 	FAA AC 120-51B, 1995 (Regulatory Organization)
<ol style="list-style-type: none"> 1. To ensure that established rules and procedures are followed routinely and without exception 2. To make the "crew concept" in practice do justice to the concept 3. To maintain a high level of flight safety awareness in all flightcrew members 4. To take constructive advantage of operational incidents 	CRM Training Goals from Orlyady, 1983 (Airline)
<ol style="list-style-type: none"> 1. Appropriate delegation of tasks and assignments 2. Establishment of a logical order of priorities 3. Continuous monitoring and cross checking of essential instruments and systems 4. Careful assessment of problems and avoidance of preoccupation with minor ones 5. Utilization of all available data to conduct an operation 6. Clear communication of all plans and intentions among crewmembers 7. Assurance of sound leadership by the pilot in command 	American Airlines' Seven Principles of Flight Deck Resource Management; Telfer, 1983 (Airline)
<ol style="list-style-type: none"> 1. Delegating tasks and assigning responsibilities 2. Establishing priorities 3. Monitoring and cross-checking 4. Assessing problems and avoiding preoccupation 5. Communicating 6. Leadership 	Fundamental Elements of Effective CRM from Steenblik, 1988 (Airline)
<ol style="list-style-type: none"> 1. Developing effective interpersonal communication styles 2. Developing leadership/followership 3. Developing decision making skills 4. Developing a "team" concept 5. Dealing with stress 	Basic CRM Concepts from Jensen, 1989 (Airline)
<ol style="list-style-type: none"> 1. Attention management 2. Crew management 3. Stress management 4. Attitude management 5. Risk management 	Cockpit Management Tools from Diehl, 1991 (Military)
<ol style="list-style-type: none"> 1. Decision making 2. Assertiveness 3. Mission analysis 4. Communication 5. Leadership 6. Adaptability/flexibility 7. Situational awareness 	Team Process Skills from Prince, Brannick, Prince, & Salas, 1992 (Military)

3.1.4 Comparison of Mainstream and Air Force CRM Dimensions

In order to apply the lessons learned found in mainstream CRM research to the special operating environment of the AMC, it is necessary to confirm that the generally accepted dimensions of CRM concur with the CRM dimensions defined by the USAF and the AMC. AFI 36-2243 (USAF, 1994) is the official doctrine detailing the CRM program objectives in the USAF, and AMC Supplement 1 (USAF, 1995) to AFI 36-2243 adds AMC-specific doctrine to the original instruction. The comparative analysis of mainstream and USAF CRM dimensions is provided in Table 3. In column 1, the USAF CRM dimension is presented. Its associated definition appears in column 2, and column 3 provides the mainstream comparable dimensions.

The core curriculum mandated in AFI 36-2243 requires the implementation of CRM training in eight different areas. These eight AFI 36-2243-specific dimensions are identified in Table 3 by normal (not bold) print. Notice that these dimensions generally agree with the CRM dimensions originally shown in Table 2.

In Supplement 1 to AFI 36-2243, AMC has delineated an additional six required CRM subjects (also found in Table 3) as AMC-specific core curriculum matters. These Supplement 1-specific subjects are identified by **bold** print. Note that these six core curriculum amplify the elements widely accepted as CRM issues (e.g., assertiveness and effective communications). For the present report, the AMC CRM dimensions will be considered as additions to AFI 36-2243, not replacements for this instruction. The AMC CRM dimensions act to augment the original instruction by more succinctly delineating and defining AFI 36-2243 dimensions.

Most of the USAF CRM dimensions concur with the mainstream CRM dimensions. Two of the USAF and AMC CRM dimensions, however, are not supported by the literature reviewed for this report. Namely, *human performance* (AFI 36-2243) and *concepts of mishap prevention* (Supplement 1) were found nowhere else in the literature as dimensions of CRM. The primary reason for this exclusion is that both dimensions are too broad for inclusion as subclassifications of CRM. For instance, the *human performance* dimension overtly overlaps two already existing concepts: *situational awareness* and *stress awareness and management* (and when further analyzed, *human performance* also overlaps several other sufficiently distinct CRM dimensions). The *concepts of mishap prevention* dimension also overlaps *situational awareness* and is once again combined with several other topic areas. Additionally, it is easily argued that CRM itself is the operational application of concepts of mishap prevention, thus illustrating the unacceptably wide scope that *concepts of mishap prevention* takes on when categorized as a dimension within CRM.

This is not to say that these subject areas are not worthwhile. However, their inherent broadness will induce difficulty in CRM assessment. For instance, if a returned CRM ARS form contained responses suggesting a problem with CRM human performance training, it would be challenging to ascertain exactly where the problem lies--is the training deficiency in stress awareness and management training, or in situational awareness training?

TABLE 3

Comparison of USAF and Mainstream CRM Dimensions

Concept	Description	Supporting References
Situational Awareness	<i>A desired end state of CRM training is a high state of situational awareness. Tools for preventing lost situational awareness, cues for recognizing lost situational awareness, techniques for recovering from lost situational awareness will be covered under this concept area.</i>	Situation awareness subtopic (FAA, 1995) Attention management (Diehl, 1991) Situational awareness (Prince et al., 1992) Avoidance of preoccupation (Telfer, 1983) Utilization of all available data (Telfer, 1983) Avoidance of preoccupation (Steenblik, 1988)
Group Dynamics	<i>Includes command authority, leadership, responsibility, assertiveness, conflict resolution, hazardous attitudes, behavioral styles, legitimate avenues of dissent, team-building, and desired traits.</i>	Leadership subtopic (FAA, 1995) "Crew concept" do justice (Orlady, 1983) Crew management (Diehl, 1991) Developing "team" concept (Jensen, 1989) Sound leadership, delegation (Telfer, 1983) Leadership, delegating (Steenblik, 1988) Developing leadership/followership (Jensen, 1989) Assertiveness, leadership (Prince et al., 1992)
Group Dynamics Training	<i>Behavior norms of groups and individuals, team building, leadership styles, synergy demonstrations, and interactive exercises for all crewmembers.</i>	Leadership subtopic (FAA, 1995) "Crew concept" do justice (Orlady, 1983) Crew management (Diehl, 1991) Developing "team" concept (Jensen, 1989) Sound leadership, delegation (Telfer, 1983) Leadership, delegating (Steenblik, 1988) Develop leadership/followership (Jensen, 1989) Assertiveness, leadership (Prince et al., 1992)
Effective Communications	<i>Includes common errors, cultural influences, and barriers such as rank, age, and position, participation of all crewmembers. Also stress coordination with other participants in a mission, interface concerns, listening, feedback, precision and efficiency of communication.</i>	Communication subtopic (FAA, 1995) Clear communication (Telfer, 1983) Communicating (Steenblik, 1988) Interpersonal communication styles (Jensen, 1989) Communication (Prince et al., 1992)
Effective Communications	<i>Importance of effective communication, barriers to communication, active listening, nonverbal communication, and challenge and response.</i>	Communication subtopic (FAA, 1995) Clear communication (Telfer, 1983) Communicating (Steenblik, 1988) Interpersonal communication styles (Jensen, 1989) Communication (Prince et al., 1992)
Assertiveness Training	<i>Impact of personality differences, empower to challenge, authority with participation, assertiveness with respect, inquiry, advocacy, and assertion.</i>	Assertiveness (Prince et al., 1992) Inquiry/advocacy/assertion (FAA, 1995)
Risk Management and Decision Making	<i>This risk assessment and risk management styles, process, tools, breakdowns in judgment and discipline, problem-solving, evaluation of hazards, management of regulatory deviation during emergencies, and the most conservative response rule.</i>	Decision making subtopic (FAA, 1995) Flight Safety awareness (Orlady, 1983) Decision making (Prince et al., 1992) Decision making skills (Jensen, 1989) Risk management (Diehl, 1991) Assessing problems (Telfer, 1983)
Decision Making	<i>Recognize need for action, gather information, evaluate course of action, select and implement the decision, evaluate the decision, risk management.</i>	Decision making subtopic (FAA, 1995) Decision making (Prince et al., 1992) Decision making skills (Jensen, 1989) Assessing problems (Telfer, 1983) Flight safety awareness (Orlady, 1983)
Workload Management	<i>This area covers overload, underload, complacency, management of automation, available resources, checklist discipline, and standard operating procedures.</i>	Workload management subtopic (FAA, 1995) Follow rules and SOPs (Orlady, 1983) Monitoring and cross-checking (Telfer, 1983) Monitoring and cross-checking (Steenblik, 1988)

TABLE 3 (CONTINUED)

Comparison of USAF and Mainstream CRM Dimensions

Concept	Description	Supporting References
Stress Awareness and Management	<i>Includes sources of stress, benefits and hazardous effects, and coping techniques.</i>	Stress subtopic (FAA, 1995) Dealing with stress (Jensen, 1989) Stress management (Diehl, 1991) Adaptability/flexibility (Prince et al., 1992)
Stress Management	<i>Recognizing the signs of stress, signs of stress on the individual, signs of stress in others, positive and negative stress, common methods for stress reduction, and workload distribution.</i>	Stress subtopic (FAA, 1995) Dealing with stress (Jensen, 1989) Stress management (Diehl, 1991) Workload management subtopic (FAA, 1995)
Mission, Planning, Review, and Critique Strategies	<i>This area covers pre mission analysis and planning, briefing, ongoing or mid-mission review, and post mission critique. This area is intended to allow individual MAJCOMs and FOAs to include mission specific and weapon system specific planning, briefing and critique tools in their CRM training programs.</i>	Critique subtopic (FAA, 1995) Constructive advantage of incidents (Orlady, 1983) Mission analysis (Prince et al., 1992) Logical order of priorities (Telfer, 1983) Establishing priorities (Steenblik, 1988)
Human Performance	<i>This includes situational awareness, cognitive processing, anomalies of attention, stress and stress management, behavioral styles, mental attitudes, fatigue effects. These aviation specific knowledge and skills are taught by operationally experienced aviation psychologists and physiologists and may be taught in conjunction with physiological training.</i>	Attitude management (Diehl, 1991)
Concepts of Mishap Prevention	<i>The error chain, attitude management, hazardous attitudes, hazardous behaviors, human nature pitfalls, situational awareness, elements of good situational awareness, and symptoms and causes of decreased situational awareness.</i>	Attitude management (Diehl, 1991) Situation awareness subtopic (FAA, 1995) Situational awareness (Prince et al., 1992)

3.2 Crew Performance Evaluation Techniques

3.2.1 Attitude Questionnaires

While specific, well-defined dimensions are essential to the assessment of CRM, each dimension must be further analyzed and items that may be rated developed. Several strategies have been proposed regarding the nature of these ratable items. Murray, Weeks, and Siem (1995) provide a summary of the current state of CRM evaluation methods:

To date, CRM assessment in civilian aviation has consisted largely of measurement of CRM attitudes with instruments such as the Cockpit Management Attitudes Questionnaire (CMAQ; Helmreich, Wilhelm & Gregorich, 1991). Similarly, in the Air Force, CRM assessment focuses on student attitudes. CRM is considered a "state of mind" and training emphasizes the importance of fostering attitudes that support CRM.

Although assessment of attitudes provides important information that helps identify training needs and student receptivity to training, the

assumption that attitudes directly influence actual behaviors is questionable (Fishbein & Azjen, 1975). As a result, requirements for measuring CRM skills and behaviors have emerged. Programs such as the Federal Aviation Administration Advanced Qualification Program (AQP; FAA, 1991) and the Air Force Instruction for CRM Training (USAF, 1994) reflect the increasing importance of CRM evaluation based on performance rather than attitudes. (p. 1)

At the conclusion of CRM training, students are often given an attitude questionnaire, which is used to assess and predict the effectiveness of the CRM training. Although useful for the immediate purpose of gathering subjective student opinion (or attitude) on CRM training, the real measure of effective CRM training is operational effectiveness (a behavioral criteria). In essence, the CRM ARS concept is perhaps the very best indicator of the success of CRM programs in the USAF. A crewmember reporting a CRM incident momentarily takes the role of an evaluator or rater. The evaluation that the rater provides is much closer to a rating of people and performance rather than attitude about the CRM acceptance.

CSERIAC recommends that the CRM Anonymous Reporting System avoid attitude measures (not described in the present report). Attitude measures are certainly useful, but considering the operational incidents from which the CRM ARS responses will be borne, the most usable information will be behavioral information. Behavioral information will be more apt to provide clear, visible signs of both excellent and poor CRM. Behavioral information can be linked to the skills which need to be taught and emphasized in CRM courses. Attitude information, on the other hand, may not directly address the CRM dimensions present in a particular CRM event.

Examining the major checklists used during training to rate crewmembers' outward, CRM-related behavior may prove useful in developing a checklist for rating CRM behaviors found in the operational environment. The two major behavioral CRM rating checklists found in the literature are described below.

3.2.2 Line/LOS and ACE Checklists

The two primary behaviorally-anchored expert rating forms found in the literature are the Line/LOS (Line Operational Simulation) Checklist (LLC, also referred to as the Line/LOFT Checklist in some reports), and the Aircrew Coordination Evaluation (ACE). The LLC was developed in the NASA/University of Texas (UT)/FAA Aerospace Crew Research Project (Helmreich and Wilhelm, 1987), while the ACE was developed for the Army Research Institute Aviation Research and Development Activity at Fort Rucker, AL (Simon, Risser, Pawlik, and Leedom, 1990). The LLC began as a 17-dimension checklist utilizing a 5-point Likert scale (Povenmire, Rockway, Bunecke, and Patton, 1989; Taggart and Butler, 1989). The ACE was derived from this work, adding 2 dimensions for a total of 19, and utilized a 7-point Likert scale rather than the 5-point Likert of the LLC. See Figure 1 for a comparison of the two original checklists. Note that similar behaviors are directly across from each other, except where an arrow points to the equivalent behavior(s).

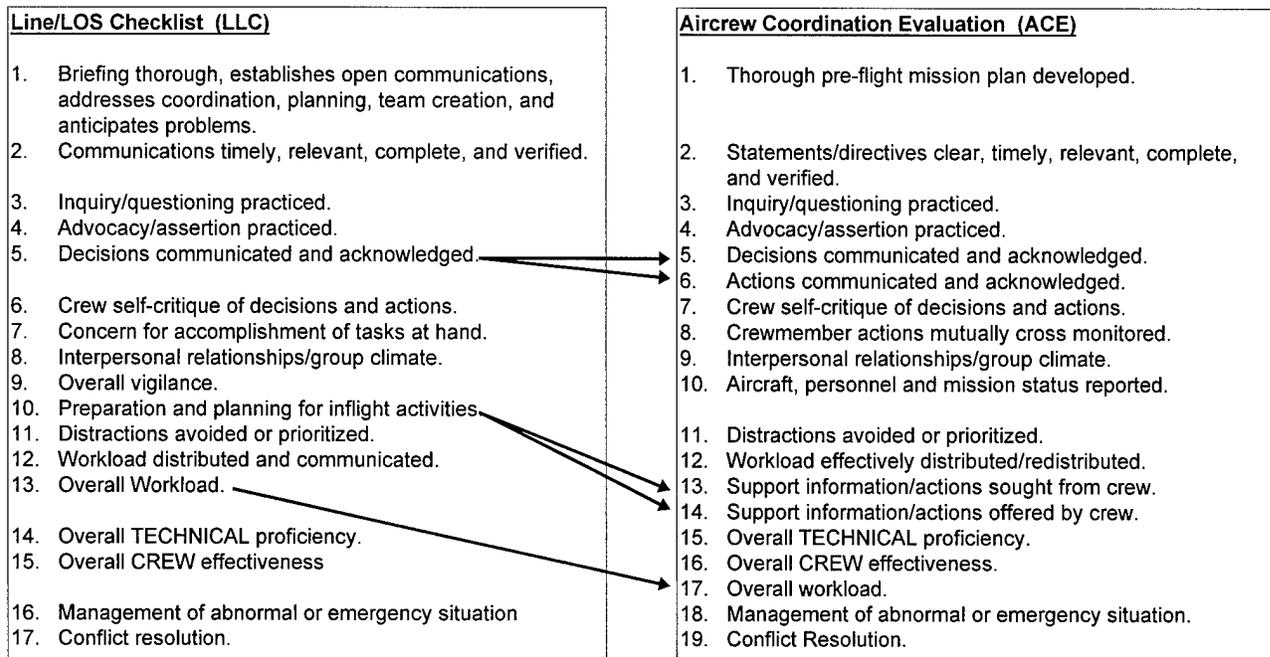


FIGURE 1. Comparison of the original LLC and ACE Checklists [Adapted from R. Simon, D.T. Risser, E.A. Pawlik and D.K. Leedom (1990). A model for evaluation and training in aircrew coordination and cockpit resource management. In *Proceedings of the Human Factors Society 34th Annual Meeting* (pp. 1377-1381). Santa Monica, CA: Human Factors Society].

From its creation until 1991, the original LLC was revised two times (Figure 1 shows the items from the unrevised, original form), and both revisions involved deletion of items. The first revision deleted items 13, 16, and 17, and the second revision (third edition) further reduced the number of observed behaviors to eight specific and two global items (Clothier, 1991). The rating items on the third edition of the LLC were functionally the same as the FAA dimensions of CRM, and used the FAA behavioral markers as references in providing a composite score for each of the rating items (Law and McFadden, 1992). In other words, the LLC, although reduced in number of top-level dimensions, required the level of detail found in the FAA's behavioral markers. Expert raters had to, at the very least, be familiar with the behavioral markers mapped to each LLC rating item to effectively provide a composite score for a dimension. See Appendix A for a full listing of the FAA CRM clusters and dimensions, and their associated behavioral markers. The latest version (version 4) of the LLC (Helmreich, Butler, Taggart, and Wilhelm, 1995) uses 31 behavioral markers to directly evaluate unique CRM behaviors. See Appendix B for a reproduction of LLC version 4.

The ACE Checklist, like the LLC, has also been revised from its original form. This revision involved the refinement of the ACE Checklist into 13 dimensions as shown in Figure 2. Like LLC version 3, although the overall number of dimensions has been reduced, the ACE Checklist is heavily reliant upon further descriptive information to complete an accurate evaluation of CRM behaviors. In contrast to the LLC version 3, however, the ACE does not use individual behavioral markers (in short form) to provide the necessary descriptive information. Instead, the ACE requires the use of a descriptive narrative (about a page in length for each rating item) which provides general information about each crew coordination basic quality. Within this narrative is also a description of three points on the

seven-point behaviorally-anchored rating scale, namely the very poor (1), acceptable (4), and superior (7) ratings, which are to be used as anchors.

AIRCREW COORDINATION EVALUATION (ACE) CHECKLIST						
For use of this form, see Aircrew Coordination Exportable Evaluation Package for Army Aviation.						
PC _____		Date _____				
PI _____						
NCM _____						

NO	CREW COORDINATION BASIC QUALITIES					RATING
1	Establish and maintain flight team leadership and crew climate (Crew Climate)					
2	Permission planning and rehearsal accomplished (Plan Rehearse)					
3	Application of appropriate decision making techniques (Decision Tech)					
4	Prioritize actions and distribute workload (Workload)					
5	Management of unexpected events (Unexp Events)					
6	Statements and directives clear, timely, relevant, complete, and verified (Info Xfer)					
7	Maintenance of situational awareness (Sit Aware)					
8	Decisions and actions communicated and acknowledged (Comm/Ack)					
9	Supporting information and actions sought from crew (Info Sought)					
10	Crewmember actions mutually cross monitored (Cross Monitor)					
11	Supporting information and actions offered by crew (Info Offered)					
12	Advocacy and assertion practiced (Advoc/Assert)					
13	Crew-level after-action reviews accomplished (AAR)					
Evaluator's Signature: _____						
Notes: Consult the behavioral anchored rating guidance. Enter a summary rating (1, 2 ... 7) in the rating block for each Basic Quality. Refer to the rating scale below.						
RATING SCALE						
Very Poor 1	Poor 2	Marginal 3	Acceptable 4	Good 5	Very Good 6	Superior 7

FIGURE 2. The Aircrew Coordination Evaluation (ACE) Checklist [Adapted from R.A. Simon and G.N. Grubb (1995). *Validation of crew coordination training and evaluation methods for Army aviation* (Report No. RN-95-45). Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences].

3.2.3 CRM Survey Issue: Number and Independence of CRM Dimensions

Survey instruments such as the LLC and ACE Checklist contain many similarities with the USAF and AMC CRM dimensions, and therefore could be appropriately modified and used for rating purposes. It must be emphasized, however, that the LLC (through version 3) and ACE Checklists are highly reliant upon behavioral markers and narrative description, and are not intended as stand-alone checklists of CRM (LLC version 4 is a stand-alone CRM checklist). Without immediate access to the appropriate behavioral markers and narrative description reference materials (used as a guide for the subject-matter expert rater), it is likely

that raters would misunderstand various CRM dimensions and fail to distinguish the important differences. The following results suggest this conclusion.

Bowers, Morgan, and Salas (1991, p. 309) faced a differentiation among dimensions problem in a study of 80 helicopter flight tasks (using a sample size of 14 pilots). Originally, Bowers et al. (1991) used seven dimensions, shown at the left side in Figure 3.

These researchers found a significant correlation of .95 between assertiveness and leadership, a correlation of .92 between adaptation and assertiveness, and a correlation of .88 between mission analysis and decision making. Bowers et al. (1991) note that these correlations are

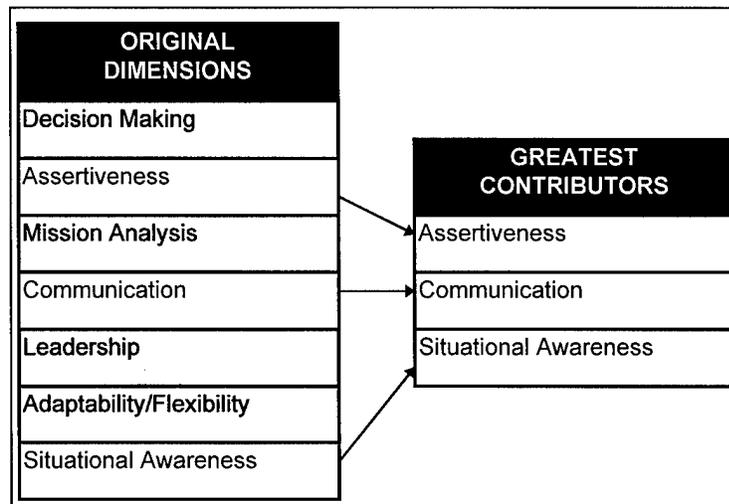


FIGURE 3. Greatest Contributors to Total Coordination Demand (Bowers, Morgan, and Salas, 1991)

“sufficiently high to merit some concern about the subject’s ability to discriminate between them” (p. 311). When used for the purpose of prediction, there were only three major contributors, assertiveness, communication, and situation awareness, which accounted for 91% of the variance in the estimating total coordination demand.

The results from this study can be interpreted in two ways. First, it can be argued that a great number of dimensions are not needed to define CRM. Indeed, Bowers et al. (1991) state that “it is possible that fewer than seven behavioral dimensions may adequately define the domain of aircrew coordination” (p. 311). In this view, the simplification of the LLC and ACE checklists make sense; superfluous dimensions have been eliminated.

However, Bowers et al. (1991) also acknowledge that “it is possible that these variables [highly correlated dimensions] are, in fact, conceptually different behavioral dimensions, but that the current sample did not possess sufficient understanding of the differences among them, leading to the high intercorrelations” (p. 311). In this view, it also makes sense that the LLC (through version 3) and ACE Checklists absolutely require the use of further clarification of dimensions (either through behavioral markers or narrative description) to provide the rater with sufficient understanding of the dimensions. It also follows that version 4 of the LLC directly provides the observer with unique, specific behavioral markers to rate. In this manner, LLC version 4 eliminates the need to provide a reference document along with a rating checklist; each behavior is defined on the LLC form.

Recall that CRM was originally developed to address safety problems caused by poor crew coordination. CRM has since grown into a much larger concept, becoming more broadly (and perhaps less succinctly) defined. This presents major problems when attempting to assess CRM, since an intended CRM assessment can easily become a very general assessment of crew performance rather than crew coordination. Because CRM is such a broad concept, there is some skepticism within the flying community that CRM can be objectively measured (Murray, Weeks and Siem, 1995).

In view of these concerns and the results presented in Bowers et al. (1991), CSERIAC recommends employing an assessment strategy that seeks to capitalize on the benefits of both reducing the number of CRM dimensions and also more clearly defining each dimension in behavioral terms. This strategy narrows the number of dimensions defining CRM by analyzing the distinctiveness of each dimension, and more clearly defines each dimension by supplying clear, behavioral markers to clarify the individual components of each dimension.

3.2.4 Linking CRM Dimensions and CRM Behaviors

3.2.4.1 FAA AC 120-51B Behavioral Markers. The FAA (1995) behavioral markers are perhaps the best place to start for the purpose of building a robust CRM rating method based on overt, observable performance. Compared to the other literature reviewed for this report, the FAA (1995) provides the most comprehensive listing of effective performance markers associated with CRM. These markers (provided in Appendix A) were used in the development of LLC version 4 and are believed to be directly applicable to the current need for behavioral markers for the AMC CRM ARS reporting form.

More AMC-specific needs for behavioral CRM assessment have been addressed by an AMC-developed behavioral checklist, the AMC CRM Assessment Sheet. It is believed that the best evaluation solution will be initiated by first synthesizing the behavioral markers from the FAA with the AMC behavioral markers.

3.2.4.2 AMC CRM Assessment Sheet. AMC has developed the AMC CRM Assessment Sheet from Supplement 1 dimensions (Table 3). This form uses ratings of behavioral observations (on a Likert scale of 1-4), with 1 representing poor performance, 2 representing minimum expectations, 3 representing standard, and 4 representing outstanding performance. Each of the six CRM core curriculum subjects outlined by AMC is used as a heading in the assessment sheet, including *Group Dynamics*, *Effective Communications*, *Assertiveness*, *Decision Making*, *Stress Management*, and *Mishap Prevention*. A seventh category, *Overall Observations*, is used to rate the crew's assessment of the complexity of the environment, severity of abnormal systems operation and overall crew technical proficiency. The other six CRM elements have from three to eleven crew performance behaviors rated under each element. An additional, expansive comments section is provided next to each of the items so raters may provide additional comments not captured by the behavioral observation rating scales. See Appendix C for an abbreviated (comments section has been deleted) view of the AMC CRM Assessment Sheet.

Some considerations should be pointed out regarding the CRM Assessment Sheet, however. Several redundant behavioral markers were identified. Redundancy of behavioral markers across dimensions was considered appropriate in the development of the Assessment Sheet according to Supplement 1, section 8.4.4 (USAF, 1995). However, this strategy will

prove ineffective in helping to uniquely define each of the dimensions in terms of behaviors because the same behavior is used to represent two or three different dimensions.

Additionally, the *concepts of mishap prevention* dimension overlaps heavily with other AFI 36-2243 and Supplement 1 dimensions. Both of these problems will challenge the ability to map proposed ARS form behaviors back to legitimate CRM training dimensions.

3.2.4.3 Comparison of FAA and AMC Behavioral Markers. Because of the need for a comprehensive list of unique behavioral markers, CSERIAC compared the FAA AC 120-51B (FAA, 1995) and AMC CRM Assessment Sheet behaviors and developed a new list of unique CRM behaviors. See Table 4 for a listing and comparison of these behaviors.

In column one of Table 4, the FAA CRM behavioral markers (FAA, 1995) are listed. For simplicity, the original structure of the FAA behavior listing has been maintained, and the FAA CRM subtopic headings are delineated in the list. For instance, behavior number 1 of the *Briefings* subtopic in Table 4 will also appear in FAA AC 120-51B (FAA, 1995) as the first behavior of the *Briefings* subtopic.

Immediately following the column 1 FAA behavioral markers are the AMC CRM Assessment Sheet behavioral markers (in column 2). AMC behavioral markers are placed directly across from the FAA behaviors (in the same row) that are equivalent. In certain cases, the AMC behavioral markers have the combined behaviors of several individual FAA behavioral markers included within a single AMC rating item. In these circumstances, the complete AMC behavior is listed in column 2 (next to the individual FAA behavior on the same row in column 1), but the AMC portion equivalent to the individual FAA behavioral marker is identified by **bold** print. The AMC behavioral markers are referenced to their source document (the AMC CRM Assessment Sheet) with a subject and number code. For instance, a code of SM4 indicates Assessment Sheet dimension *Stress Management* and item number 4. Other codes include: GD (*Group Dynamics*), AS (*Assertiveness*), EC (*Effective Communications*), DM (*Decision Making*), MP (*Mishap Prevention*), and OO (*Overall Observations*). A combination of two codes separated by a comma (e.g., SM4, MP3) indicates that the same behavior is replicated in another AMC CRM Assessment Sheet dimension (in this case, the overlap occurs between *Stress Management* item number 4 and *Mishap Prevention* item number 3).

In all cases, FAA and AMC behavioral markers with shared properties appear in the same row. In certain cases, there is no equivalent AMC behavior for a particular FAA behavior (and vice versa). In these cases, a blank space in the appropriate column indicates that no equivalent behavior was identified. In a small number of cases, the FAA and AMC behavioral markers shared most qualities, but had important differences. In these cases, the similar behavioral markers are still included in the same row, but notes describing the differences are added to the items, appearing in (*italics and parentheses*).

Overall, the goal of this comparison was to identify as many unique CRM-specific behavioral markers which could be used for the purpose of rating CRM on the AMC CRM ARS form. Therefore, where the FAA and AMC behaviors concur (on a row), the selection rule is to maintain a single behavioral marker for that row. In cases where a behavioral marker is unique to either the FAA or AMC list, the selection rule is to maintain that unique behavioral marker for the final, comprehensive behavioral marker list.

TABLE 4

Comparison of FAA AC 120-51B and AMC CRM Assessment Sheet Behavioral Markers

FAA CRM SUBTOPIC: Briefings

FAA AC 120-51B Behavioral Markers	AMC CRM Assessment Sheet Equivalent
(1) The briefing establishes an environment for open/interactive communications (for example, the captain calls for questions or comments, answers questions directly, listens with patience, does not interrupt or "talk over," does not rush through the briefing, and makes eye contact as appropriate).	GD1: Crewmembers establish and maintain a team concept and an environment for open communications (i.e., crewmembers listen with patience, do not interrupt or "talk over," do not rush through the briefings, & make eye contact when appropriate).
(2) The briefing is interactive and emphasizes the importance of questions, critique, and the offering of information.	
(3) The briefing establishes a "team concept" (for example, the captain uses "we" language, encourages all to participate and to help with the flight).	GD1: Crewmembers establish and maintain a team concept and an environment for open communications (i.e., crewmembers listen with patience, do not interrupt or "talk over," do not rush through the briefings, & make eye contact when appropriate).
(4) The briefing covers pertinent safety and operational issues.	
(5) The briefing identifies potential problems such as weather, delays, and abnormal system operations.	
(6) The briefing provides guidelines for crew actions; division of labor and crew workload is addressed.	GD2: The entire crew participates in briefings as a team, when appropriate, and the crew establishes guidelines for coordination between all crew positions . Crewmembers brief and update passengers when needed (i.e., mx delays, weather, etc.).
(7) The briefing includes the cabin crew as part of the team.	GD2: The entire crew participates in briefings as a team , when appropriate, and the crew establishes guidelines for coordination between all crew positions. Crewmembers brief and update passengers when needed (i.e., mx delays, weather, etc.).
(8) The briefing sets expectations for handling deviations from standard operating procedures.	EC1: The crew's briefings are operationally thorough, interesting, and address crew coordination while planning for potential problems. The crew sets expectations on how to handle deviations from normal operations .
(9) The briefing establishes guidelines for the operation of automated systems (for example, when systems will be disabled; which programming actions must be verbalized and acknowledged).	MP2: The crew establishes guidelines for the operation of automated systems (i.e., when they will disable systems and when they must verbalize and acknowledge programming actions).
(10) The briefing specifies pilot flying and pilot not flying duties and responsibilities with regard to automated systems.	SM4, MP3: The pilot team (crew) outlines PF and PNF duties and responsibilities with regard to automated systems (i.e., FMS entry and cross checking).
	EC1: The crew's briefings are operationally thorough, interesting, and address crew coordination while planning for potential problems. The crew sets expectations on how to handle deviations from normal operating procedures.
	GD8: When appropriate, crewmembers take the initiative and time to share operational knowledge and experience (i.e., new: crewmembers, routing, airfields, situations).

FAA CRM SUBTOPIC: Inquiry/Advocacy/Assertion

FAA AC 120-51B Behavioral Markers	AMC CRM Assessment Sheet Equivalent
(1) Crewmembers speak up and state their information with appropriate persistence until there is some clear resolution.	EC2, AS2: Crewmembers speak up and state their information with <u>appropriate</u> persistence, until there is some clear resolution and decision (i.e., effective advocacy and assertion).
(2) "Challenge and response" environment is developed.	
(3) Questions are encouraged and are answered openly and nondefensively.	
(4) Crewmembers are encouraged to question the actions and decisions of others.	AS1: Crewmembers openly ask questions regarding crew actions and decisions (i.e., effective inquiry).
(5) Crewmembers seek help from others when necessary.	
(6) Crewmembers question status and programming of automated systems to confirm situational awareness.	EC4, MP4: Crewmembers periodically review and verify the status of aircraft automated systems. (Note: This wording does not capture the <u>questioning</u> aspect of the FAA CRM wording).

TABLE 4 (CONTINUED)

Comparison of FAA AC 120-51B and AMC CRM Assessment Sheet Behavioral Markers

FAA CRM SUBTOPIC: Crew Self-Critique Regarding Decisions and Actions

FAA AC 120-51B Behavioral Markers	AMC CRM Assessment Sheet Equivalent
(1) Critique occurs at appropriate times, which may be times of low or high workload.	
(2) Critique deals with positive as well as negative aspects of crew performance.	GD5, EC7: Crewmembers provide (receive) positive and negative performance feedback at appropriate times, and the atmosphere creates a positive learning experience for the entire crew—feedback is specific, objective, based on observable behavior, and given constructively.
(3) Critique involves the whole crew interactively.	
(4) Critique makes a positive learning experience. Feedback is specific, objective, usable, and constructively given.	GD5, EC7: Crewmembers provide (receive) positive and negative performance feedback at appropriate times, and the atmosphere creates a positive learning experience for the entire crew—feedback is specific, objective, based on observable behavior, and given constructively.
(5) Critique is accepted objectively and nondefensively.	GD6, EC8: Crewmembers accept performance feedback objectively and nondefensively.

FAA CRM SUBTOPIC: Conflict Resolution

FAA AC 120-51B Behavioral Markers	AMC CRM Assessment Sheet Equivalent
	GD7, AS3, SM7: When conflicts arise, the crew's focus remains on the problem or situation at hand. Crewmembers listen actively to each others' ideas and opinions and admit mistakes when wrong (i.e., the crew resolves conflict).

FAA CRM SUBTOPIC: Communications and Decisionmaking

FAA AC 120-51B Behavioral Markers	AMC CRM Assessment Sheet Equivalent
(1) Operational decisions are clearly stated to other crewmembers.	EC3, DM1: Crewmembers clearly state operational decisions to other crewmembers and receive acknowledgment. Crewmembers communicate the decisions to the entire aircrew and others when appropriate.
(2) Crewmembers acknowledge their understanding of decisions.	EC3, DM1: Crewmembers clearly state operational decisions to other crewmembers and receive acknowledgment. Crewmembers communicate the decisions to the entire aircrew and others when appropriate.
(3) "Bottom lines" for safety are established and communicated.	
(4) The "big picture" and the game plan are shared within the team, including flight attendants and others as appropriate.	EC3, DM1: Crewmembers clearly state operational decisions to other crewmembers and receive acknowledgment. Crewmembers communicate the decisions to the entire aircrew and others when appropriate.
(5) Crewmembers are encouraged to state their own ideas, opinions, and recommendations.	
(6) Efforts are made to provide an atmosphere that invites open and free communications.	
(7) Initial entries and changed entries to automated systems are verbalized and acknowledged.	EC5: Crewmembers verbalize and acknowledge entries and changes to automated systems parameters.
	OO2: The crew assesses the severity of abnormal systems operation and other systems events during the mission.

TABLE 4 (CONTINUED)

Comparison of FAA AC 120-51B and AMC CRM Assessment Sheet Behavioral Markers

FAA CRM SUBTOPIC: Leadership/Followership/Concern for Tasks

FAA AC 120-51B Behavioral Markers	AMC CRM Assessment Sheet Equivalent
(1) All available resources are used to accomplish the job at hand.	
(2) Flightdeck activities are coordinated to establish an acceptable balance between respect for authority and the appropriate practice of assertiveness.	GD4, DM2: The aircraft commander coordinates flightdeck activities to establish proper balance between command authority and crewmember participation. The aircraft commander acts decisively when the situation requires. (Note: AMC specifies this as a responsibility of the <u>aircraft commander</u> in contrast to the FAA).
(3) Actions are decisive when the situation requires.	GD4, DM2: The aircraft commander coordinates flightdeck activities to establish proper balance between command authority and crewmember participation. The aircraft commander acts decisively when the situation requires. (Note: AMC specifies this as a responsibility of the <u>aircraft commander</u> in contrast to the FAA).
(4) A desire to achieve the most effective operation possible is clearly demonstrated.	
(5) The need to adhere to standard operating practices is recognized.	
(6) Group climate appropriate to the operational situation is continually monitored and adjusted (for example, social conversation may occur during low workload, but not high).	GD3: Group climate matches the operational situation (i.e., presence or lack of social conversation). The crew also ensures these non-operational factors to not interfere with necessary tasks.
(7) Effects of stress and fatigue on performance are recognized.	
(8) Time available for the task is well managed.	SM1: Crewmembers clearly communicate workload and task distribution and receive acknowledgment from other crewmembers. The crew allots adequate time to complete tasks.
(9) Demands on resources posed by operation of automated systems are recognized and managed.	
(10) When programming demands could reduce situational awareness or create work overloads, levels of automation are reduced appropriately.	SM6: The crew uses automated systems at optimal levels (i.e., when programming demands could reduce situational awareness and create work overloads, the crew reduces the level of automation or disengages automated systems).

FAA CRM SUBTOPIC: Interpersonal Relationships/Group Climate

FAA AC 120-51B Behavioral Markers	AMC CRM Assessment Sheet Equivalent
(1) Crewmembers remain calm under stressful conditions.	DM4, SM11: The crew remains calm under stress.
(2) Crewmembers show sensitivity and ability to adapt to the personalities of others.	
(3) Crewmembers recognize symptoms of psychological stress and fatigue in self and in others (for example, recognizes when he/she is experiencing "tunnel vision" and seeks help from the team; or notes when a crewmember is not communicating and draws him/her back into the team).	
(4) "Tone" in the cockpit is friendly, relaxed, and supportive.	
(5) During times of low communication, crewmembers check in with others to see how they are doing. (Note: AMC specifies that crewmembers are to check in with others during times of <u>high and low workload</u>).	

TABLE 4 (CONTINUED)

Comparison of FAA AC 120-51B and AMC CRM Assessment Sheet Behavioral Markers

FAA CRM SUBTOPIC: Preparation/Planning/Vigilance

FAA AC 120-51B Behavioral Markers	AMC CRM Assessment Sheet Equivalent
(1) Demonstrating and expressing situational awareness; for example, the "model" of what is happening is shared within the crew.	
(2) Active monitoring of all instruments and communications and sharing relevant information with the rest of the crew.	OO1: The crew consistently assesses the complexity of the operating environment (WX, ATC, traffic, threat).
(3) Monitoring weather and traffic and sharing relevant information with the rest of the crew.	OO1: The crew consistently assesses the complexity of the operating environment (WX, ATC, traffic, threat).
(4) Avoiding "tunnel vision" caused by stress; for example, stating or asking for the "big picture."	
(5) Being aware of factors such as stress that can degrade vigilance and watching for performance degradation in other crewmembers.	
(6) Staying "ahead of the curve" in preparing for planned situations or contingencies.	DM3, SM3: The crew prepares for expected or contingency situations including approaches, weather, etc. (i.e., the crew stays ahead of the power curve).
(7) Ensuring that cockpit/cabin crewmembers are aware of plans.	
(8) Including all appropriate crewmembers in the planning process.	
(9) Allowing enough time before maneuvers for programming of the flight management computer.	EC6, SM5, MP6: Crewmembers allow (plan for) sufficient time for programming of flight management computers prior to maneuvers.
(10) Ensuring that all crewmembers are aware of initial entries and changed entries in the flight management system.	EC5, MP5: Crewmembers verbalize and acknowledge entries and changes to automated systems parameters.
	SM9: The crew's actions do not create self-imposed stress and additional workload (i.e., a late descent due to lack of situational awareness/planning).

FAA CRM SUBTOPIC: Workload Distributed/Distractions Avoided

FAA AC 120-51B Behavioral Markers	AMC CRM Assessment Sheet Equivalent
(1) Crewmembers speak up when they recognize work overloads in themselves or in others.	SM10: Crewmembers recognize and report when their duties or the duties they observe others performing cause overload.
(2) Tasks are distributed in ways that maximize efficiency.	
(3) Workload distribution is clearly communicated and acknowledged.	SM1: Crewmembers clearly communicate workload and task distribution and receive acknowledgment from other crewmembers. The crew allots adequate time to complete tasks.
(4) Non-operational factors such as social interaction are not allowed to interfere with duties.	GD3: Group climate matches the operational situation (i.e., presence or lack of social conversation). The crew also ensures these non-operational factors do not interfere with necessary tasks.
(5) Task priorities are clearly communicated.	
(6) Secondary operational tasks (for example, dealing with passenger needs and communications with company) are prioritized so as to allow sufficient resources for primary flight duties.	SM2: The crew prioritizes secondary operational tasks (i.e., dealing with passenger needs, command post communications) to retain sufficient resources to deal effectively with primary task duties.
(7) Potential distractions posed by automated systems are anticipated, and appropriate preventive action is taken, including reducing or disengaging automated features as appropriate.	
	MP1: Crewmembers check-in with each other during times of high and low workload to maintain situational awareness and to remain alert. <i>(Note: The FAA states that crewmembers check in with each other during times of low communication).</i>

FAA CRM SUBTOPIC: Individual Factors/Stress Reduction

FAA AC 120-51B Behavioral Markers	AMC CRM Assessment Sheet Equivalent
	SM8: During long duty periods, crewmembers are pro-active in remaining alert, and plan and use fatigue countermeasures.

CSERIAC found considerable agreement between the two lists of behavioral markers, adding support to the belief that an integration of the two lists could provide an appropriate master behavioral marker list for the AMC CRM ARS form. In certain cases, the AMC behavioral markers appeared to combine several of the FAA behavioral markers into a single rating item. CSERIAC elected to use the original FAA behavioral markers in these cases. This rationale was taken in order to rate individual behaviors rather than combinations of behaviors. The comparison also emphasized that several of the AMC behavioral markers overlap with each other in different AMC CRM dimensions, making them difficult to map to a specific dimension. In several instances, however, each of the FAA and the AMC lists provided behavioral markers not found in the other of the two lists.

Overall, this comparison began with a total of 60 FAA and 44 AMC CRM behavioral markers. Removing the overlapping effects between the lists of behavioral markers, (and retaining the unique qualities of each behavioral marker) CSERIAC developed a final list of 67 behavioral markers that may be used as a guide in the development of a revised AMC CRM ARS form. This list is provided in Table 5, in conjunction with a comparison of the current AMC CRM ARS form 12 CRM factors (described below).

3.2.4.4 Comparison of FAA and AMC Behavioral Markers with ARS Form.

Upon integrating the FAA and AMC Assessment Sheet behavioral markers, a comparison with the current version of the AMC CRM ARS form (see Appendix D) was performed. This comparison (Table 5) emphasized the weaknesses of the current ARS form, and also emphasized the strengths of using behavioral markers for the purpose of rating.

As presently configured, the CRM ARS reporting form lists 12 factors that contribute to problems with CRM. These factors include *Interruption in a planned activity*, *Non-standard/misunderstood communications*, *Proficiency*, *Misleading/erroneous guidance or manuals*, *High workload*, *Complacency*, *Inadequate planning*, *Crew coordination*, *Equipment failure*, *Visual illusion/spatial disorientation*, *Insufficient training*, and *Stress or anxiety*. In several instances, these 12 factors do address aspects of CRM. However, the factors lack the specificity of behavioral markers and the definition of the CRM dimensions. As shown in Table 5, the factors that do relate to behavioral markers are generally too broad to assess the level of detail found in the behavioral markers. In many cases, several factors overlap a single marker, bringing associated problems with differentiation between dimensions.

For instance, the *Crew coordination* factor can be associated with 39 of the 67 combined behavioral markers (this fact is not surprising considering that the entire CRM concept is focused on crew coordination). The association of *Crew coordination* with a high number of behavioral markers raises concerns with the usefulness of this factor; it is likely that it will not accurately pinpoint problems with current USAF CRM behaviors. Also, in 23 of the 39 times that *Crew coordination* mapped to behavioral markers, other AMC CRM ARS form factors also mapped to these same behavioral markers. This problem suggests that the 12 factors on the current ARS form may not be differentiated enough from each other. As expressed earlier in this report, without behavioral markers or significant descriptive information, crewmembers may not be able to differentiate behaviors into the correct dimension (or in this case, factor).

TABLE 5

Combined Behavioral Marker List Comparison with Present AMC CRM ARS 12 Factors

Integrated List of FAA and USAF Behavioral Markers	AMC CRM ARS Comparison
(1) The briefing establishes an environment for open/interactive communications (for example, the captain calls for questions or comments, answers questions directly, listens with patience, does not interrupt or "talk over," does not rush through the briefing, and makes eye contact as appropriate).	Crew coordination, Non-standard/ misunderstood communications
(2) The briefing is interactive and emphasizes the importance of questions, critique, and the offering of information.	Crew coordination
(3) The briefing establishes a "team concept" (for example, the captain uses "we" language, encourages all to participate and to help with the flight).	Crew coordination
(4) The briefing covers pertinent safety and operational issues.	Inadequate planning
(5) The briefing identifies potential problems such as weather, delays, and abnormal system operations.	Inadequate planning
(6) The briefing provides guidelines for crew actions; division of labor and crew workload is addressed.	Inadequate planning, Crew coordination, High workload
(7) The briefing includes the cabin crew as part of the team.	Crew Coordination
(8) The briefing sets expectations for handling deviations from standard operating procedures.	Inadequate planning, Interruption in a planned activity
(9) The briefing establishes guidelines for the operation of automated systems (for example, when systems will be disabled; which programming actions must be verbalized and acknowledged).	Crew coordination, Inadequate planning
(10) The briefing specifies pilot flying and pilot not flying duties and responsibilities with regard to automated systems.	Crew coordination, Inadequate planning
(11) EC1: The crew's briefings are operationally thorough, interesting, and address crew coordination while planning for potential problems. The crew sets expectations on how to handle deviations from normal operating procedures.	Crew coordination, Inadequate planning
(12) GD8: When appropriate, crewmembers take the initiative and time to share operational knowledge and experience (i.e., new: crewmembers, routing, airfields, situations).	Crew coordination
(13) Crewmembers speak up and state their information with appropriate persistence until there is some clear resolution.	Non-standard/ misunderstood communications
(14) "Challenge and response" environment is developed.	Complacency
(15) Questions are encouraged and are answered openly and nondefensively.	
(16) Crewmembers are encouraged to question the actions and decisions of others.	
(17) Crewmembers seek help from others when necessary.	Crew coordination, Complacency
(18) Crewmembers question status and programming of automated systems to confirm SA.	Crew coordination, Complacency
(19) Critique occurs at appropriate times, which may be times of low or high workload.	
(20) Critique deals with positive as well as negative aspects of crew performance.	
(21) Critique involves the whole crew interactively.	Crew coordination
(22) Critique makes a positive learning experience. Feedback is specific, objective, usable, and constructively given.	Crew coordination, Non-standard/ misunderstood communications
(23) Critique is accepted objectively and nondefensively.	
(24) GD7, AS3, SM7: When conflicts arise, the crew's focus remains on the problem or situation at hand. Crewmembers listen actively to each others' ideas and opinions and admit mistakes when wrong (i.e., the crew resolves conflict).	Crew coordination
(25) Operational decisions are clearly stated to other crewmembers.	Non-standard/ misunderstood communications, Crew coordination
(26) Crewmembers acknowledge their understanding of decisions.	Non-standard/ misunderstood communications, Crew coordination
(27) "Bottom lines" for safety are established and communicated.	Crew coordination
(28) The "big picture" and the game plan are shared within the team, including flight attendants and others as appropriate.	Crew coordination, Non-standard/ misunderstood communications
(29) Crewmembers are encouraged to state their own ideas, opinions, and recommendations.	Crew coordination
(30) Efforts are made to provide an atmosphere that invites open and free communications.	Crew coordination
(31) Initial entries and changed entries to automated systems are verbalized and acknowledged.	Crew coordination
(32) OO2: The crew assesses the severity of abnormal systems operation and other systems events during the mission.	Crew coordination
(33) All available resources are used to accomplish the job at hand.	Crew coordination, Complacency
(34) Flightdeck activities are coordinated to establish an acceptable balance between respect for authority and the appropriate practice of assertiveness.	Crew coordination

TABLE 5 (CONTINUED)

Combined Behavioral Marker List Comparison with Present AMC CRM ARS 12 Factors

Integrated List of FAA and USAF Behavioral Markers	AMC CRM ARS Comparison
(35) Actions are decisive when the situation requires.	Complacency
(36) A desire to achieve the most effective operation possible is clearly demonstrated.	Complacency
(37) The need to adhere to standard operating practices is recognized.	Complacency
(38) Group climate appropriate to the operational situation is continually monitored and adjusted (for example, social conversation may occur during low workload, but not high).	Crew coordination, Complacency
(39) Effects of stress and fatigue on performance are recognized.	Stress or anxiety
(40) Time available for the task is well managed.	High workload, Complacency
(41) Demands on resources posed by operation of automated systems are recognized and managed.	High workload, Stress or anxiety
(42) When programming demands could reduce situational awareness or create work overloads, levels of automation are reduced appropriately.	High workload, Stress or anxiety
(43) Crewmembers remain calm under stressful conditions.	Stress or anxiety
(44) Crewmembers show sensitivity and ability to adapt to the personalities of others.	Crew coordination
(45) Crewmembers recognize symptoms of psychological stress and fatigue in self and in others (for example, recognizes when he/she is experiencing "tunnel vision" and seeks help from the team; or notes when a crewmember is not communicating and draws him/her back into the team).	Stress or anxiety, Visual illusion/ spatial disorientation
(46) "Tone" in the cockpit is friendly, relaxed, and supportive.	Crew coordination
(47) During times of low communication, crewmembers check in with others to see how they are doing. (Note: AMC specifies that crewmembers are to check in with others during times of high and low workload).	Non-standard/ misunderstood communications, Crew coordination, Complacency
(48) Demonstrating and expressing situational awareness; for example, the "model" of what is happening is shared within the crew.	Visual illusion/ spatial disorientation
(49) Active monitoring of all instruments and communications and sharing relevant information with the rest of the crew.	Crew coordination
(50) Monitoring weather and traffic and sharing relevant information with the rest of the crew.	Crew coordination
(51) Avoiding "tunnel vision" caused by stress; for example, stating or asking for the "big picture."	Visual illusion/ spatial disorientation
(52) Being aware of factors such as stress that can degrade vigilance and watching for performance degradation in other crewmembers.	Stress or anxiety, Crew coordination
(53) Staying "ahead of the curve" in preparing for planned situations or contingencies.	Inadequate Planning, High Workload
(54) Ensuring that cockpit and cabin crewmembers are aware of plans.	Crew coordination, Inadequate planning
(55) Including all appropriate crewmembers in the planning process.	Crew coordination, Inadequate planning
(56) Allowing enough time before maneuvers for programming of the flight management computer.	Inadequate planning, High workload
(57) Ensuring that all crewmembers are aware of initial entries and changed entries in the flight management system.	Crew coordination
(58) SM9: The crew's actions do not create self-imposed stress and additional workload (i.e., a late descent due to lack of situational awareness/planning).	High workload, Stress or anxiety
(59) Crewmembers speak up when they recognize work overloads in themselves or in others.	High workload, Stress or anxiety
(60) Tasks are distributed in ways that maximize efficiency.	Crew coordination, High workload
(61) Workload distribution is clearly communicated and acknowledged.	Crew coordination, High workload
(62) Non-operational factors such as social interaction are not allowed to interfere with duties.	Crew coordination, Interruption in a planned activity
(63) Task priorities are clearly communicated.	Non-standard/ misunderstood communications, Inadequate planning
(64) Secondary operational tasks (for example, dealing with passenger needs and communications with company) are prioritized so as to allow sufficient resources for primary flight duties.	Inadequate planning, Crew coordination, Interruption in a planned activity, High workload
(65) Potential distractions posed by automated systems are anticipated, and appropriate preventive action is taken, including reducing or disengaging automated features as appropriate.	Inadequate planning, Interruption in a planned activity
(66) MP1: Crewmembers check-in with each other during times of high and low workload to maintain situational awareness and to remain alert. (Note: The FAA states that crewmembers check in with each other during times of low communication).	High workload, Stress or anxiety, Complacency, Crew Coordination
(67) SM8: During long duty periods, crewmembers are pro-active in remaining alert, and plan and use fatigue countermeasures.	Complacency

Overall, 8 of the 12 factors from the present AMC CRM ARS form were found to be related to the comprehensive list of behavioral markers. As with the *Crew coordination* factor, the seven other factors overlap with each other and a number of the behavioral markers. In other cases, there are factors on the present ARS that do not relate to any aspect of CRM. This is not to say that these factors are not useful; in some cases, they provide queries for experience or context information surrounding a particular incident. These factors could be useful in more accurately describing a CRM event, but should not be categorized as CRM dimensions.

In all of the 12 factors on the present AMC CRM ARS form, weaknesses exist in issues of definition, differentiation, and utility. Consider the following recommendations for refinement of the 12 current ARS factors. Table 6 provides the factors, their challenges, and recommendations for improvement. Refer to Table 5 for a depiction of the extent of overlap individual factors share with each other and different behavioral markers. CSERIAC recommends that the information originally addressed by the 12 factors be gathered in three specific sections: crew background, event context, and CRM behaviors. These sections are described in more detail in section 3.3 of this report.

TABLE 6
Current AMC CRM ARS Form Factors, Challenges, and Recommendations

AMC ARS Form Factor	Challenge	Recommendation
1) Interruption in a planned activity	Borderline CRM-specific variable, too broad, cuts across many CRM behaviors.	Reassess factor as a CRM variable, use specific behavioral markers.
2) Non-standard/ misunderstood communications	Too broad, cuts across many CRM behaviors.	Maintain as CRM variable, but use specific behavioral markers.
3) Proficiency	Not a CRM-specific variable.	Place in crew background section. Include general proficiency and CRM proficiency in this section.
4) Misleading/erroneous guidance or manuals	Not a CRM-specific variable.	Place in event context section.
5) High workload	Too broad, cuts across many CRM behaviors.	Maintain as CRM variable, but use specific behavioral markers.
6) Complacency	Borderline CRM-specific variable, too broad, cuts across many CRM behaviors.	Reassess factor as a CRM variable, use specific behavioral markers.
7) Inadequate planning	Too broad, cuts across many CRM behaviors.	Maintain as CRM variable, but use specific behavioral markers.
8) Crew coordination	Too broad, cuts across many CRM behaviors.	Maintain as CRM variable, but use specific behavioral markers.
9) Equipment failure	Not a CRM-specific variable.	Place in event context section.
10) Visual illusion/ spatial disorientation	Borderline CRM-specific variable, too broad, cuts across many CRM behaviors.	Reassess factor as a CRM variable, use specific behavioral markers.
11) Insufficient training	Not a CRM-specific variable.	Place in crew background section.
12) Stress or anxiety	Too broad, cuts across many CRM behaviors.	Maintain as CRM variable, but use specific behavioral markers.

Central to the purpose of this report is the issue of appropriate assessment of CRM dimensions. Since the current AMC CRM ARS form factors do not effectively assess CRM, a new listing of appropriate CRM rating items must be developed. The previous discussion and comparison of FAA and AMC CRM behavioral markers provided a comprehensive list of behavioral markers that may be used in rating CRM. This behavioral marker list is believed to provide a basis for the further refinement of the AMC CRM ARS reporting form.

3.2.4.5 Narrowing the CRM Dimensions and Remapping Behavioral Markers.

In their present form, the 67 behavioral markers identified in this report represent a list that defines CRM as a whole. These behavioral markers could be incorporated into a revised AMC CRM ARS reporting form. Crewmembers could then provide ratings on specific CRM behaviors that were observed the operational environment. Having this information alone would provide significant insight into behaviors believed to compose CRM as a whole.

As an added benefit, the 67 behavioral markers may also be mapped to the Air Force and AMC CRM dimensions identified earlier in Table 3. Such a categorization would provide specific, observable behaviors for each of the applicable CRM dimensions, and hence, a link back to the core curriculum. Such a mapping is valuable because recurring problems exposed by the ARS database may be traced back to specific CRM core curriculum dimensions.

Since behavioral markers are believed to provide the best basis for evaluating CRM behaviors, CSERIAC undertook an effort to identify possible behavioral markers for each of the USAF CRM dimensions described in Table 3 (by using dimension definitions), including *mission, planning, review, and critique strategies, assertiveness training, group dynamics, effective communications, stress awareness and management, workload management, situation awareness, and decision making*. *Human performance and concepts of mishap prevention* were intentionally excluded from this list because, (1) these areas overlap other distinct CRM concepts extensively, and (2) there are no behavioral markers that distinctly and uniquely support these constructs. Note that the heading *overall observations* is excluded as well, as it is not a CRM-specific dimension. The results of this categorization of behavioral markers into dimensions are provided in Table 7.

Table 7 provides the applicable USAF CRM dimensions in **bold** print above the associated behavioral markers. Each behavioral marker may be traced back to the combined FAA and AMC behavioral marker list (Table 5) through the number in **bold** and parentheses after the marker. Notice that *mission, planning, review and critique strategies, group dynamics, and workload management* are all well represented by behavioral markers; each dimension has more than 10 behaviors associated with it. *Assertiveness training, effective communications, and stress awareness and management* are fairly well represented with between five and seven behaviors each, while *decision making* and *situational awareness* have four and three associated behavioral markers respectively. This list is by no means meant to be the final word in behavioral markers for each dimension. Some behavioral markers may need to be added or deleted from dimensions, depending on the goals and needs of AMC. The categorization does, however, provide a sound strategy for collecting CRM data that is traceable to CRM training. Therefore, when problems surface in a particular behavior, that behavior is linked to its dimension and core curriculum training course. From this link, improvements to the appropriate CRM training course may be made.

TABLE 7

Summary of CRM Behaviors Mapped to USAF CRM Dimensions (Dimension Headings from USAF, 1994 and USAF, 1995)

MPR&CS: Mission, Planning, Review and Critique Strategies

1. The briefing establishes an environment for open/interactive communications. (1)
2. The briefing is interactive and emphasizes the importance of questions, critique, and the offering of information. (2)
3. The briefing establishes a "team concept." (3)
4. The briefing covers pertinent safety and operational issues. (4)
5. The briefing identifies potential problems (weather, delays, abnormal system operations). (5)
6. The briefing provides guidelines for crew actions (division of labor and crew workload). (6)
7. The briefing includes the cabin crew as part of the team. (7)
8. The briefing sets expectations for handling deviations from standard operating procedures. (8)
9. The briefing establishes guidelines for the operation of automated systems. (9)
10. The briefing specifies pilot flying and pilot not flying duties and responsibilities with regard to automated systems. (10)
11. The crew's briefings are operationally thorough, interesting, and address crew coordination while planning for potential problems. (11)
12. When appropriate, crewmembers share operational knowledge and experience. (12)
13. Critique occurs at appropriate times, which may be times of low or high workload. (19)
14. Critique deals with positive as well as negative aspects of crew performance. (20)
15. Critique involves the whole crew interactively. (21)
16. Critique makes a positive learning experience (with appropriate feedback considerations). (22)
17. Critique is accepted objectively and nondensively. (23)

GD: Group Dynamics

1. Crewmembers seek help from others when necessary. (17)
2. When conflicts arise, the crew's focus remains on the problem or situation at hand. Crewmembers listen actively to ideas and opinions and admit mistakes when wrong. (24)
3. All available resources are used to accomplish the job at hand. (33)
4. The aircraft commander coordinates flightdeck activities to establish proper balance between command authority and crewmember participation. (34)
5. The aircraft commander...acts decisively when the situation requires. (35)
6. A desire to achieve the most effective operation possible is clearly demonstrated. (36)
7. Group climate appropriate to the operational situation is continually monitored/adjusted. (38)
8. Crewmembers show sensitivity and ability to adapt to the personalities of others. (44)
9. "Tone" in the cockpit is friendly, relaxed, and supportive. (46)
10. Including all appropriate crewmembers in the planning process. (55)
11. Group climate matches the operational situation (i.e., presence or lack of social conversation). The crew ensures these non-operational factors do not interfere with necessary tasks. (52)

WM: Workload Management

1. The need to adhere to standard operating practices is recognized. (37)
2. Time available for the task is well managed. (40)
3. Resource demands posed by operation of automated systems are recognized/managed. (41)
4. The crew uses automated systems at optimal levels (avoid work overloads). (42)
5. The crew prepares for expected or contingency situations (i.e., approaches, weather). (53)
6. Crew allows enough time to program flight management computers prior to maneuvers. (56)
7. The crew's actions do not create self-imposed stress and additional workload. (58)
8. Crewmembers recognize and report when their duties or the duties they observe others performing cause an overload. (59)
9. Tasks are distributed in ways that maximize efficiency. (60)
10. Crewmembers clearly communicate workload and task distribution and receive acknowledgment from other crewmembers. (61)

WM: Workload Management (Continued)

11. Task priorities are clearly communicated. (63)
12. The crew prioritizes secondary tasks (i.e., dealing with passenger needs, command post communications) to retain enough resources to deal with primary task duties. (64)
13. Potential distractions posed by automated systems are anticipated, and appropriate preventive action is taken, including reducing or disengaging automated features as appropriate. (65)
14. Crewmembers check-in with each other during times of high and low workload to maintain situational awareness and to remain alert. (66)

AS: Assertiveness Training

1. Crewmembers speak up and state their information with appropriate persistence until there is some clear resolution. (13)
2. "Challenge and response" environment is developed. (14)
3. Questions are encouraged and are answered openly and nondensively. (15)
4. Crewmembers are encouraged to question the actions and decisions of others. (16)
5. Crewmembers question status and programming of automated systems to confirm SA. (18)

EC: Effective Communications

1. The "big picture" is shared within the team, including others as appropriate. (28)
2. Crewmembers are encouraged to state their own ideas, opinions, and recommendations. (29)
3. Efforts are made to provide an atmosphere that invites open and free communications. (30)
4. Initial entries and changed entries to automated systems are verbalized/acknowledged. (31)
5. During times of low communication, crewmembers check in with others. (47)
6. Ensuring that cockpit and cabin crewmembers are aware of plans. (54)
7. Crewmembers verbalize/acknowledge entries/changes to automated systems. (57)

DM: Decision Making

1. Operational decisions are clearly stated to other crewmembers. (25)
2. Crewmembers acknowledge their understanding of decisions. (26)
3. "Bottom lines" for safety are established and communicated. (27)
4. The crew assesses the severity of abnormal systems operation and other systems events during the mission. (32)

SM: Stress Awareness and Management

1. Effects of stress and fatigue on performance are recognized. (39)
2. Crewmembers remain calm under stressful conditions. (43)
3. Crewmembers recognize symptoms of psychological stress and fatigue in self/others. (45)
4. Avoiding "tunnel vision" caused by stress; i.e., stating or asking for the "big picture". (51)
5. Being aware of factors such as stress that can degrade vigilance and watching for performance degradation in other crewmembers. (52)
6. During long duty periods, crewmembers are pro-active in remaining alert, and plan and use fatigue countermeasures. (67)

SA: Situational Awareness

1. Demonstrating and expressing situational awareness. For example, the "model" of what is happening is shared within the crew. (48)
2. Active monitoring of all instruments and communications and sharing relevant information with the rest of the crew. (49)
3. The crew consistently assesses the complexity of the operating environment (WX, ATC, traffic, threat). (50)

3.3 Further Suggestions for Present AMC CRM ARS Form Improvement

To this point, the focus has been placed on the CRM construct and its definition, dimensions, and appropriate rating methodologies. This focus has been taken because of the primary importance that CRM assessment assumes in the AMC CRM ARS reporting form. Other issues central to the refinement of the form should be considered as well. The present section presents suggestions and structure that may be applied to the AMC CRM ARS form revision. Based on these suggestions, an evaluation copy of a possible AMC CRM ARS form is provided in Appendix F. Note that this form is presented for comment and refinement only; it does not represent a final ARS form.

3.3.1 Neutral Terminology

AMC may want to consider replacing the term incident in the introduction with a more neutral or less heavily loaded word, dissociating the word incident from CRM. In the vernacular, the term incident has been used by the Air Force, the FAA, and the NTSB to connote a principally negative outcome that was short of an accident by some measure (loss of life, loss of equipment, loss of operational capacity, and so forth). Because the CRM ARS has been designed to gather both positive and negative examples of CRM, it is necessary that the terminology in the form reflect this. **Event** and **situation** are probably the more desired terms to use.

3.3.2 Contact Information

It is appropriate to ask for contact information. This information would allow the analyst reviewing a CRM event to contact the reporter to gain a better understanding of the event. See Appendix E for a view of the NASA Aviation Safety Reporting System (ASRS) form contact information section. NASA ASRS has never breached anonymity in collecting this information (Drew, 1995). Contact information simply includes the reporter's name, address, and telephone number, and is used only for the purpose of gaining additional insight into a particular CRM event. The contact information could (as with the NASA ASRS) be placed on a section of the final ARS form which may be returned to the reporter as an additional assurance of anonymity. Anonymity may be guaranteed by not archiving the contact data.

3.3.3 Crew Background

The AMC CRM ARS form is intended to be used to assess and improve the training system. Hence, it makes sense to ask questions regarding the particular respondent's past background both with general proficiency and with CRM (i.e., what CRM training has the respondent taken part in?). The selections on the AMC CRM ARS form should be representative of CRM training methods and media used in USAF and AMC courses. In this manner, it may be found that particular types of training (or lack of them) are more highly correlated with certain accidents (or augmented safety) than others. From these statistics, future course content may be tailored to improve training, and ultimately, safety. In tailoring

the form, AMC may want to exclude references to training that is mandatory and consistent throughout AMC, the reserve, and guard participants (i.e., eliminate the need to encode information that will be common to all reporting, information that can not provide any discriminative power during subsequent analysis efforts).

Additionally, general crew background information may also be desired. Such information could include rank, ratings, crew position during CRM event, and general proficiency. See Appendix E for the NASA ASRS organization of crew background information. Items originally appearing in the 12 factors of the original AMC CRM ARS form that deal with crew background issues (such as *proficiency*) could be placed in this section.

3.3.4 Event Context

It is important to ascertain the context of the reported situation, including environment, conflicts, weather, etc. The NASA ASRS (Appendix E) provides an excellent example of the kinds of items which the context section could contain. AMC may want to tailor this section based on what AMC, the reserve, and the guard crews are likely to experience. This may involve adding military-specific checklist items. Items originally appearing in the 12 factors of the original AMC CRM ARS form that deal with event context issues (such as *equipment failure*) could be placed in this section.

3.3.5 CRM Dimensions

After the crew background and event context are established, the actual CRM dimensions should be assessed through the use of behavioral markers (as previously discussed). Behavioral markers should be rated via the use of a Likert scale. These behavioral markers should be referenced back to CRM curriculum dimensions.

3.3.6 Narrative Summary

Finally, as with the present ARS form, a narrative summary section should be included to facilitate free expression on the part of the reporter. If desired, mnemonic prompts could be provided to assist the reporter in organizing their thoughts about the chain of events. The NASA ASRS form (Appendix E) provides such prompts for their respondents. Pilots and aircrew must be permitted to provide open-ended narrative description of the event, particularly where the objective selection options do not adequately capture the complexities of an operational CRM situation. The narrative summary section in the current ARS allows this, but may necessarily be shortened in the revised survey (due to possible space limitations). This narrative summary section should be analyzed according to accepted text analysis methods using appropriate algorithms. These methods are not discussed here, but may be delineated at a later time.

4. CONCLUSION AND RECOMMENDATIONS

Based on the findings of the literature reviewed for this report, the USAF and AMC CRM dimensions concur with mainstream literature on CRM. The most defensible USAF and AMC CRM dimensions include *mission, planning, review, and critique strategies, group dynamics, workload management, assertiveness training, effective communications, decision making, stress awareness and management, and situational awareness.*

For the rating of CRM dimensions, current literature supports the use of behavioral markers. FAA AC 120-51B (FAA, 1995) and the AMC CRM Assessment Sheet (USAF, 1995) provide extensive lists of CRM behaviors. When appropriately compared and combined, these lists provide an extensive summary of possible CRM behaviors. From the combined list, the individual behavioral markers may be mapped back to USAF CRM dimensions. In this manner, data gathered from behavioral markers may be used to test the effectiveness of CRM training for a particular core curriculum CRM dimension.

CSERIAC recommends the revision of the current AMC CRM ARS reporting form. In its present state, the form does not appear to map well to AFI 36-2243 (including Supplement 1), accepted taxonomies of CRM, or CRM behavioral markers. Additionally, the form presents 12 factors which overlap heavily and address a combination of CRM, crew experience, and situational context issues.

CSERIAC recommends that the ARS form be extensively revised and divided into the following five sections:

- Contact information
- Crew background information
- Event context information
- CRM behavioral markers
- Narrative description

Contact information would simply include name, address, and telephone numbers. The crew experience section would include information on the crew's training, proficiency, and background. The event context section would provide weather, conflict, and equipment failure information (along with other context-related data) of the situation being reported. The CRM behavioral marker section would address the CRM-specific elements surrounding the situation being reported by allowing the reporter to rate (on Likert scale) specific, observable behaviors which can be readily traced back to USAF CRM dimensions. Finally, the narrative description section would allow AMC CRM ARS reporters to freely write an account of the reported situation from start to finish, providing suggested improvements where appropriate.

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APPENDIX A
Crew Performance Marker Clusters (from FAA, 1995, pp. A1:1--A1:6)

(Italicized Markers apply to Advanced Technology Flight Decks)

These behavioral markers are provided to assist organizations in program and curriculum development and to serve as guidelines for feedback. They are not presented as a checklist for evaluating individual crewmembers.

1. COMMUNICATIONS PROCESSES AND DECISION BEHAVIOR CLUSTERS

a. Briefings. The effective briefing is interesting and thorough. It addresses coordination, planning, and problems. Although briefings are primarily a captain's responsibility, other crewmembers may add significantly to planning and should be encouraged to do so.

Behavioral Markers

- (1) The briefing establishes an environment for open/interactive communications (for example, the captain calls for questions or comments, answers questions directly, listens with patience, does not interrupt or "talk over", does not rush through the briefing, and makes eye contact as appropriate).
- (2) The briefing is interactive and emphasizes the importance of questions, critique, and the offering of information.
- (3) The briefing establishes a "team concept" (for example, the captain uses "we" language, encourages all to participate and to help with the flight).
- (4) The briefing covers pertinent safety and operational issues.
- (5) The briefing identifies potential problems such as weather, delays, and abnormal system operations.
- (6) The briefing provides guidelines for crew actions; division of labor and crew workload is addressed.
- (7) The briefing includes the cabin crew as part of the team.
- (8) The briefing sets expectations for handling deviations from standard operating procedures.
- (9) *The briefing establishes guidelines for the operation of automated systems (for example, when systems will be disabled; which programming actions must be verbalized and acknowledged).*
- (10) *The briefing specifies pilot flying and pilot not flying duties and responsibilities with regard to automated systems.*

b. Inquiry/Advocacy/Assertion. These behaviors relate to crewmembers' promoting the course of action that they feel is best, even when it involves conflict with others.

Behavioral Markers

- (1) Crewmembers speak up and state their information with appropriate persistence until there is some clear resolution.
- (2) "Challenge and response" environment is developed.
- (3) Questions are encouraged and are answered openly and nondefensively.
- (4) Crewmembers are encouraged to question the actions and decisions of others.
- (5) Crewmembers seek help from others when necessary.
- (6) *Crewmembers question status and programming of automated systems to confirm situational awareness.*

c. Crew Self-Critique Regarding Decisions and Actions. These behaviors relate to the effectiveness of a group and/or an individual crewmember in critique and debriefing. Areas covered should include the product, the process, and the people involved. Critique may occur during an activity, and/or after completing it.

Behavioral Markers

- (1) Critique occurs at appropriate times, which may be times of low or high workload.
- (2) Critique deals with positive as well as negative aspects of crew performance.
- (3) Critique involves the whole crew interactively.
- (4) Critique makes a positive learning experience. Feedback is specific, objective, usable, and constructively given.
- (5) Critique is accepted objectively and nondefensively.

d. Communication/Decisions. These behaviors related to free and open communication. They reflect the extent to which crewmembers provide necessary information at the appropriate time (for example, initiating checklists and alerting others to developing problems). Active participation in the decision making process is encouraged. Decisions are clearly communicated and acknowledged. Questioning of actions and decisions is considered routine.

Behavioral Markers

- (1) Operational decisions are clearly stated to other crewmembers.
- (2) Crewmembers acknowledge their understanding of decisions.
- (3) "Bottom lines" for safety are established and communicated.
- (4) The "big picture" and the game plan are shared within the team, including flight attendants and others as appropriate.
- (5) Crewmembers are encouraged to state their own ideas, opinions, and recommendations.
- (6) Efforts are made to provide an atmosphere that invites open and free communications.
- (7) *Initial entries and changed entries to automated systems are verbalized and acknowledged.*

2. TEAM BUILDING AND MAINTENANCE CLUSTER

a. Leadership Followership/Concern for Tasks. These behaviors relate to appropriate leadership and followership. They reflect the extent to which the crew is concerned with the effective accomplishment of tasks.

Behavioral Markers

- (1) All available resources are used to accomplish the job at hand.
- (2) Flightdeck activities are coordinated to establish an acceptable balance between respect for authority and the appropriate practice of assertiveness.
- (3) Actions are decisive when the situation requires.
- (4) A desire to achieve the most effective operation possible is clearly demonstrated.
- (5) The need to adhere to standard operating practices is recognized.
- (6) Group climate appropriate to the operational situation is continually monitored and adjusted (for example, social conversation may occur during low workload, but not high).
- (7) Effects of stress and fatigue on performance are recognized.
- (8) Time available for the task is well managed.
- (9) *Demands on resources posed by operation of automated systems are recognized and managed.*
- (10) *When programming demands could reduce situational awareness or crew work overloads, levels of automation are reduced appropriately.*

b. Interpersonal Relationships/Group Climate. These behaviors relate to the quality of interpersonal relationships and the pervasive climate of the flightdeck.

Behavioral Markers

- (1) Crewmembers remain calm under stressful conditions.
- (2) Crewmembers show sensitivity and ability to adapt to the personalities of others.
- (3) Crewmembers recognize symptoms of psychological stress and fatigue in self and in others (for example, recognizes when he/she is experiencing "tunnel vision" and seeks help from the team; or notes when a crewmember is not communicating and draws him/her back into the team).
- (4) "Tone" in the cockpit is friendly, relaxed, and supportive.
- (5) During times of low communication, crewmembers check in with others to see how they are doing.

3. WORKLOAD MANAGEMENT AND SITUATIONAL AWARENESS CLUSTER

a. Preparation/Planning/Vigilance. These behaviors relate to crews' anticipating contingencies and the various actions that may be required. Excellent crew are always "ahead of the curve" and generally seem relaxed. They devote appropriate attention to required tasks and respond without undue delay to new developments. (They may engage in casual social conversation during periods of low workload and not necessarily diminish their vigilance).

Behavioral Markers

- (1) Demonstrating and expressing situational awareness; for example, the "model" of what is happening is shared within the crew.
- (2) Active monitoring of all instruments and communications and sharing relevant information with the rest of the crew.
- (3) Monitoring weather and traffic and sharing relevant information with the rest of the crew.
- (4) Avoiding "tunnel vision" cause by stress; for example, stating or asking for the "big picture".
- (5) Being aware of factors such as stress that can degrade vigilance and watching for performance degradation in other crewmembers.
- (6) Staying "ahead of the curve" in preparing for planned situations or contingencies.
- (7) Ensuring that cockpit and cabin crewmembers are aware of plans.
- (8) Including all appropriate crewmembers in the planning process.
- (9) *Allowing enough time before maneuvers for programming of the flight management computer.*
- (10) *Ensuring that all crewmembers are aware of initial entries and changed entries in the flight management system.*

b. Workload Distributed/Distractions Avoided. These behaviors relate to time and workload management. They reflect how well the crew manages to prioritize tasks, share the workload, and avoid being distracted from essential activities.

Behavioral Markers

- (1) Crewmembers speak up when they recognize work overloads in themselves or in others.
- (2) Tasks are distributed in ways that maximize efficiency.
- (3) Workload distribution is clearly communicated and acknowledged.
- (4) Non-operational factors such as social interaction are not allowed to interfere with duties.

- (5) Task priorities are clearly communicated.
- (6) Secondary operational tasks (for example, dealing with passenger needs and communications with company) are prioritized so as to allow sufficient resources for primary flight duties.
- (7) *Potential distractions posed by automated systems are anticipated, and appropriate preventive action is taken, including reducing or disengaging automated features as appropriate.*

APPENDIX B
NASA/UT/FAA LINE/LOS Checklist, Version 4

The Line/LOS Checklist Version 4 is discussed in:

Helmreich, R. L., Butler, R. E., Taggart, W. R., & Wilhelm, J. A. (1995). *The NASA/University of Texas/FAA Line/LOS Checklist: A behavioral marker-based checklist for CRM skills assessment* (Technical Paper 94-02). Austin, TX: NASA/University of Texas/FAA Aerospace Crew Research Project.

Additionally, the Line/LOS Checklist Version 4 has been provided to CSERIAC courtesy of Mr. John Wilhelm at the NASA/UT/FAA Aerospace Crew Research Project. Mr. Wilhelm's contact information is:

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Telephone: (512) 480-9997
World-wide web homepage:
<http://www.psy.utexas.edu/psy/helmreich/nasaut.htm>

NASA/UT/FAA LINE/LOS CHECKLIST, VERSION 4

Observer is to complete one form for each flight segment

Airline	
Date (Mo. Yr.)	
Observer ID	
Route	
A/C Type & Series	
Hrs. Observed	

LOE	
LOFT	
Scenario ID	
Line Obs.	

Demographics	Capt.	1st Off	Engineer	Relief 1	Relief 2
Domicile					
Years of experience - all airlines					
Years in position - this A/C					

If crew observed for more than one leg: Leg No. of

Indicate Pilot Flying:

Check One Box

First leg flown together	More than one day flown together
First day flown together	

CREW PERFORMANCE RATING BY PHASE OF FLIGHT

<p>1 - Observed performance is significantly below expectations. This includes instances where necessary behavior was not present, and examples of inappropriate behavior that was detrimental to mission effectiveness.</p>	<p>2 - Minimum Expectations - Observed performance meets minimum requirements but there is ample room for improvement. This level of performance is less than desired for effective crew operations.</p>	<p>3 - Standard - The demonstrated behavior promotes and maintains crew effectiveness. This is the level of performance that should be normally occurring in flight operations.</p>	<p>4 - Performance represents exceptional skill in the application of specific behaviors, and serves as a model for teamwork - truly noteworthy and effective.</p>
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The following performance markers are specific behaviors that serve as indicators of how effectively resource management is being practiced. They are not intended to be exhaustive lists of behaviors that should be seen, but rather as exemplars of behaviors associated with more and less effective crew resource management. It is not expected that all behaviors will be seen for every phase of a specific flight. When performance is rated either as (4) or (1), please describe the causes for the specific rating in the COMMENTS section. Be concise. General comments are to be made at the end of this form.

Team Management & Crew Communications

Team Management & Crew Communications	Pre - Depart	T/O & Climb	Cruise	Des/Appr Landing	SPECIFIC COMMENTS
1. Team concept and environment for open communications established and/or maintained, e.g., crewmembers listen with patience, do not interrupt or "talk over", do not rush through the briefing, make eye contact as appropriate.					
2. Briefings are operationally thorough, interesting, and address crew coordination and planning for potential problems. Expectations are set for how possible deviations from normal operations are to be handled, e.g., rejected T/O, engine failure after lift-off, go-around at destination.					
3. Cabin crew is included as part of team in briefings, as appropriate, and guidelines are established for coordination between flight deck and cabin. Passengers are briefed and updated as needed, i.e., delays, weather, etc.					
4. Group climate is appropriate to operational situation, e.g., presence of social conversation at appropriate times. Crew ensures that non-operational factors such as social interaction do not interfere with necessary tasks.					

Team Management & Crew Communications (Cont.)

	Pre-depart	T/O & Climb	Cruise	Des/Appr Landing	COMMENTS
5. Crewmembers ask questions regarding crew actions and decisions, e.g., effective inquiry about uncertainty of clearance limits, clarification of confusing/unclear ATC instructions.					
6. Crewmembers speak up, and state their information with appropriate persistence, until there is some clear resolution and decision, e.g., effective advocacy & assertion: "I'm uncomfortable with..., Let's...."					
7. Operational decisions are clearly stated to other crewmembers and acknowledged, and include cabin crew and others when appropriate, e.g., good cross-talk between pilots, everyone "on same page."					
8. Captain coordinates flightdeck activities to establish proper balance between command authority and crew member participation, and acts decisively when the situation requires.					

Situational Awareness & Decision Making

9. Workload and task distribution is clearly communicated and acknowledged by crew members. Adequate time is provided for completion of tasks, e.g., establish well in advance who is flying the leg, establish responsibility for non-routine types of communications.					
10. Secondary operational tasks are prioritized so as to allow sufficient resources for dealing effectively with primary flight duties, e.g., dealing with passenger needs, crew meals, company communications.					
11. Crewmembers demonstrate high levels of vigilance in both high and low workload conditions, e.g., active monitoring, scanning, cross-checking, attending to radio calls, switch settings, altitude callouts, crossing restrictions.					
12. Crew prepares for expected or contingency situations including approaches, weather, etc. e.g., stays "ahead of curve".					

Automation Management

13. Guidelines are established/followed for the operation of automated systems, i.e., when systems will be disabled, programming actions that must be verbalized and acknowledged.					
14. PF and PNF duties and responsibilities with regard to automated systems are established/followed, e.g., FMS entry and cross-checking.					
15. Crewmembers periodically review and verify the status of aircraft automated systems, e.g., optimum cruise level, correct profile for active runway.					
16. Crewmembers verbalize and acknowledge entries and changes to automated systems parameters.					
17. Crew plans for sufficient time prior to maneuvers for programming of Flight Management Computer.					
18. Automated systems are used at appropriate levels, i.e., when programming demands could reduce situational awareness and create work overloads, the level of automation is reduced or disengaged, or automation is effectively used to reduce workload.					

Special Situations	Pre-Depart	T/O & Climb	Cruise	Des/Appr Landing	COMMENTS
19. Positive and negative performance feedback is given at appropriate times and is made a positive learning experience for the whole crew – feedback is specific, objective, based on observable behavior, and given constructively, e.g., critique of takeoffs and/or landings.					
20. Performance feedback is accepted objectively and non-defensively.					
21. When conflicts arise, the crew remains focused on the problem or situation at hand. Crewmembers listen actively to ideas and opinions and admit mistakes when wrong, conflict issues are identified and resolved.					
22. Crewmembers recognize fatigue and take specific steps to help maintain crew alertness, e.g., use of fatigue countermeasures such as social conversation, physical activity, caffeine management, walking through the cabin.					
23. Crew actions avoid the creation of self-imposed workload and stress, e.g., avoiding late descents due to lack of situational awareness/planning.					
24. Crewmembers recognize and report work overloads in self and others, e.g., stating "I'm getting loaded up here; Can you take over...."					
25. When appropriate, crewmembers take the initiative and time to share operational knowledge and experience, i.e., new crewmembers, routing, airports, situations.					

Augmented or Relief Crewmember/s

26. There is active planning and scheduling for inflight crew transition and rest periods.					
27. Inflight transition coordination and briefings (including cabin crew as appropriate) maintain total crew awareness.					

Overall Observations

Overall Observations	Overall Crew Rating
28. Overall technical proficiency	
29. Overall crew effectiveness	

Operational Considerations

Operational Considerations	Overall Rating
30. Assess the severity of abnormalities and other systems events that occur during flight. This item is rated 1=low to 4=high.	
31. Assess the complexity of operating environment, e.g., WX, ATC, Traffic, MEL's, XCM's), rated 1=low to 4=high. Comment on conditions affecting flight here.	

APPENDIX C

AMC CRM Assessment Sheet

Rating ("R") Scale

Poor (1) - Observed performance is significantly below expectations. This includes situations where necessary behaviors are not present and examples of inappropriate behavior are detrimental to mission effectiveness.	Minimum Expectations (2) - Observed performance meets minimum standards, but there is room for improvement. The level of performance is less than desired for effective crew operations.	Standard (3) - The demonstrated behavior promotes and maintains crew effectiveness. This level of performance should normally occur in day-to-day flight operations.	Outstanding (4) - Observed performance represents exceptional skill in the application of specific behaviors, and serves as a model for teamwork -truly noteworthy and effective.
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Group Dynamics	R
1. Crewmembers establish and maintain a team concept and an environment for open communications (i.e., crewmembers listen with patience, do not interrupt or "talk over," do not rush through the briefings, & make eye contact when appropriate).	
2. The entire crew participates in briefings as a team, when appropriate, and the crew establishes guidelines for coordination between all crew positions. Crewmembers brief and update passengers when needed (i.e. mx delays, weather, etc.).	
3. Group climate matches the operational situation (i.e., presence or lack of social conversation). The crew also ensures these non-operational factors do not interfere with necessary tasks.	
4. The aircraft commander coordinates activities to establish a proper balance between command authority and crewmember participation. The aircraft commander acts decisively when situations require.	
5. Crewmembers receive positive and negative performance feedback at appropriate times, and the atmosphere creates a positive learning experience for the entire crew--feedback is specific, objective, based on observable behavior, and given constructively.	
6. Crewmembers accept performance feedback objectively and non-defensively.	
7. When conflicts arise, the crew's focus remains on the problem or situation at hand. Crewmembers listen actively to ideas and opinions and admit mistakes when wrong (i.e., the crew resolves conflict).	
8. When appropriate, crewmembers take the initiative and time to share operational knowledge and experience (i.e., new: crewmembers, routing, airfields, situations).	

Effective Communications	R
1. The crew's briefings are operationally thorough, interesting, and address crew coordination while planning for potential problems. The crew sets expectations on how to handle deviations from normal operations.	
2. Crewmembers speak up and state their information with appropriate persistence, until there is some clear resolution and decision (i.e., effective advocacy and assertion).	
3. Crewmembers clearly state operational decisions to other crewmembers and receive acknowledgment. Crewmembers communicate the decisions to the entire aircrew and others when appropriate.	
4. Crewmembers periodically review and verify the status of aircraft automated systems.	
5. Crewmembers verbalize and acknowledge entries and changes to automated systems parameters.	
6. Crewmembers allow sufficient time for programming of flight management computers prior to maneuvers.	
7. Crewmembers provide positive and negative performance feedback at appropriate times and create a positive learning experience for the whole crew--feedback is specific, objective, based on observable behavior, and constructive.	
8. Crewmembers accept performance feedback objectively and non-defensively.	

Assertiveness	R
1. Crewmembers openly ask questions regarding crew actions and decisions (i.e., effective inquiry).	
2. Crewmembers speak up and state their information with appropriate persistence, until there is some clear resolution and decision (i.e., effective advocacy and assertion).	
3. When conflicts arise, the crew's focus remains on the problem or situation at hand. Crewmembers listen actively to ideas and opinions and admit mistakes when wrong (i.e., the crew resolves conflict).	

Decision Making	R
1. Crewmembers clearly state operational decisions to other crewmembers and receive acknowledgment. The crew includes all crewmembers and others when appropriate.	
2. The aircraft commander coordinates flightdeck activities to establish proper balance between command authority and crewmember participation, while acting decisively when the situation requires.	
3. The crew prepares for expected and/or contingency situations including approaches, weather, etc.	
4. The crew remains calm under stress.	

Stress Management	R
1. Crewmembers clearly communicate workload and task distribution and receive acknowledgment from other crewmembers. The crew allots adequate time to complete tasks.	
2. The crew prioritizes secondary operational tasks (i.e., dealing with passenger needs, command post communications, ...) to retain sufficient resources to deal effectively with primary flight duties.	
3. The crew prepares for expected or contingency situations including approaches, weather, etc. (i.e., the crew stays ahead of the power curve).	
4. The pilot team outlines PF and PNF duties and responsibilities with regard to automated systems (i.e., FMS entry and cross-checking).	
5. Crewmembers allow sufficient time for programming of flight management computers prior to maneuvers.	
6. The crew uses automated systems at optimal levels (i.e., when programming demands could reduce situational awareness and create work overloads, the crew reduces the level of automation or disengages automated systems).	
7. When conflicts arise, the crew's focus remains on the problem or situation at hand. Crewmembers listen actively to each others' ideas and opinions and admit mistakes when wrong (i.e., the crew resolves conflict).	
8. During long duty periods, crewmembers are pro-active in remaining alert, and plan and use fatigue countermeasures.	
9. The crew's actions do not create self-imposed stress and additional workload (i.e., a late descent due to lack of situational awareness/planning).	
10. Crewmembers recognize and report when their duties or the duties they observe others performing cause an overload.	
11. The crew remains calm under stress.	

Mishap Prevention	R
1. Crewmembers check-in with each other during times of high and low workload to maintain situational awareness and to remain alert.	
2. The crew establishes guidelines for the operation of automated systems (i.e., when they will disable systems and when they must verbalize and acknowledge programming actions).	
3. The crew outlines the duties and responsibilities of the PF and PNF with regard to automated systems (i.e., FMS entries and cross-checking).	
4. Crewmembers periodically review and verify the status of aircraft automated systems.	
5. Crewmembers verbalize and acknowledge entries and changes to automated systems parameters.	
6. The crew plans for sufficient time for programming of flight management computers prior to maneuvers.	

Overall Observations	R
1. The crew consistently assesses the complexity of the operating environment (WX, ATC, traffic, threat).	
2. The crew assesses the severity of abnormal systems operation and other systems events during the mission.	
3. Overall, the crew displays technical proficiency.	
4. Overall, the crew effectively performs the mission.	

APPENDIX D
AMC CRM ARS Form

AIR MAIL
CREW RESOURCE MANAGEMENT
ANONYMOUS REPORTING SYSTEM

Air Mail provides you with a way to improve Crew Resource Management training. Fill out the form when you feel you have experienced or observed a positive or negative example of CRM. Your inputs will be sanitized and sent to our CRM training contractors and "blue-suit" trainers for use in CRM programs. This program is strictly anonymous unless you want to provide more information or wish to be contacted about this incident. If so, include your name and DSN phone number. HQ AMC guarantees crewmembers complete anonymity and non-retribution. This guarantee applies to all data from AIR MAIL reports. This guarantee does not apply to similar information gleaned from other sources or information relating to criminal conduct. This form does not require postage, even if you attach additional sheets to the original. Sharing your experience will enhance flight safety.

fold here last

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST-CLASS MAIL PERMIT NO. 867 BELLEVILLE IL

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SCOTT AFB IL 62225-9904

fold here first

PLEASE TAKE TIME TO COMPLETE THE FOLLOWING:

Your answers to the following will be entered into a CRM trend analysis data base and used to improve operations and training programs. Please check any factors you feel contributed to the incident.

- | | |
|---|---|
| <input type="checkbox"/> 1. Interruption in a planned activity | <input type="checkbox"/> 7. Inadequate planning |
| <input type="checkbox"/> 2. Non-standard/misunderstood communications | <input type="checkbox"/> 8. Crew coordination |
| <input type="checkbox"/> 3. Proficiency | <input type="checkbox"/> 9. Equipment failure |
| <input type="checkbox"/> 4. Misleading/erroneous guidance or manuals | <input type="checkbox"/> 10. Visual illusion/spatial disorientation |
| <input type="checkbox"/> 5. High workload | <input type="checkbox"/> 11. Insufficient training |
| <input type="checkbox"/> 6. Complacency | <input type="checkbox"/> 12. Stress or anxiety |

Other: _____

APPENDIX E
NASA ASRS Form

**DO NOT REPORT AIRCRAFT ACCIDENTS AND CRIMINAL ACTIVITIES ON THIS FORM.
ACCIDENTS AND CRIMINAL ACTIVITIES ARE NOT INCLUDED IN THE ASRS PROGRAM AND SHOULD NOT BE SUBMITTED TO NASA.
ALL IDENTITIES CONTAINED IN THIS REPORT WILL BE REMOVED TO ASSURE COMPLETE REPORTER ANONYMITY.**

(SPACE BELOW RESERVED FOR ASRS DATE/TIME STAMP)

IDENTIFICATION STRIP: Please fill in all blanks to ensure return of strip.
NO RECORD WILL BE KEPT OF YOUR IDENTITY. This section will be returned to you.

TELEPHONE NUMBERS where we may reach you for further details of this occurrence:

HOME Area _____ No. _____ - _____ Hours _____

WORK Area _____ No. _____ - _____ Hours _____

NAME _____

ADDRESS/PO BOX _____

CITY _____ **STATE** _____ **ZIP** _____

TYPE OF EVENT/SITUATION _____

DATE OF OCCURRENCE _____

LOCAL TIME (24 hr. clock) _____

PLEASE FILL IN APPROPRIATE SPACES AND CHECK ALL ITEMS WHICH APPLY TO THIS EVENT OR SITUATION.

REPORTER	FLYING TIME	CERTIFICATES/RATINGS	ATC EXPERIENCE	
<input type="radio"/> Captain <input type="radio"/> First Officer <input type="radio"/> pilot flying <input type="radio"/> pilot not flying <input type="radio"/> Other Crewmember <input type="radio"/> _____	total _____ hrs. last 90 days _____ hrs. time in type _____ hrs.	<input type="radio"/> student <input type="radio"/> commercial <input type="radio"/> instrument <input type="radio"/> multiengine <input type="radio"/> _____	<input type="radio"/> private <input type="radio"/> ATP <input type="radio"/> CFI <input type="radio"/> F/E <input type="radio"/> _____	<input type="radio"/> FPL <input type="radio"/> radar _____ yrs. <input type="radio"/> non-radar _____ yrs. <input type="radio"/> supervisory _____ yrs. <input type="radio"/> military _____ yrs. <input type="radio"/> Developmental

AIRSPACE	WEATHER	LIGHT/VISIBILITY	ATC/ADVISORY SERV.				
<input type="radio"/> Class A (PCA) <input type="radio"/> Class B (TCA) <input type="radio"/> Class C (ARSA) <input type="radio"/> Class D (Control Zone/ATA) <input type="radio"/> Class E (General Controlled) <input type="radio"/> Class G (Uncontrolled)	<input type="radio"/> Special Use Airspace <input type="radio"/> airway/route _____ <input type="radio"/> unknown/other _____	<input type="radio"/> VMC <input type="radio"/> IMC <input type="radio"/> mixed <input type="radio"/> marginal <input type="radio"/> rain <input type="radio"/> fog	<input type="radio"/> ice <input type="radio"/> snow <input type="radio"/> turbulence <input type="radio"/> tstorm <input type="radio"/> windshear <input type="radio"/> _____	<input type="radio"/> daylight <input type="radio"/> dawn <input type="radio"/> ceiling _____ feet <input type="radio"/> visibility _____ miles <input type="radio"/> RVR _____ feet	<input type="radio"/> night <input type="radio"/> dusk <input type="radio"/> _____ feet <input type="radio"/> _____ miles <input type="radio"/> _____ feet	<input type="radio"/> local <input type="radio"/> ground <input type="radio"/> apch <input type="radio"/> dep <input type="radio"/> Name of ATC Facility: _____	<input type="radio"/> center <input type="radio"/> FSS <input type="radio"/> UNICOM <input type="radio"/> CTAF

	AIRCRAFT 1	AIRCRAFT 2
Type of Aircraft (Make/Model)	(Your Aircraft) _____ <input type="radio"/> EFIS <input type="radio"/> FMS/FMC	(Other Aircraft) _____ <input type="radio"/> EFIS <input type="radio"/> FMS/FMC
Operator	<input type="radio"/> air carrier <input type="radio"/> commuter <input type="radio"/> military <input type="radio"/> private <input type="radio"/> corporate <input type="radio"/> other _____	<input type="radio"/> air carrier <input type="radio"/> commuter <input type="radio"/> military <input type="radio"/> private <input type="radio"/> corporate <input type="radio"/> other _____
Mission	<input type="radio"/> passenger <input type="radio"/> cargo <input type="radio"/> training <input type="radio"/> pleasure <input type="radio"/> business <input type="radio"/> unk/other _____	<input type="radio"/> passenger <input type="radio"/> cargo <input type="radio"/> training <input type="radio"/> pleasure <input type="radio"/> business <input type="radio"/> unk/other _____
Flight plan	<input type="radio"/> VFR <input type="radio"/> IFR <input type="radio"/> SVFR <input type="radio"/> DVFR <input type="radio"/> none <input type="radio"/> unknown	<input type="radio"/> VFR <input type="radio"/> IFR <input type="radio"/> SVFR <input type="radio"/> DVFR <input type="radio"/> none <input type="radio"/> unknown
Flight phases at time of occurrence	<input type="radio"/> taxi <input type="radio"/> takeoff <input type="radio"/> climb <input type="radio"/> cruise <input type="radio"/> descent <input type="radio"/> approach <input type="radio"/> landing <input type="radio"/> missed apch/GAR <input type="radio"/> other _____	<input type="radio"/> taxi <input type="radio"/> takeoff <input type="radio"/> climb <input type="radio"/> cruise <input type="radio"/> descent <input type="radio"/> approach <input type="radio"/> landing <input type="radio"/> missed apch/GAR <input type="radio"/> other _____
Control status	<input type="radio"/> visual apch <input type="radio"/> controlled <input type="radio"/> no radio <input type="radio"/> on vector <input type="radio"/> none <input type="radio"/> radar advisories <input type="radio"/> on SID/STAR <input type="radio"/> unknown	<input type="radio"/> visual apch <input type="radio"/> controlled <input type="radio"/> no radio <input type="radio"/> on vector <input type="radio"/> none <input type="radio"/> radar advisories <input type="radio"/> on SID/STAR <input type="radio"/> unknown

If more than two aircraft were involved, please describe the additional aircraft in the "Describe Event/Situation" section.

LOCATION	CONFLICTS
Altitude _____ <input type="radio"/> MSL <input type="radio"/> AGL Distance and radial from airport, NAVAID, or other fix _____ Nearest City/State _____	Estimated miss distance in feet: horiz _____ vert _____ Was evasive action taken? <input type="radio"/> Yes <input type="radio"/> No Was TCAS a factor? <input type="radio"/> TA <input type="radio"/> RA <input type="radio"/> No Did GPWS activate? <input type="radio"/> Yes <input type="radio"/> No

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AVIATION SAFETY REPORTING SYSTEM

NASA has established an Aviation Safety Reporting System (ASRS) to identify issues in the aviation system which need to be addressed. The program of which this system is a part is described in detail in FAA Advisory Circular 00-46C. Your assistance in informing us about such issues is essential to the success of the program. Please fill out this form as completely as possible, enclose in a sealed envelope, affix proper postage, and send it directly to us.

Section 91.25 of the Federal Aviation Regulations (14 CFR 91.25) prohibits reports filed with NASA from being used for FAA enforcement purposes. This report will not be made available to the FAA for civil penalty or certificate actions for violations of the Federal Air Regulations. Your identity strip, stamped by NASA, is proof that you have submitted a report to the Aviation Safety Reporting System. We can only return the strip to you, however, if you have provided a mailing address. Equally important, we can often obtain additional useful information if our safety analysts can talk with you directly by telephone. For this reason, we have requested telephone numbers where we may reach you.

The information you provide on the identity strip will be used only if NASA determines that it is necessary to contact you for further information. THIS IDENTITY STRIP WILL BE RETURNED DIRECTLY TO YOU. The return of the identity strip assures your anonymity.

Thank you for your contribution to aviation safety.

NOTE: AIRCRAFT ACCIDENTS SHOULD NOT BE REPORTED ON THIS FORM. SUCH EVENTS SHOULD BE FILED WITH THE NATIONAL TRANSPORTATION SAFETY BOARD AS REQUIRED BY NTSB Regulation 830.5 (49CFR830.5).

Please fold both pages (and additional pages if required), enclose in a sealed, stamped envelope, and mail to:



NASA AVIATION SAFETY REPORTING SYSTEM
POST OFFICE BOX 189
MOFFETT FIELD, CALIFORNIA 94035-0189

DESCRIBE EVENT/SITUATION

Keeping in mind the topics shown below, discuss those which you feel are relevant and anything else you think is important. Include what you believe really caused the problem, and what can be done to prevent a recurrence, or correct the situation. (USE ADDITIONAL PAPER IF NEEDED)

CHAIN OF EVENTS

- How the problem arose
- Contributing factors
- How it was discovered
- Corrective actions

HUMAN PERFORMANCE CONSIDERATIONS

- Perceptions, judgments, decisions
- Factors affecting the quality of human performance
- Actions or inactions



AMC CREW RESOURCE MANAGEMENT ANONYMOUS REPORTING SYSTEM (AMC CRM ARS)



The AMC CRM ARS provides you with a way to improve Crew Resource Management (CRM) training. Fill out the form when you feel you have experienced or observed a positive or negative example of CRM. Your inputs will be sanitized (i.e., information leading to your association with the reported event will be removed) and sent to our CRM training contractors and "blue-suit"

trainers for use in CRM programs. This program is strictly anonymous unless you want to provide more information or wish to be contacted about this event. If so, please complete the contact information below. Contact data will not be archived and the contact information you provide will be returned to you. HQ AMC guarantees crewmembers complete anonymity and non-retribution. This guarantee applies to all data from AMC CRM ARS reports. This guarantee does not apply to similar information gleaned from other sources or information relating to criminal conduct. This form does not require postage, even if you attach additional sheets to the original. Sharing your experience will enhance flight safety.

(OPTIONAL)

Your Name _____

Home/Work Phone: _____

Address: _____

Type (e.g., a "Title") of Event: _____

City/State/ZIP: _____

Date/Local Time of Event: _____

CREW BACKGROUND: Please respond with the most accurate information you have available (print *N/A* where data is not applicable, and *UN* if unknown).

Crew Member	Total Hours	Hours In Type	Hours/90 Day	Last CRM Train Date	Special CRM Training Type
Instructor Pilot	_____	_____	_____	_____	Type 1 <input type="checkbox"/> Type 2 <input type="checkbox"/> Type 3 <input type="checkbox"/>
Pilot	_____	_____	_____	_____	Type 1 <input type="checkbox"/> Type 2 <input type="checkbox"/> Type 3 <input type="checkbox"/>
Copilot	_____	_____	_____	_____	Type 1 <input type="checkbox"/> Type 2 <input type="checkbox"/> Type 3 <input type="checkbox"/>
Navigator	_____	_____	_____	_____	Type 1 <input type="checkbox"/> Type 2 <input type="checkbox"/> Type 3 <input type="checkbox"/>
Aft Crew	_____	_____	_____	_____	Type 1 <input type="checkbox"/> Type 2 <input type="checkbox"/> Type 3 <input type="checkbox"/>
ATC Specialist	_____	_____	_____	_____	Type 1 <input type="checkbox"/> Type 2 <input type="checkbox"/> Type 3 <input type="checkbox"/>
CREWMEMBER FLYING WAS _____ (Pilot, Copilot)					

EVENT CONTEXT: Please respond to all that apply.

Your Aircraft/Flight Phase/Location: Type _____ Mission _____ Flight Phase: Taxi Takeoff
 Climb Cruise Descent Approach Landing Missed Apch Other Altitude _____ MSL AGL
 Nearest NAV Fix _____ Distance from Fix _____ (Miles). Radial _____ °FROM _____
 Weather/Light/Visibility: IMC VMC Mixed Marginal Ice Snow Rain Fog TStorm Turbulence Windshear
 Daylight Dusk Night Dawn Ceiling _____ (Feet). Visibility _____ (Miles). RVR _____ (Feet).
 Airspace/Air Traffic Control/Advisory Services: MOA IR/VR Training Route # _____ ADIZ Airspace Class: A B
 C D E G ATC: Cinc Del Ground Tower Dep Center Apch FSS UNICOM CTAF ATC Facility
 Name _____ Control Status: Visual Apch Controlled NoRad None On Vector Radar Advisories SID/STAR
 Conflicts (Please describe situation completely in narrative summary): Miss distance (feet): Horiz _____ Vert _____

CRM BEHAVIORS: Please rate the following behaviors on a scale of 1 (poor) to 4 (outstanding) as described below.

Description of 4-Point Likert Rating Scale
1 (Poor): Observed performance is significantly below expectations.
2 (Minimum Expectations): Observed performance meets minimum standards, but there is room for improvement.
3 (Standard): The documented behavior promotes and maintains crew effectiveness.
4 (Outstanding): Observed performance represents exceptional skill in the application of specific behaviors, and serves as a model for teamwork—truly noteworthy and effective.

MPR&CS: Mission, Planning, Review and Critique Strategies	Rating
1. The crew's briefings were operationally thorough, interesting, and addressed crew coordination while planning for potential problems.	1.
2. The briefing established an environment for open/interactive communications.	2.
3. The briefing was interactive and emphasized the importance of questions, critique, and the offering of information.	3.
4. The briefing established a "team concept."	4.
5. The briefing covered pertinent safety and operational issues.	5.
6. The briefing identified potential problems (weather, delays, and abnormal system operations).	6.
7. The briefing provided guidelines for crew actions (division of labor and crew workload).	7.
8. The briefing included the cabin crew as part of the team.	8.
9. The briefing set expectations for handling deviations from standard operating procedures.	9.
10. The briefing established guidelines for the operation of automated systems.	10.
11. The briefing specified pilot flying and pilot not flying duties and responsibilities with regard to automated systems.	11.
12. When appropriate, crew members shared operational knowledge and experience.	12.
13. Critique occurred at appropriate times (which could be times of low or high workload).	13.
14. Critique dealt with positive and negative aspects of crew performance.	14.
15. Critique involved the whole crew interactively.	15.
16. Critique made a positive learning experience. Feedback was specific, objective, usable and constructive.	16.
17. Critique was accepted objectively and nondefensively.	17.

WM: Workload Management	Rating
1. The need to adhere to standard operating practices was recognized.	1.
2. Time available for the task was well managed.	2.
3. Resource demands posed by operation of automated systems were recognized and managed.	3.
4. The crew used automated systems at optimal levels.	4.
5. The crew prepared for expected or contingency situations including approaches, weather, etc.	5.
6. The crew allowed sufficient time for programming flight management computers prior to maneuvers.	6.
7. The crew's actions did not create self-imposed stress and additional workload.	7.
8. Crew members recognized and reported when their duties or the duties they observed others performing caused an overload.	8.
9. Tasks were distributed in ways that maximized efficiency.	9.
10. Crew members communicated workload and task distribution and received acknowledgment from other crew members.	10.
11. Task priorities were clearly communicated.	11.
12. The crew prioritized secondary operational tasks (i.e., dealing with passenger needs, command post communications) to retain sufficient resources to deal with primary task duties.	12.
13. Potential distractions posed by automated systems were anticipated, and appropriate preventive actions were taken, (i.e., reducing or disengaging automated features as appropriate).	13.
14. Crew members checked in with each other during times of high/low workload to maintain situational awareness and to remain alert.	14.

EC: Effective Communications	Rating
1. The "big picture" was shared within the team, including others as appropriate.	1.
2. Crewmembers were encouraged to state their own ideas, opinions, and recommendations.	2.
3. Efforts were made to provide an atmosphere that invited open and free communications.	3.
4. Initial entries and changed entries to automated systems were verbalized and acknowledged.	4.
5. During times of low communication, crewmembers checked in with others.	5.
6. Cockpit and cabin crewmembers were aware of plans.	6.
7. Crew members verbalized/acknowledged entries/changes to automated systems parameters.	7.

APPENDIX F
Vision of Possible ARS Form

About CSERIAC

The Crew System Ergonomics Information Analysis Center (CSERIAC) is the gateway to worldwide sources of up-to-date human factors and ergonomics information and technologies for designers, engineers, researchers, and human factors specialists. CSERIAC provides a variety of products and services to government, industry, and academia promoting the use of human factors and ergonomics in the design of human-operated equipment and systems.

CSERIAC's primary objective is to acquire, analyze, and disseminate timely information on human factors and ergonomics. On a cost-recovery basis, CSERIAC will:

- Distribute human factors and ergonomics technologies and publications
- Perform customized bibliographic searches and reviews
- Prepare state-of-the-art reports and critical reviews
- Conduct specialized analyses and evaluations
- Organize and conduct workshops and conferences

CSERIAC is a Department of Defense Information Analysis Center sponsored by the Defense Technical Information Center. It is technically managed by the Armstrong Laboratory Human Engineering Division and operated by the University of Dayton Research Institute.



Published by:
CSERIAC
AL/CFH/CSERIAC Bldg 248
2255 H Street
Wright-Patterson AFB OH 45433-7022
Phone: (513) 255-4842
DSN: 785-4842
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