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Development of Rating Instruments and Procedures for Aviation Mishap Investigation

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and Tina M. Bronkhorst**

Dynamics Research Corporation

for

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Research Institute for the Behavioral and Social Sciences**

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13. ABSTRACT (Maximum 200 words) This report summarizes the development of improved techniques, procedures, measures, and reporting methods for identifying and reporting aircrew coordination errors in U.S. Army aviation mishaps. Based on an analysis of historical aviation accident data, researchers identified a number of recurring crew coordination errors that have contributed to rotary wing accidents. The errors were categorized and used, along with a theoretical framework and associated set of rating instruments, to produce a supplemental set of investigation and reporting procedures for U.S. Army aviation mishap investigations. The supplemental investigation and reporting procedures were demonstrated and validated in the field in three Class A aviation mishap investigations conducted during the summer of 1990. Participating research psychologists accompanied the U.S. Army Safety Center accident investigation board to assess and refine the procedures in actual use.			
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FOREWORD

This report describes a portion of an ongoing research project of the U.S. Army Research Institute for the Behavioral and Social Sciences Fort Rucker Field Unit. The goal of this project is to provide the U.S. Army with a prototype system for training and evaluating aircrew coordination skills in rotary wing aviators. The research responds to the belief that current approaches to training (which have been adapted from commercial transport aviation) are not appropriate for rotary wing aviators.

U.S. Army rotary wing flight operations typically experience degraded environmental conditions and very short reaction times. This is not surprising, given the high percentage of missions flown at extremely low altitudes (e.g., terrain flight, nap-of-the-earth), under tactical conditions (e.g., night vision devices), and with the threat of hostile actions (e.g., enemy surface-to-air threats, air-to-air engagements). In contrast, commercial transport pilots normally fly routine flight profiles, at high altitude, and over highly controlled air lanes. Commercial transport crews may have several minutes to coordinate critical decisions and actions regarding mission performance or flight safety. The typical Army helicopter crew has only a few seconds. Such differences suggest the need for alternative training and evaluation approaches for managing cockpit workload and coordinating crew actions. Thus, the following questions motivated this research project.

- What are the U.S. Army's specific requirements for aircrew coordination in low-level, tactical, rotary wing flight operations?
- What is the best approach for ensuring rotary wing aviator proficiency in this skill area?
- What combination of new standards, procedures, training, and evaluation techniques is needed?

Findings of the initial phase of this project have been briefed to the Director of Army Safety (July 1990); the Commanding General of the U.S. Army Aviation Center (July 1990); the Deputy Chief of Staff for Combat Developments, Headquarters, Training and Doctrine Command (August 1990); and the Army's Director of MANPRINT (September 1990). Technical products developed in the initial phase of this project are being implemented as field-deployable, prototype training and evaluation packages for training Army rotary wing aircrew coordination skills.

DEVELOPMENT OF RATING INSTRUMENTS AND PROCEDURES FOR AVIATION MISHAP INVESTIGATION

EXECUTIVE SUMMARY

Requirement:

To develop improved techniques, procedures, measures, and reporting methods for identifying and reporting aircrew coordination errors in U.S. Army aviation mishap investigations.

Procedure:

Based on an analysis of historical aviation accident data, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) identified a number of recurring crew coordination errors that have contributed to rotary wing accidents. Together with a theoretical framework and an associated set of rating instruments developed by the Dynamics Research Corporation, these error categories were used to produce a supplemental set of investigation and reporting procedures for U.S. Army aviation mishap investigations.

Findings:

The supplemental investigation and reporting procedures were field demonstrated and validated in a series of three Class A aviation mishap investigations conducted during the summer of 1990. Participating research psychologists from ARI and the Dynamics Research Corporation accompanied the U.S. Army Safety Center accident investigation board to assess and refine these procedures in actual use.

Utilization of Findings:

The new procedures have been accepted by the U.S. Army Safety Center for eventual incorporation into a future revision of DA Pamphlet 385-95, "Safety Aircraft Accident Investigation and Reporting." This pamphlet will be expanded and fielded as DA Pamphlet 385-40. In addition, ARI has provided training on the use of these new procedures to all investigation personnel currently assigned to the U.S. Army Safety Center.

DEVELOPMENT OF RATING INSTRUMENTS AND PROCEDURES FOR AVIATION MISHAP INVESTIGATION

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**DEVELOPMENT OF RATING INSTRUMENTS AND PROCEDURES
FOR AVIATION MISHAP INVESTIGATION
SECTION 1 - GENERAL**

1.0 INTRODUCTION

This report is in response to a U.S. Army Research Institute (ARI) request for development of improved techniques, procedures, measures, and reporting methods currently used for identifying and reporting aircrew coordination errors in accident investigations. It is envisioned that the improved methods will assist the United States Army Safety Center (USASC) accident investigation boards to identify and report crew coordination task errors and system inadequacies.

1.1 BACKGROUND

In 1987, the Vice Chief of Staff of the Army asked the Army Research Institute (ARI) to initiate an R&D program aimed at reducing Army accident rates through better personnel selection, training, and system design. To this end, ARI established a safety research program as part of its overall MANPRINT methods R&D program.

ARI's analysis of Army aviation accidents suggested that crew coordination errors represent a major category of human error-induced accidents in aviation operations. To improve crew coordination in aviation system operations, the Army adapted an Aircrew Coordination Training (ACT) program originally developed in the civilian airline industry. However, Army ACT programs have not been objectively evaluated in terms of their impact on crew performance. In June 1989, ARI tasked Dynamics Research Corporation (DRC) to develop measures of Aircrew Coordination to assist the Army in evaluating the effectiveness of its ACT program.

During the development of the measures it became apparent that the same basic framework developed and used by DRC to create the measures of aircrew coordination could be used to develop an improved methodology for investigating crew coordination errors during aviation accident investigations. In February 1990, ARI tasked DRC to translate candidate measurement methods into techniques and procedures of potential use by USASC accident investigation teams to identify and document crew coordination errors and system inadequacies.

SECTION 2 - TECHNICAL APPROACH

2.0 GENERAL

Army aviation accident investigators receive guidance from DA Pam 385-95, Safety Aircraft Accident Investigation and Reporting, to conduct their investigations. DRC determined that any additional investigative procedures should be proposed to USASC in a manner in which they currently do business. Consequently, one of the primary products of this task is a proposed supplement to DA Pam 385-95 which will allow accident investigators to incorporate aircrew coordination considerations into USASC investigations.

To develop both the proposed supplement to DA Pam 385-95, and the procedures to be used to incorporate aircrew coordination considerations into Army aviation accident investigations, DRC used data from a variety of sources. These sources included: (1) the USASC and ARI aircraft accident case history study, (2) the model of aircrew coordination DRC developed to construct measures of crew coordination under Delivery Order 0001 of this contract, and (3) DA Pam 385-95. This section describes how data from each of these sources was used to develop the supplement, i.e., a Handbook covering the aircrew coordination aspects of the USASC human factors investigation. The Handbook is designed to aid investigators in determining the extent to which inadequate aircrew coordination contributed to aviation accidents.

2.1 USASC and ARI CASE HISTORY STUDY

USASC and ARI reviewed 596 class A, B, and C aircraft accident case histories occurring between FY 1984 and FY 1989. As a result of this review, USASC proposed the following definition of aircrew coordination:

Aircrew coordination is the interaction between crewmembers (communications) and actions (sequence or timing) necessary for flight tasks to be performed efficiently, effectively, and safely.

Considering the above definition, DRC constructed a working definition of aircrew coordination errors as that category of errors which occur due to a failure to coordinate activities between two or more members of the aircrew. If an aircrew error does not involve a coordination (interaction) failure, it is classified as an individual human error. Individual errors are addressed in the supplement for the sole purpose of assisting investigators in differentiating between aircrew and individual errors. When an error is determined to be an individual error, the standard DA Pam 385-95 applies.

Of the 596 cases reviewed, 130 cases were subjected to an in-depth analysis to determine to what degree, if any, aircrew coordination errors were a factor in the accident. Results of the analysis indicated that crew coordination errors were a factor in 88 of the 130 cases. Each of the 88 cases was then sorted according to the type of error made. Definitions for nine error categories evolved as a result of this sorting process. Consequently, the nine categories were used to define the aircrew coordination task errors in the proposed supplement. DRC included a category of "other" to provide for coding aircrew coordination task errors that may occur in future accidents that do not fit within the parameters of the nine previously defined categories. The task error categories are as follows:

- 01 Lack of positive communication technique (transmission, acknowledgement, confirmation) using standard terminology with specific qualifiers.
- 02 Failure to announce decisions or actions that affect other crew members' duties or performance.
- 03 Failure to appropriately assign clearance responsibilities during pre-mission briefing or to direct clearing assistance during a critical maneuver.
- 04 Failure to properly distribute workload by directing a non-flying crew member to provide assistance in monitoring airspeed, altitude, engine power; to perform required actions inside the cockpit; or to assume a transfer of the controls.
- 05 Failure to anticipate and offer assistance or information required by the flying crew member.
- 06 Assuming control of the aircraft or making control inputs without positive transfer of controls.
- 07 Failure to allow sufficient time for another crew member to perform a directed action.
- 08 Inappropriately directing a non-flying crew member to a lower priority task.
- 09 Lack of assertiveness or excessive dominance; failure of a crew member to challenge or correct actions, tasking, and decisions which place the aircraft in marginal or unauthorized flight conditions. The crew is reluctant to offer assistance and, when assistance is offered, it may be ignored.
- 10 Other: Aircrew coordination task errors not adequately defined by codes 01-09.

2.2 DRC DEVELOPED MEASURES OF CREW COORDINATION

The same basic framework developed and used by DRC to formulate measures of crew coordination on Delivery Order 0001 of this contract was utilized in this Delivery Order. The framework imposed a structure for our approach to develop procedures intended to aid accident investigators to identify aircrew coordination task errors and related system inadequacies.

The first step to develop investigation procedures was to generate an investigator's checklist (see Appendix A of Tab E). Checklist items were grouped under each task error category listed above. Items associated with each task error category were written using guidance provided by the:

- Linkages Between Beliefs-Attitudes-Behaviors (Table 2-1),
- Resource Integration for Crewed System (RICS) Model (Figure 2-1),
- ACE Checklist and its Behaviorally Anchored Rating Scales (see Final Technical Report: Development of Measures of Crew Coordination, 31 August 90), and
- Proposed revisions to ATM tasks (see Final Technical Report: Development of Measures of Crew Coordination, 31 August 90).

In addition to identification of the task errors, system inadequacies were defined to identify the underlying causes that permit a task error to become an accident cause. Since effective crew coordination is a product of the relationship between beliefs, attitudes, and behaviors, it was determined that the system inadequacies should be linked to the behavioral objectives delineated in column four of Table 2-1. Each of the four behavioral objectives of aircrew coordination were translated into negative phrases to create the system inadequacies. Finally, a matrix of the most common relationships between aircrew coordination task errors and system inadequacies was developed to assist the investigator to link task errors and system inadequacies (Table 2-2).

2.3 DA Pam 385-95

DA Pam 385-95 was used to determine the format and structure of the aircrew coordination accident investigator Handbook. This format and structure was used to facilitate future incorporation of the Handbook into a potential revision of DA Pam 385-95. The proposed Handbook does not change any of USASC's existing procedures or techniques. It is simply designed to provide specific procedures for identifying a new category of task errors and system inadequacies related to aircrew coordination.

2.4 TRAINING

DRC was tasked to provide aircrew coordination accident investigation techniques and procedures training to USASC investigators. A complete Program of Instruction (POI) was developed and delivered under separate cover in June 1990. As part of this effort DRC provide classroom instruction to USASC investigators. To ensure that all investigators had an opportunity to attend, three complete courses were given. Class dates were 27 & 29 June 1990, and 5 July 1990. A total of 20 individuals received aircrew coordination accident investigation training. Tab A includes DRC's report on the USASC accident investigator training.

2.5 VALIDATION

Validation of the Aircrew Coordination Accident Investigators Handbook was accomplished by accompanying USASC investigation teams on actual investigations and through feedback from USASC. Tabs B,C, and D contain reports of those investigations and recommended modifications to the draft Handbook.

As a result of the actual investigations three modifications were made to the Handbook. They are as follows:

- a. A contributing factor code of "Possible (P)" was added in the event that investigators could not document with factual evidence that an aircrew coordination error contributed to the accident, but suspect that it may have.
- b. Duty position codes were expanded to allow for reporting of task errors made by individuals that have a direct interaction with the aircrew, but are not part of the on-board aircrew.
- c. Aircrew coordination task error 09 (lack of assertiveness) was slightly modified to include "excessive dominance" on the part of a crew member. The third investigation pointed to the fact that often lack of assertiveness and excessive dominance are simultaneously present. To check this, DRC looked at reports of other aviation accidents and found that both factors *are* often present so the definition was duly modified.

One of the three investigations involved serious injuries and fatalities. Although it was determined that aircrew coordination errors were not causation factors, the fact that one could reasonably determine the presence or absence of aircrew coordination errors without interviewing key aircrew members contributed to the validation of the techniques and procedures within the Handbook.

During the first session of classroom training USASC investigators questioned documentation of aircrew coordination information on DA Form 2397-3R. Their main concern was that paragraphs 1, 2, and 3 of the form are releasable under the Freedom of Information Act. They suggested that since aircrew coordination information requires a judgement on the part of investigators, perhaps it should not be included within the paragraphs. However, in the remaining training sessions USASC investigators did not anticipate any problems with including the aircrew coordination information in these paragraphs. Subsequently, instructions for completion of the aircrew coordination portions of paragraphs 1 and 2 were submitted to the Director of the Investigations Directorate for official USASC comments. As a result of this action, items requiring a subjective judgement were moved from paragraphs 1 and 2 to paragraph 4.

The main concern during classroom training, actual investigations, and discussions with USASC personnel is that current regulations, ATMs, field manuals, etc. do not sufficiently define specific aircrew coordination duties. The point was also made that without proper authorization, techniques and procedures outlined in the Handbook could not be utilized. Both these points are important. It is our understanding that ARI and USASC are taking steps to address these concerns and are continuing to transition aircrew coordination considerations into the mainstream of Army aviation doctrine, training, flight operations, and accident investigations.

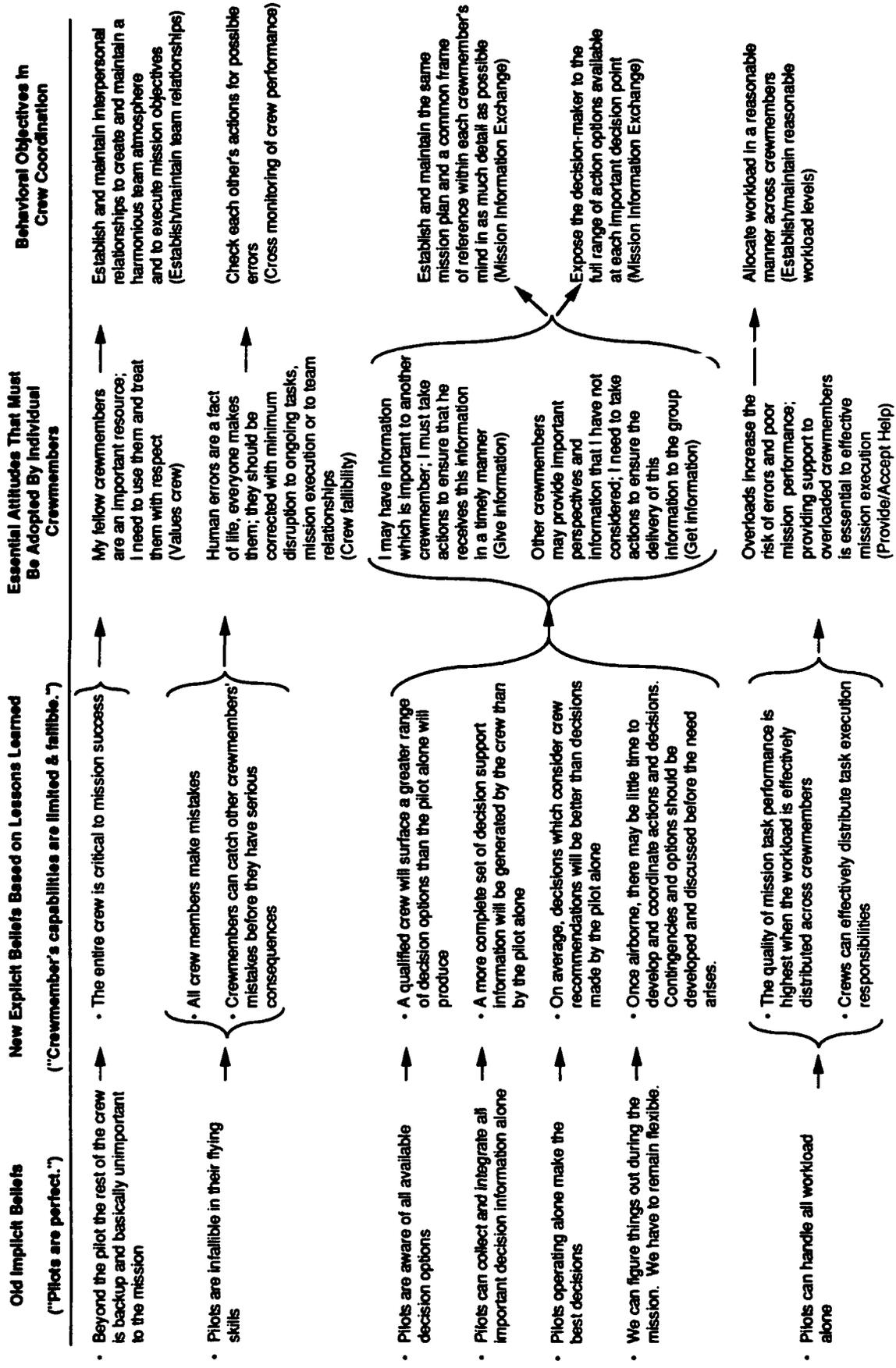


TABLE 2-1

LINKAGES BETWEEN BELIEFS - ATTITUDES - BEHAVIORS

SYSTEM INADEQUACIES

- TASK ERRORS**
- 01 Lack of positive communication technique (transmission, acknowledgement, or confirmation) using standard terminology with specific qualifiers
 - 02 Failure to announce decisions or actions that affect other crew members' duties or performance
 - 03 Failure to properly assign clearance responsibilities during pre-mission briefing or to direct clearing assistance during a critical maneuver
 - 04 Failure to appropriately distribute workload by directing a non-flying crew member to provide assistance in monitoring airspeed, altitude and engine power; to perform required actions inside the cockpit; or to assume a transfer of the controls
 - 05 Failure to anticipate or offer assistance or information required by the flying crew member
 - 06 Assuming control of the aircraft or making control inputs without positive transfer of controls
 - 07 Failure to allow sufficient time for another crew member to perform a directed action
 - 08 Inappropriately directing a non-flying crew member to a lower priority task
 - 09 Lack of Assertiveness or Excessive Dominance: Failure of a crew member to challenge or correct actions, tasking, and decisions which place the aircraft in marginal or unauthorized flight conditions. The crew is reluctant to offer assistance and, when assistance or information is offered, it may be ignored
 - 10. Other: Aircrew coordination task errors not adequately defined by codes 01-09

	CS101 Inadequate mission information exchange	CS102 Inadequate workload prioritization/distribution	CS103 Inadequate cross monitoring of crew performance	CS104 Inadequate team relationships
01	X			
02	X			X
03	X	X		
04		X		
05	X		X	X
06	X		X	
07	X		X	
08	X	X		
09	X		X	X
10	X	X	X	X

TABLE 2-2

TASK ERROR AND SYSTEM INADEQUACY MATRIX

SECTION 3 - HANDBOOK OVERVIEW

3.0 GENERAL

This section provides an overview of the aircrew coordination accident investigator handbook.

3.1 RESPONSIBILITIES

The Board President of each USASC accident investigation team has overall responsibility for the accident investigation report. However, since aircrew coordination errors are human errors, it is the primary responsibility of the board member assigned the human factors portion of the investigation to identify and document aircrew coordination errors. Normally he will be assisted by an on-site flight surgeon and a SIP or IP. It is his duty to brief the assigned members concerning identification and documentation of aircrew coordination task errors. During the investigation, the SIP or IP and the flight surgeon must be cognizant of the type of errors that fall within the realm of aircrew coordination and be able to identify them as such.

3.2 DOCUMENTATION FORMS

In order to provide for documenting present and contributing, and present but not contributing aircrew coordination factors during investigations it was necessary to create a supplement to DA Form 2397-2-R (Figure 3-1). The supplemental form does not change any of the existing sections of the current form, but adds Part III B for documentation of aircrew coordination factors. Block 1 of Part III B is identical to Block 1 of Part III, DA Form 2397-2-R. Block 2 (summary.) It is similar in format, but is designed to specifically accommodate crew coordination causation factors, system inadequacies and remedial measures. Coding information provided in Block 2 of the supplemental form will provide structure for a database. The database, when established, will allow analysts to detect trends and recommend specific actions to eliminate or reduce aircrew coordination errors as accident causation factors.

Since aircrew coordination entails an interaction between crew members, it is possible that there may be two task errors for each finding. Provisions are made in the supplemental form to allow for the recording of primary and secondary aircrew coordination task errors.

DA Form 2397-3-R is the only other form affected when aircrew coordination errors are identified during the accident investigation. It was not necessary to modify this form. Instructions for completing both Part III B of 2397-2-R and the crew coordination paragraphs of 2397-3-R are included in the Handbook.

**TECHNICAL REPORT OF U.S. ARMY AIRCRAFT ACCIDENT
FOR CRM TEST PROJECT**

PART IIIB - FINDINGS AND RECOMMENDATIONS

1. FINDINGS AND RECOMMENDATIONS (Attach additional sheet, if required)

2. SUMMARY OF CRM ACCIDENT CAUSES, SYSTEM INADEQUACIES AND RECOMMENDATIONS

		CONTRIBUTING FACTOR	DUTY POSITION	MISSION PHASE	AC TASK ERROR CODE	SYSTEM INADEQUACIES	REMEDIES		
1.	CRM Error (Primary)								
	CRM Error (Secondary)								
2.	CRM Error (Primary)								
	CRM Error (Secondary)								
3.	CRM Error (Primary)								
	CRM Error (Secondary)								

3. CASE NUMBER

a. DATE (YYMMDD)	b. TIME	c. AIRCRAFT SERIAL NO.	

Figure 3-1

3.3 AIRCREW COORDINATION CODES

Except for remedial measure codes it was necessary to develop an entire set of new codes for completing Block 2, Part III B of the supplemental DA Form 2397-2-R. The new codes will, when incorporated into the Army Safety Management Information System (ASMIS), allow analysts to identify areas that should receive additional emphasis. The codes are structured to provide the following information without the requirement to review text or hard copies of accident reports:

- Pilot-In-Command
- If the pilot committing the error was on the controls or not on the controls
- Phase of mission during which the error was committed
- ATM task being performed at the time the error was committed
- Aircrew coordination task error committed
- Whether the error was primary or secondary
- Whether the error was present and contributing, present but not contributing, or possibly contributing but insufficient evidence was available during the investigation
- Aircrew coordination system inadequacy
- Recommended corrective action

3.4 PROCEDURES AND TECHNIQUES

The basic procedures and techniques presented in DA Pam 385-95 for aircraft accident investigations do not require modification to identify aircrew coordination errors. However, investigators must understand the type of errors that constitute aircrew coordination errors to identify them as such. Thus, the Handbook is designed to assist the investigator to identify aircrew coordination errors by providing explanations and examples. In addition, Appendix A of the Handbook contains an investigator's checklist that will help to highlight aircrew coordination errors. As explained in the witness interview technique section of DA Pam 385-95, the checklist is not intended for use during the interview. It is the responsibility of the investigator to answer each question after the interview. If an answer(s) is unknown, then he should seek additional factual information to obtain the answer(s).

USASC and ARI identified flight profiles when aircrew coordination errors most commonly occur. These profiles are also provided in the Handbook to alert the investigator to flight profiles during which there is a high probability of aircrew coordination errors occurring.

SECTION 4 - FUTURE ACTIONS and RECOMMENDATIONS

4.0 GENERAL

This section describes the actions remaining that are necessary to incorporate the products of this Delivery Order into the Army Safety Program.

4.1 TRAINING

It is recommended that USASC establish a block of instruction within the Safety Officers Course using the aircrew coordination accident investigation POI developed by DRC. Furthermore, as additional, untrained personnel arrive at USASC, internal training should be provided to investigators and analysts using the POI developed by DRC.

4.2 REVISION OF DA Pam 385-95

The result of this delivery order is a combination of the latest research in aircrew coordination with proven accident investigation techniques, thus enabling the Army to clearly identify aircrew coordination failures and develop countermeasures to mitigate their effect. It is recommended that USASC take steps to incorporate the aircrew coordination investigation procedures into DA Pam 385-95. This will provide authorization for both USASC and field investigation teams to use the products of this task.

4.3 ARMY SAFETY MANAGEMENT INFORMATION SYSTEM

To realize the full potential of this product it is of utmost importance to modify the Army Safety Management Information System (ASMIS) to accommodate the coding information generated when aircrew coordination errors are identified. Failure to include the information in ASMIS will result in the loss of data that may be used to improve mission effectiveness and enhance safety within Army aviation.

APPENDIX A

Report

USASC Investigator Training

MEMORANDUM

TO: ARIARDA

FROM: Gene Pawlik

DATE: 9 July 90

SUBJECT: Copy of Trip Report, Fort Rucker, AL; 25 June - 5 July 90

1. **PURPOSE OF TRIP:** To train US Army Safety Center (USASC) aviation accident investigators in the techniques of aircrew coordination (AC) and in the administration of the forms and proposed supplement to DA PAM 385-95 developed by DRC covering the investigation of AC failures as part of the Human Factors portion of the accident investigation.

2. **DATES:** 25 - 29 June and 5 July 90

3. **PERSONNEL CONTACTED:**

Mr. Dennis Dunn, Manager, DRC Enterprise Office
Dr. Dennis Leedom, Technical Team Leader, ARIARDA
LTC Charles Canon, Chief, Investigation Division, USASC
MAJ Kenneth Wood, Operations Representative, USASC

4. **SUMMARY OF VISIT:**

a. Worked out of the DRC Enterprise Office to finalize development of the ACT-AAI accident investigation workshop and scenarios. On 25 June 90, effected liaison with USASC to verify the number of students and to ensure that the classroom was prepared and unlocked for the first day of instruction. ACT-AAI training materials were delivered to Enterprise via FEDEX on 26 June 90 with the notebooks for the student handout arriving later that evening. Notebooks were then "stuffed" and final preparations completed for the first day of instruction. During the period 25 - 27 May, Mr. Dunn, the office manager, was on an accident investigation at Fort Riley, KS, in support of the effort to validate the AC accident investigation procedures developed by DRC.

b. On the first training day (27 June 90), five students initially reported with a sixth student arriving during the second hour of instruction. (ACT-AAI attendees are listed by name at Enclosure 1 for each of the three training sessions conducted). Training went very well for the first iteration of the course; and all activities were completed within the eight hours allocated. Initial reaction of the students was to get the recommended procedures, forms, and supplement into effect as soon as possible. Reasons for not doing so were explained; however, the students considered the AC approach vital to the human factors investigation and did not appreciate a parallel investigation resulting in additional work for the accident investigation board.

c. On 28 June 90, revisions recommended by the first group of students were made to the accident investigation workshop scenarios. Changes were finalized and posted to the student notebooks prior to the second day of instruction. Changes were also furnished to the first group of students to update their notebooks.

d. On the second training day (29 June 90), four students reported; however, one student had a prior commitment for that afternoon and was unable to attend the full day of training. Again the reaction from the students was to implement the AC system of investigation as soon as possible. One of the students was the president of the Fort Riley accident investigation board in which Mr. Dunn had participated to conduct validation of the new AC reporting requirements. His statement was that he had initially advised Mr. Dunn that there were no AC considerations in the accident. After talking over the accident with Mr. Dunn, he saw how there might be AC involvement. After attending the ACT-AAI, he said he was now convinced that AC failures were definitely involved in the accident and that, for him, the training had opened up a completely different way of looking at accident causality.

e. At the conclusion of the scheduled training period, only nine of the 20 investigation and support personnel initially planned for had been trained. A recommendation was therefore made by DRC to USASC Operations that, since the instructor would be on vacation in the Fort Rucker area through 6 July 90, consideration be given to conducting an additional class for those personnel who had been unable to attend the previous two sessions. The DRC recommendation resulted in a request by the Army on 3 July 90 to conduct an additional training session on 5 July 90.

f. On 4 July 90, four additional student notebooks were prepared to support the 5 July 90 training session. The additional notebook requirement resulted due to requests made by USASC investigation and educational specialist personnel for the training materials. In that student attendance had not matched forecasted requirements, the notebooks initially had been given away upon informal request; however, with the scheduling of an additional training session, the shortage resulted. This situation was corrected and 12 student notebooks were made available to support the third training day.

g. On 5 July 90, twelve students were scheduled for training; however, only ten students reported, one of whom was not able to attend the afternoon session. As with the previous two sessions, the students recommended that the AC elements of the human factors investigation be implemented as soon as possible. LTC Canon, the Chief of the Investigation Division, explained why this could not be done immediately and what his charter from the command level of the USASC was with respect to the new procedures. While this did not satisfy the students, they understood why the delay in implementation was in effect and that after the validation period was completed, they could most likely look forward to working with the AC reporting system.

5. CONCLUSIONS AND RECOMMENDATIONS:

a. Conclusions

(1) All objectives of the Aircrew Coordination Training for Aviation Accident Investigators (ACT-AAI) Course were accomplished.

(2) Student acceptance of the training materials and investigative techniques was outstanding. To restrict their implementation of the new concepts without stifling their enthusiasm was a difficult chore but one that was necessary to prevent the new codes from contaminating the current Army Safety Management Information System (ASMIS) data base.

(3) A problem was surfaced with the information recommended for inclusion in the History of Flight and Human Factors Investigation sections of the DA Form 2397-3-R. First, several items appeared to be judgmental, e.g., "whether or not the pilot in command established an atmosphere conducive to good crew coordination,"; and secondly, such judgements were generally tied to witness statements which are to be protected from freedom of information act (FOIA) requests because of their sensitive nature, especially if made under a promise of confidentiality. Placing such information in the "Analysis" section of the form would remove the witness statements from danger of release since that section is always excluded in a sanitized report, i.e., it contains conjecture, etc., used by the Board in reaching their findings and conclusions and is not releasable outside DOD.

(4) Support from USASC authorities resulted in all accident investigators and several technical support personnel being trained in AC principles with only two investigators not receiving instruction in the reporting procedures contained in the proposed supplement to DA Pam 385-95. This extremely high percentage of completed training among the accident investigators will provide more than ample expertise from which to draw as investigators are cycled through assignment to the USASC.

b. Recommendations

(1) That the ACT-AAI Course furnished to ARIARDA on 30 June 90, together with the changes made on-site during the conduct of accident investigator training, be accepted as the deliverable required by Delivery Order #0002, Task 8, of the ARI Research Support of MANPRINT Estimation Measures (RSMEM).

(2) That the information recommended for inclusion in the DA Form 2397-3-R sections covering the history of flight and human factors investigation be referred to the USASC legal officer for resolution.

6. ACTION ITEMS:

a. Incorporate any changes resulting from the USASC legal officer review into the ACT-AAI and furnish such changes to ARIARDA to update their copies of the training materials.

b. Support any USASC requests for clarification or elaboration of the ACT-AAI training materials during the validation phase of the proposed supplement to DA Pam 385-95. This action can be effectively accomplished through the services of Mr. Dunn during the three accident investigations to be supported by DRC.

1 Enclosure:

as

ACT-AAI ATTENDEES

Wednesday, 27 June 90

<u>Name</u>	<u>Grade</u>	<u>Phone</u>
Lovely, R.	GS12	(205) 255-3262
Wilkins, B.	GS12	"
DeCurtis, J.	MW4	"
Revert, M.	MW4	"
James, W.	MW4	6510
Valle, P.	GS13	3943
Kennamore, J.	GS12	6585

Friday, 29 June 90

Rendzio, R.	CW4	3262
Royer, L	O4	4198 (1/2 day)
Phillips, G.	O5	3262
Toothman, R.	CW4	"

Thursday, 5 July 90

Wenrich, J.	GS12	3262
Mynard, D.	GS12	"
McMahan, B.	O4	"
Ault, T.	CW4	"
Rotolo, D.	O4	"
Mathis, N.	CW4	" (1/2 day)
Knause, C.	GS12	"
Canon, C.	O5	3493
Myrick, J.	CW4	3262
Owens, E.	O4	"

Note: 20 students completed the course; 2 did not due to 1/2 day attendance.

Enclosure 1

APPENDIX B

Report

UH-1V Accident Investigation

Fort Riley, Kansas

TO: Dr. Dennis K. Leedom
FROM: Mr. Dennis J. Dunn
SUBJECT: Aircrew Coordination Accident Investigation
DATE: 3 July 1990

1. At approximately 0900 hours, 26 June, I was notified of an aircraft accident at Fort Riley, KS. that possibly involved aircrew coordination errors. I arrived on site at 1800 hours and received a preliminary briefing from the accident investigation board. Interviews were conducted with the PF and the PNF on 27 June. As a result of these interviews three possible primary crew coordination errors were identified. The remainder of this day was spent reviewing documentation and holding discussions with board members. Mr. John Stewart joined us at approximately 1500 hours and was briefed on the accident and data gathered up to that point. On 28 June, John and I interviewed the crew chief and medic that were a part of the aircrew.

2. As a result of the data gathered and interviews with all aircrew members it was determined that a primary and secondary on-board aircrew coordination task error possibly contributed to the accident. An indepth investigation revealed that the other two primary errors initially identified as possibly present were not factors in this accident. A 2397-2-R, Technical Report of U.S. Army Aircraft Accident for CRM Test Project, is attached. In addition, a 2397-3-R (narrative account of investigation) is also attached.

3. The primary purpose of the trip was to validate the aircrew coordination investigator handbook recently completed by DRC. Results are as follows:

a. Present codes for Block 2, Contributing Factor column, are "Y" for Yes and "N" for No. From this accident investigation it is apparent that the accident board will not always be able to document with factual evidence that an aircrew coordination error did or did not contribute to the accident. Therefore, it is recommended that a code P (Possible) be included for those cases where an aircrew coordination error may have been a contributing factor but facts, circumstances, and the available evidence do not clearly support a definite contributing finding.

b. The aircrew coordination investigator handbook needs to be expanded to allow for reporting task errors made by individuals that have a direct interaction with the aircrew but are not a part of the on-board aircrew. This accident was clearly the result of coordination/communication errors committed by individuals relaying landing instructions to the aircrew from the ground. Attachment 1 is the recommended change to the aircrew investigator handbook.

ATTACHMENT 1

6.0 CODES:

6.1 DUTY POSITION CODES:

*CODE	DUTY POSITION
PF	Pilot Flying
PNF	Pilot Not Flying
ADC	Approach/Departure Controller
AMC	Air Mission Commander
CE	Crew Chief/Flight Engineer
CET	Combat Equipped Troops/Jumpers
FCO	Flight Leader
G	Gunner
GCA	Final Controller
GC	Ground Guide/"Follow Me"
O	Aircraft Observer
OAY	Others Aboard Aircraft
TO	Technical Observer
TWC	Tower Personnel

* When using the codes "PF" and "PNF" an asterisk should be entered in front of the code for the individual who was the PIC.

Normally the PF, PNF, and the CE will be the individuals involved in committing aircrew coordination errors. The other individuals indicated in the above codes, while not an integral part of the aircrew, may commit coordination errors while interacting with the aircrew that influence the accident. While these errors are not considered to be aircrew coordination errors they will be reported in the same manner.

6.2 MISSION PHASE CODES:

A	Mission Planning	J	Approach
B	Aircraft Preflight	K	Autorotation
C	Taxi	L	Go-around
D	Takeoff	M	Landing
E	Hover, IGE	N	Low Level
F	Climb	O	Contour
G	Cruise	P	NOE
H	Combat maneuver	Q	OGE hover
I	Descent	R	After landing



**DYNAMICS
RESEARCH
CORPORATION**

119 Laurel Breeze Rd., Enterprise, AL. 36330 Telephone (205) 393-3270 FAX (205) 393-4685

TO: Dr. Dennis K. Leedom
FROM: Mr. Dennis J. Dunn
DATE: 10 July 90
SUBJECT: Aircrew Coordination Accident Investigation

Attached are the revised narrative, finding, and recommendations for the UH-1V accident at Ft. Riley. The revision incorporates the changes proposed for the Aircrew Coordination Accident Investigator Handbook as a result of the validation process.

TECHNICAL REPORT OF U.S. ARMY AIRCRAFT ACCIDENT FOR CRM TEST PROJECT

PART IIIB - FINDINGS AND RECOMMENDATIONS

1. FINDINGS AND RECOMMENDATIONS (Attach additional sheet, if required)

FINDING 1 (Present and Contributing)

During the hours of darkness, while directing the landing of a MAST helicopter to a confined area approach, the ground controller (a local sheriffs deputy) failed to use specific qualifiers which resulted in a wire strike and the loss of a helicopter. The intent of the deputy was to have the helicopter crew make the approach at 90 degrees to a road bed, landing between two sets of vehicles lighting the intended landing site. However, when the deputy told the crew to land in front of the first lights and the flight path was parallel to the road, the approach was continued straight ahead to the road and to the front of the first set of lights (a flare behind one set of vehicles). The sheriffs deputy's instructions were not clear, and the on-board aircrew did not realize until post crash that their intended landing point and the expected landing point were not the same. The inadequate information exchange would have been avoided had the deputy told the on-board aircrew to land east to west (90 degrees to road), between the two sets of vehicle lights illuminating the intended landing area.

RECOMMENDATION 1:

a. Unit Level Actions: Commander, 82nd Medical Detachment, 4th Battalion, 1st Brigade inform assigned personnel of facts and circumstances of this accident.

b. Higher Level Actions: Commander, 4th Battalion, 1st Brigade and higher level commands ensure that a training program is in place and that training is being completed for the civil populace that is expected to work as a team with U.S. Army helicopter aircrews during MAST operations.

c. Army Level Actions: USASC publish the fact and circumstances of this accident in Flight FAX.

2. SUMMARY OF CRM ACCIDENT CAUSES, SYSTEM INADEQUACIES AND RECOMMENDATIONS

		CONTRIBUTING FACTOR	DUTY POSITION	MISSION PHASE	AC TASK ERROR CODE	SYSTEM INADEQUACIES	REMEDIES		
a.	CRM Error (Primary)	Y	ADC	J1031	01	CS101	U06	H02	A06
	CRM Error (Secondary)								
b.	CRM Error (Primary)								
	CRM Error (Secondary)								
c.	CRM Error (Primary)								
	CRM Error (Secondary)								

3. CASE NUMBER

a. DATE (YYMMDD)	b. TIME	c. AIRCRAFT SERIAL NO.
900624	0122	7422354

**TECHNICAL REPORT OF U.S. ARMY AIRCRAFT ACCIDENT
FOR CRM TEST PROJECT**

PART III B - FINDINGS AND RECOMMENDATIONS

1. FINDINGS AND RECOMMENDATIONS (Attach additional sheet, if required)

FINDING 2 (Present and possible contributing)

During a night approach to a confined area the *PNF did not provide required obstacle clearing assistance to the PF. During the most critical part of the maneuver (short final) the *PNF was diverting his attention to a less critical crew task of radio communication (inadequate workload prioritization). As a result, the *PNF did not see the single strand wire crossing the approach path in sufficient time to allow the PF to take effective evasive action. However, the medic seated behind the *PNF, saw the wire by looking over the shoulder of the *PNF and called out a warning prior to actual contact with the wire. Since the *PNF had a better field-of-view and viewing angle than the medic, it is possible that he may have seen the wire in time to allow for effective evasive action.

The PF, fully cognizant that the *PNFs attention was inside the aircraft, erred by not directing/requesting that the *PNF direct his attention to the task of providing obstacle clearance during the critical part of the maneuver. The task error committed by the PF was also a result of inadequate workload prioritization. That is, he allowed the *PNF to remain inside the aircraft instead of requesting assistance with obstacle clearance during a night confined area approach.

RECOMMENDATION 2:

- a. Unit Level Actions: Commander, 82nd Medical Detachment, 4th Battalion, 1st Brigade inform assigned personnel of how inadequate workload prioritization may have contributed to this accident.
- b. Higher Level Actions: Commander, 4th Battalion, 1st Brigade and higher level commands ensure that increased emphasis is placed on unit crew coordination training.
- c. Army Level Actions: USASC publish the fact and circumstances of this accident in Flight FAX.

2. SUMMARY OF CRM ACCIDENT CAUSES, SYSTEM INADEQUACIES AND RECOMMENDATIONS

		CONTRIBUTING FACTOR	DUTY POSITION	MISSION PHASE	AC TASK ERROR CODE	SYSTEM INADEQUACIES	REMEDIES		
a.	CRM Error (Primary)	P	*PNF	J1031	05	CS102	U06	H02	A06
	CRM Error (Secondary)	P	PF	J1031	03	CS102	U06	H02	A06
b.	CRM Error (Primary)								
	CRM Error (Secondary)								
c.	CRM Error (Primary)								
	CRM Error (Secondary)								

3. CASE NUMBER

a. DATE (YYMMDD)	b. TIME	c. AIRCRAFT SERIAL NO.	
900624	0122	7422354	

This narrative account of the investigation is not a complete narrative. The following paragraphs contain information pertinent only to crew coordination.

1. History of Flight

a. Preflight Phase. Due to the nature of MAST missions, general mission planning and crew coordination are briefed when a crew is designated to be on call. When the crew of this flight came on duty the PIC used a checklist to ensure that all necessary pre-mission information was discussed. When notified of the mission in which the accident occurred, the crew worked as a team and accomplished required tasks. The atmosphere surrounding the entire crew was conducive to good crew coordination.

b. Flight Phase. Although there was not a great deal of discussion concerning mission details (flight procedures) there were no maneuvers performed that the on-board aircrew did not expect. During the enroute flight to the intended landing area the PF made the comment that he was somewhat familiar with the landing site and that there was the possibility of wires in the area. Aircrew team relationships were good.

2. Human Factors Investigation

a. Personnel Background Information. The PIC, (PNF) 1st Lt. Frame, had received formal crew coordination training in IERW and AMED. He had also been in attendance at Professional Officer Development meetings in which aircrew coordination was a topic of discussion. 1st Lt. Frame did not have any medical or personal problems that affected individual performance.

The Copilot (PF), CW2 Holden, stated that the only aircrew coordination training he had received was through Professional Officer Development meetings. CW2 Holden did not have any medical or personal problems that affected individual performance.

The ground controller (sheriffs deputy) was inexperienced and had not received any type of training concerning direct interaction with military helicopter aircrews.

b. Personnel Management. As stated above, the unit conducted Professional Officer Development meetings in which aircrew coordination was a topic of discussion. Commercial aviation films were shown depicting aircrew coordination errors that were accident causation factors in the commercial sector.

3. Material Factors Investigation

Material factors investigation is not applicable to aircrew coordination

NARRATIVE ACCOUNT OF INVESTIGATION (Continued)

4. Analysis

a. After analyzing the human factors data collected during the accident investigation it was concluded that inadequate communication between the deputy and the on-board aircrew was the primary causation factor in this accident. It was also concluded that on-board aircrew coordination was a possible contributing factor in this accident. The rationale for these decisions are as follows.

(1) While issuing landing instructions to a military aircrew for a night confined area approach the ground controller (sheriffs deputy) failed to use specific qualifiers which resulted in a wire strike causing the loss of a UH-1V helicopter. The deputy having verified visual contact with the helicopter instructed the aircrew to land in front of the first set of lights. What he actually intended was for the helicopter to land between two sets of vehicle lights with an approach path 90 degrees to the road. The aircrew being on a flight path parallel with the road, sighted flares to the rear of the vehicles closest to them and continued a straight-in approach. Based on the aircrew's interpretation of the instructions received from the deputy sheriff the aircrew's intent was to touch down just short of the flares which would have been to the front of the first set of lights. Had the deputy's instructions been clear the approach path would have been clear of obstacles which would have eliminated the main causation factor in this accident.

(2) During short final (below 50 feet AGL) of a night, confined area approach the *PNF was concentrating on radio frequencies and reporting arrival at the landing site to unit operations. His attention was inside the aircraft instead of performing the more crucial task of providing obstacle clearance information to the PF. The failure to provide obstacle clearance information was due to inadequate workload prioritization on the part of the *PNF in that he was focusing on the minor task of notifying unit operations instead of being outside the aircraft at a critical point in the flight.

The PF also erred by not specifically requesting the *PNF to prioritize his tasks and place emphasis on providing obstacle clearance. The PF had previously commented that he knew the landing site was in close proximity to wires, but made no specific request for support during the night confined area approach though he was fully cognizant of the obstacle possibilities and the fact that the *PNF was directing his attention inside the aircraft. It was concluded that the PF's error was also a result of inadequate workload prioritization. He did not request assistance during a time when his workload was such that he was unable to provide obstacle clearance in the sector that would have normally been the responsibility of the *PNF.

After analysis of all the facts it was concluded that the primary crew coordination error was committed by the *PNF and the error committed by the PF was a secondary error. This conclusion is based on the fact that in accordance with FM 1-204, page 4-11, para. 4-14 d (3), it is the copilot's (PNF) duty to provide information about obstacle avoidance, altitude, airspeed, and approach angle during night approaches and the fact that the *PNF was also the pilot-in-command for this flight.

APPENDIX C

Report

**CH-47D Accident Investigation
Fort Campbell, Kentucky**

MEMORANDUM

TO: Dr. Dennis K. Leedom
FROM: Mr. Dennis J. Dunn
DATE: 30 July 1990
SUBJECT: Fort Campbell CH-47D Accident

1. The CH-47D accident on 24 July, 1990 at Fort Campbell, Ky. was investigated to determine if crew coordination errors were a factor. After analyzing the facts available, it was determined that crew coordination was not a factor in this accident.
2. The following is the background, narrative and rationale for this decision:

a. BACKGROUND - The purpose of the flight was (1) NVG evaluation of the PF to attain RL1 status; (2) evaluation of the flight engineer assigned the responsibility of monitoring the sling load. The PF was an IP and the PNF was an SIP. Both aviators were relatively high time pilots and considered to be excellent pilots by other unit personnel. The SP4 flight engineer was being evaluated as a flight engineer by an NCO of a sister unit.

b. NARRATIVE - The crew of the accident aircraft was on reverse cycle and reported to duty at the assigned time. Mission planning and briefing were conducted as required. Prior to the flight the PF briefed the entire crew concerning the mission and individual responsibilities. The briefing was detailed and did cover obstacle clearance instructions and instructions for monitoring of the load with expected communications and emergency procedures. In addition, the flight engineer being evaluated was briefed by his evaluator concerning proper procedures and techniques. During the initial briefing between the PF and PNF, the PNF did mention to the PF that on previous flights she had a tendency to be a little too hot on night approaches.

The aircraft was flown to the training site and dropped off the hook up man. They then picked up the approximately 15,000 pound external load and made a normal takeoff. The mission plan called for several traffic patterns to be flown. The first traffic pattern was a fly-over without any approach being attempted. During the second traffic pattern the approach was made and the load was unhooked and rehooked. The SIP then took control of the aircraft and flew a third pattern to demonstrate the complete maneuver. During both these approaches 100 ft. AGL was called by the PF and the flight engineer called all required altitudes of the

load. After the demonstration, the IP took control of the aircraft and started the fourth traffic pattern. As they were flying the fourth pattern the PNF and the PF discussed and coordinated a slight adjustment to the traffic pattern which shortened the downwind leg. The PF called out 100 ft AGL and the flight engineer acknowledged and called out 75 ft AGL. Within a reported 5 to 7 seconds of the flight engineer calling out 75 ft. the load contacted the ground. Once the load contacted the ground the PNF was heard to say "what did we hit" followed by "I got the controls." Response time between the load hitting the ground and the aircraft contacting the ground was not sufficient for any corrective action to have been taken.

c. DECISION RATIONAL - The fact that the PNF did not say anything to the PF concerning aircraft altitude or rate of decent was considered as a possible crew coordination error. However, due to the circumstances of the mission and the role of on-board personnel and unexpected terrain features this error was considered an individual error and not a crew coordination error. That is, the PNF may have noticed a lower altitude or higher rate of decent than normal, but did not say anything because it was an evaluation ride and was waiting to see if the PF took corrective action. Unknown to the PNF was the fact that their adjustment to the traffic pattern placed an approximate 30 foot rise in terrain within their flight path. The load contacted the ground at the ridge line of the rising terrain. Had the flight path been the same as the previous approaches the accident probably would not have occurred. It was also determined that the rapidly rising terrain was the probable reason the flight engineer did not have a chance to call out the 50 ft. load height. Information sources were limited due to the seriousness of the injuries and fatalities involved. However, because of the items stated above and the fact that there was good crew coordination throughout the rest of the flight it was determined that crew coordination was not a factor in this accident.

APPENDIX D

Report

UH-60 Accident Investigation
Fort Hunter-Ligget, California



**DYNAMICS
RESEARCH
CORPORATION**

119 Laurel Breeze Rd., Enterprise, AL. 36330 Telephone (205) 393-3270 FAX (205) 393-4685

TO: Dr. Dennis K. Leedom
FROM: Mr. Dennis J. Dunn
DATE: 29 August 1990
SUBJECT: Fort Hunter Liggett UH-60A Crew Coordination Accident Investigation

The results of the investigation of the UH-60A Fort Hunter Liggett accident are attached. This report incorporates a change to the definition of task error 09. The proposed rewording of the task error is as follows:

09 Lack of Assertiveness or Excessive Dominance; failure of a crew member to challenge or correct actions, tasking, and decisions which place the aircraft in marginal or unauthorized flight conditions. The crew is reluctant to offer assistance and, when assistance or information is offered, it may be ignored.

This change will be incorporated into the final report due 19 September 1990. The definition will be modified throughout the report and this case will be included as an example.

Please provide any desired changes to the wording of this task error to DRC by 7 September to ensure incorporation into the final product.

TECHNICAL REPORT OF U.S. ARMY AIRCRAFT ACCIDENT FOR CRM TEST PROJECT

PART 111B - FINDINGS AND RECOMMENDATIONS

1. FINDINGS AND RECOMMENDATIONS (Attach additional sheet, if required)

FINDING 1 (Present and Contributing)

During the preflight briefing phase and the flight phase of a NVG training mission the *PF failed to brief, assign, or direct any crew coordination duties to other on-board aircrew members with the exception of transfer of controls and basic emergency actions. Failure to comply with sound aircrew coordination principals was a result of inadequate team relationships. The *PF stated that the PNF's flight skills were marginal, the crew chief could not be relied upon, and the gunner was a newly assigned 11B with very limited flight experience. Approximately 3 seconds prior to touchdown in an unimproved PZ the *PF ignored the crewchief's warning to pull up. The main gear of the UH-60 touched down and when the collective was lowered the aircraft started to roll backwards due to the severe slope of the terrain. Attempting to compensate, the *PF abruptly applied collective, at a high hover perceived a nonexisting emergency (tail rotor failure), then bottomed the collective causing a hard landing resulting in extensive damage to the aircraft.

RECOMMENDATION 1:

a. Unit Level Actions: Commander, B Company, 3rd regiment, 123rd Aviation Brigade inform assigned personnel of facts and circumstances of this accident.

b. Higher Level Actions: Commander, 123rd Aviation Brigade ensure that all subordinate aviation units emphasize the importance of aircrew coordination by periodically including aircrew coordination topics/training in monthly safety meetings.

c. Army Level Actions: USASC publish the fact and circumstances of this accident in Flight FAX.

2. SUMMARY OF CRM ACCIDENT CAUSES, SYSTEM INADEQUACIES AND RECOMMENDATIONS

		CONTRIBUTING FACTOR	DUTY POSITION	MISSION PHASE	AC TASK ERROR CODE	SYSTEM INADEQUACIES	REMEDIES		
a.	CRM Error (Primary)	Y	*PF	M1031	09	CS104	U06	H02	A06
	CRM Error (Secondary)								
b.	CRM Error (Primary)								
	CRM Error (Secondary)								
c.	CRM Error (Primary)								
	CRM Error (Secondary)								

3. CASE NUMBER

a. DATE (YYMMDD)	b. TIME	c. AIRCRAFT SERIAL NO.	
900816	2355	8524392	

NOTE: This report is part of a test project being administered by a civilian contractor for the Army Research Institute. It is NOT part of the official USASC accident investigation report.

This narrative account of the investigation is not a complete narrative. The following paragraphs contain information pertinent only to crew coordination.

1. History of Flight

a. Preflight Phase. The *PF and the PNF attended an 1830 field operation mission briefing for the mission of troop movement in support of the ongoing field problem. After the mission brief a through flight inspection was completed. The *PF had briefed the crew at the beginning of the field problem (3 days prior) concerning basic emergency procedures and control transfer. Clearance responsibilities and other crew duties were not briefed or discussed. The atmosphere surrounding the entire crew was not conducive to good crew coordination.

b. Flight Phase. Crew coordination was minimal during the flight. Although the *PF did transfer control of the aircraft to the PNF earlier in the mission the *PF did not effectively distribute the workload, utilize the crew to maintain situational awareness, nor give the impression that crew inputs were desired or used in the decision making process. Throughout the flight there was distrust (lack of confidence) between crew members which made each crew member an individual rather than a team player.

2. Human Factors Investigation

a. Personnel Background Information. The *PF, CW2 Calloway, records do not reflect that he received any formal aircrew coordination training. CW2 Calloway was involved in a previous accident that was determined by the USASC and ARI study to be caused by aircrew coordination factors. CW2 Calloway did not have any medical or personal problems that affected individual performance.

The PNF, CPT. Hyde, records also do not reflect that any aircrew coordination training had been received. CPT. Hyde, did not have any medical or personal problems that affected individual performance.

The Crew Chief, SPC Wisdom, had four years of aviation experience, but no reported aircrew coordination training. At the time of the accident he did not have any medical or personal problems that affected individual performance.

The Gunner, SPC Likes (an 11B), was attached to B Company for the purpose of providing a fourth crew member. SPC Likes had been attached to the unit since 1 June 1990. He had not received any crew coordination training or detailed briefing on duties normally expected of a gunner. He had 20 hours of flight time and no known medical or personal problems that affected individual performance. However, he had not received a crew member flight physical.

b. Personnel Management. The unit has no documentation of any unit aircrew coordination training.

3. Material Factors Investigation

Material factors investigation is not applicable to aircrew coordination

NOTE: This report is part of a test project being administered by a civilian contractor for the Army Research Institute. It is NOT part of the official USASC accident investigation report.

NARRATIVE ACCOUNT OF INVESTIGATION (Continued)

4. Analysis

a. After analyzing the human factors data collected during the accident investigation it was concluded that excessive assertiveness on the part of the *PF was the primary causation factor in this accident.

The rationale for this decision is as follows:

While attempting to land at an unimproved LZ, in near zero ambient light conditions, using NVGs the *PF did not heed the warning of the crewchief that the terrain to which they were making an approach was unsuitable for landing. The result was a hard landing, causing major structural damage to the helicopter. The reason for the *PF not responding to the crewchief's warning was due to inadequate team relationships. Inadequate team relationships were caused by the attitude of the *PF and his belief that his on-board crew had only marginal capabilities. A summary of the *PF's comments concerning the on-board crew follows:

- (1) PNF - The PNF was the company commander and flying skills (stick & rudder) were marginal at best.
- (2) Crewchief - The crewchief had tested positive for drugs and was not to be trusted. In addition the crewchief would only provide the information and services specifically requested.
- (3) Gunner - The gunner was a 11B attached to the unit, was not aviation oriented, and basically was excess baggage.

Interviews with all crew members and other unit personnel were conducted. As a result of these interviews the following comments are made concerning the skills of each crew member:

- (1) *PF - The *PF was considered a good pilot in regards to his ability to fly the aircraft. However, his attitude was that he was in charge and did not need nor necessarily want other crew members' input into the decision making process. Crew members were intimidated by his attitude and actions and were reluctant to provide inputs. Unit personnel who were interviewed and who had flown with him on previous missions perceived that their inputs were ignored and that decisions were made based solely on the *PF's judgement. This is supported by a previous Class C accident report where the *PF ignored a ground guide's signal to stop and consequently hit the tail rotor of a parked aircraft with his main rotor.
- (2) PNF - At this time the post crash evaluation ride results are not known. However, the interviews indicate that the PNF may be marginal in his flying skills.

NOTE: This report is part of a test project being administered by a civilian contractor for the Army Research Institute. It is **NOT** part of the official USASC accident investigation report.

NARRATIVE ACCOUNT OF INVESTIGATION (Continued)

(3) Crewchief - Interviews indicated that the crewchief is extremely knowledgeable concerning his duties as a crewchief and also as an aircraft mechanic. Supervisors indicate that he is probably one of the best crewchiefs in the company. He previously tested positive for drugs during a Panama deployment, but charges were dropped. Supervisors seemed to think that if the positive test was actually positive it was due to the fact that the local Panama populace was lacing drinks with drugs.

The crewchief had two additional drug tests in the year following the positive test and did not test positive on either. The interviews indicate that the *PF's attitude and beliefs towards the crewchief are unfounded and inaccurate.

(4) Gunner - Through no fault of his own the gunner was inexperienced and unknowledgeable concerning gunner duties. He had not been briefed and was unaware of the fact that his duties included clearing the aircraft to the rear and down. In addition, he was not aware that he should have been checking to ensure security of passengers and cargo. During the interview the impression was formed that had he been properly trained and briefed he would have performed his duties and been a valuable member of the on-board aircrew team.

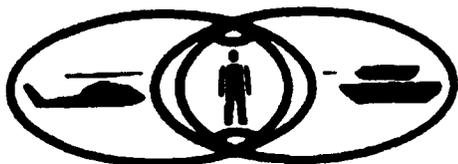
After analysis of all the facts it was concluded that the crew chief did clear the aircraft properly and reported the hazard in time to allow the *PF sufficient time to react and avoid the accident. Therefore the primary causation factor in this accident is attributed to the *PF's failure to react to, and utilize information provided by other crewmembers.

NOTE: This report is part of a test project being administered by a civilian contractor for the Army Research Institute. It is **NOT** part of the official USASC accident investigation report.

APPENDIX E

Aircraft Accident Investigator Handbook

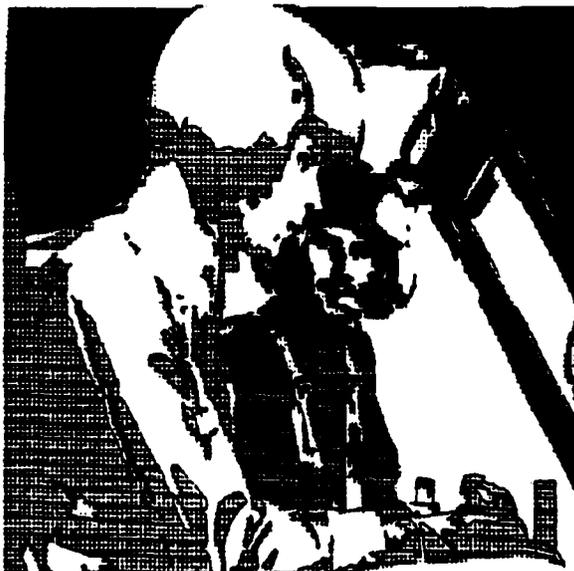
Aircrew Coordination Aspects of the Human Factors Investigation



U.S. ARMY SAFETY CENTER



**AIRCREW COORDINATION ASPECTS
OF THE
HUMAN FACTORS INVESTIGATION**



AIRCRAFT ACCIDENT INVESTIGATOR HANDBOOK



**DYNAMICS
RESEARCH
CORPORATION**

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1.0 INTRODUCTION

USASC and ARI reviewed 596 Class A, B, and C aircraft accident case histories occurring from FY 1984 through FY 1989. The review indicated that aircrew coordination errors may have been a contributing factor in 130 cases. Each of these 130 cases was subjected to an indepth analysis which revealed that aircrew coordination errors were a factor in 88 of the cases (15% of all reported Class A, B, and C accidents). Furthermore, a trend analysis showed that aircrew coordination errors increased in FY 89 whereby they were a factor in 37% of all reported A, B, and C accidents. In the past, aircrew coordination errors were merged into existing human factors errors and not specifically identified. As a result, emphasis has not been placed on eliminating the systemic causes of poor aircrew coordination. To rectify this problem, specific aircrew coordination task errors and systemic causes were identified and targeted for emphasis to reduce these types of errors.

2.0 GENERAL

2.1 PURPOSE

This document provides guidance, format and other information required to identify and document aircrew coordination task errors resulting in or relevant to aircraft accidents.

2.2 WITNESS INTERVIEW TECHNIQUES

Refer to Chapter 4, DA Pam 385-95, for witness interviewing techniques.

2.3 DUTIES AND RESPONSIBILITIES

It is the primary duty and responsibility of the USASC Human Factors board member to identify and document aircrew coordination task errors. To assist him in this task, other board members, especially the SIP or IP and the flight surgeon, should be briefed concerning the identification and documentation of aircrew coordination task errors. During the investigation, the SIP or IP and the flight surgeon must be cognizant of the type of errors that fall within the realm of aircrew coordination and be able to identify them as such.

3.0 AIRCREW COORDINATION TASK ERRORS

3.1 DEFINITION

Aircrew coordination is the interaction between crewmembers (communications) and actions (sequence or timing) necessary for flight tasks to be performed efficiently, effectively, and safely. Therefore, aircrew coordination errors are defined as those errors which occur due to a lack of coordinated activities on the part of the aircrew. If an error does not involve a coordination (interaction) failure, it is not an aircrew coordination error. Errors that do not involve coordination (interaction) are classified as individual human errors. Aircrew coordination task errors will generally be described by one of nine task error (TE) codes listed in paragraph 6.3. A tenth aircrew coordination task error code, "OTHER", is provided for those aircrew coordination task errors not otherwise defined. Aircrew coordination task errors are defined in detail, together with examples, in Appendix B.

3.2 IDENTIFYING AIRCREW COORDINATION TASK ERRORS

As with other types of human error, the first step in identifying aircrew coordination task errors is to develop a chronology of events occurring before and during the accident flight. A Cockpit Resource Management (CRM) Checklist (Appendix A) is provided to assist the investigator in ensuring that adequate data is obtained during the field investigation. Prior to leaving the field, the investigator should be able to answer each item in the checklist. Since the best (and sometimes the only) source of information for aircrew coordination task errors is the flight crew, accidents in which there are no survivors present a difficult situation for the investigator. In this case, substantiation of an aircrew coordination task error may not be possible. However, the investigator may be able to determine possible aircrew coordination task errors through a review of tower, ATC, or cockpit voice recordings; or through conducting interviews with tower operators and unit personnel.

3.3 OPERATIONAL PROFILES

Eight operational profiles have been identified, from the case history studies, where aircrew coordination task errors are most likely to manifest themselves. While these are not the only operational profiles where aircrew coordination task errors may occur, the probability of errors occurring increases while flying these profiles. The profiles having high probability for aircrew coordination task errors are:

- (1) Tactical terrain missions at night.
- (2) Cruise phase of tactical terrain flight missions.
- (3) Crew briefings.
- (4) Night proficiency/transition missions.
- (5) Taxi phase of administrative/support missions.
- (6) Landing approach.
- (7) Hover ((Pilot not flying (PNF) not offering assistance to the pilot flying (PF)).
- (8) Hover (PF not properly directing clearing).

3.4 DEFINING AIRCREW COORDINATION TASK ERRORS

Defining aircrew coordination task errors requires the procedural steps stated in DA Pam 385-95, page 5-1. The procedural steps are:

- (1) Identification of the individual's duty position when the error occurred.
- (2)* The specific task or function the individual was performing and the phase of operation/flight when the error occurred.
- (3) An explanation of how that specific task or function was improperly performed.

(4) How the error was related to the accident.

* "Phase of operation/flight when the error occurred" is a modification of step (2) and is restricted solely to aircrew coordination error documentation.

3.5 AIRCREW VS. INDIVIDUAL ERRORS

As stated in the definition of aircrew coordination, an aircrew coordination task error must involve an interaction between two or more members of the crew. For example, an accident involving an obstacle strike may be caused by not directing or providing adequate clearance information -- this would be an aircrew coordination task error. However, it would be an individual error if the pilot flying (PF) misjudged the distance to the obstacle. While the dividing line between individual and aircrew coordination errors may be quite thin, the investigator should be able to distinguish between the two based on the facts of the specific accident being investigated. It should also be noted that since aircrew coordination errors involve two or more crew members, if one error has been committed, then it is quite likely that a second error is also involved. For example, there may be a failure to provide clearance as a primary error; the secondary error is a failure to request or direct clearance. Provisions have been made for recording both primary and secondary errors. Figure 1 provides an example of an accident in which both primary and secondary aircrew coordination task errors were present.

3.6 CAUSES OF AIRCREW COORDINATION TASK ERRORS

Adequate performance of aircrew coordination is a function of certain attributes of aircrew members including 1) personality, 2) skills (including flying skills and coordination skills), and 3) attitudes that promote an inclination to incorporate aircrew coordination in the cockpit. When the right mix of personality, skills, and attitudes are not present, the aircrew is prone to commit aircrew coordination errors. Currently, one of the major contributing factors for shortfalls in the attributes mentioned above is the fact that crew responsibilities are not adequately addressed in AR 95-1, Operator's Manuals, School POIs, ATMs, or SOPs.

3.7 SYSTEM INADEQUACIES

The Army has extended its definition of an effective pilot to include knowledge and skills in the area of cockpit resource management (CRM) techniques. Table 1 shows the linkages between the old and new beliefs, the new attitudes the Army wants to instill in aviators, and the expected behaviors necessary for effective aircrew coordination. For purposes of accident investigations, the behaviors listed in the far right column directly lead to the four aircrew coordination system inadequacies.

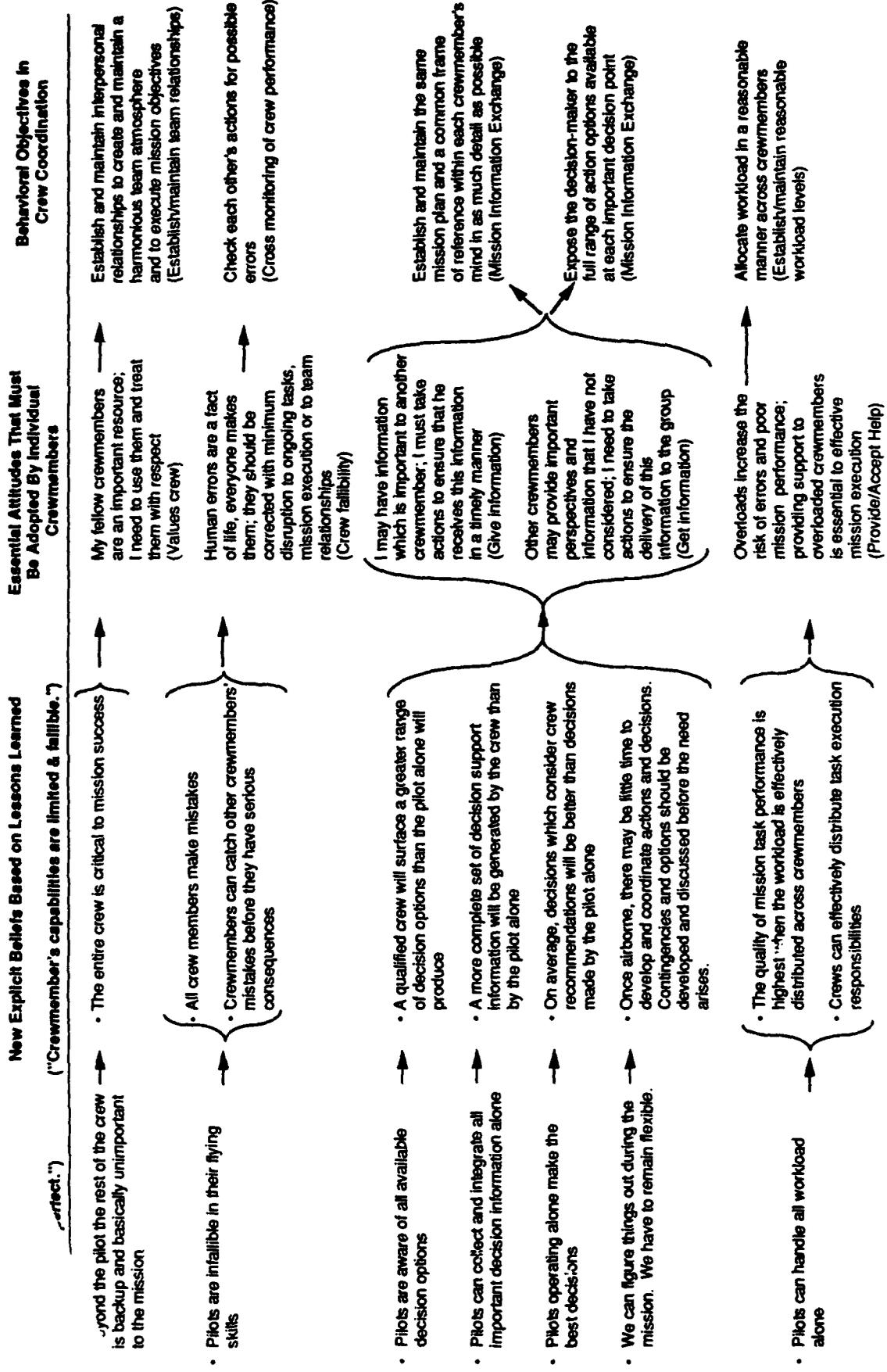


TABLE 1

LINKAGES BETWEEN BELIEFS - ATTITUDES - BEHAVIORS

4.0 TECHNICAL REPORT OF US ARMY AIRCRAFT ACCIDENT FOR CRM TEST PROJECT (CRM TEST FORM)

4.1 DOCUMENTATION OF AIRCREW COORDINATION TASK ERRORS

Aircrew coordination task error findings and recommendations are documented on the Technical Report of US Army Aircraft Accident for CRM Test Project (CRM Test Form) (Figure 1). This form is virtually identical to the current DA FORM 2397-2-R with the exception of the coding information in Block 2. Block 2 information will be used to provide structure for a database that will allow analysts to detect trends and recommend specific actions to eliminate or reduce aircrew coordination errors. The form allows for the coding of present but not contributing aircrew coordination errors. Since present but not contributing aircrew coordination task errors have a high potential for causing future accidents, it is as important for the analyst to consider these types of errors as it is to consider those errors which are present and contributing. A listing of duty position codes, mission phase codes, aircrew coordination task error codes, and system inadequacy codes is contained in paragraph 6. Definitions, examples and criteria are in Appendices B and C. Investigators should use the same remedial measure codes as those in DA Pam 385-95, page 8-16.

4.2 INSTRUCTIONS FOR COMPLETING BLOCK 1, FINDINGS AND RECOMMENDATIONS

Instructions for completing Block 1 are in DA Pam 385-95, Paragraph 8-6, Page 8-10.

- (1) Instructions for reporting findings. There may be more than one task error for each finding. As shown in Figure 1, the pilot not flying (PNF) made the primary aircrew coordination task error and the pilot flying (PF) made the secondary aircrew coordination task error. In the event that primary and secondary errors are present, the investigator must determine which error was primary and which was secondary. Provisions are made in Block 2 for recording both primary and secondary task error codes.
- (2) Instructions for reporting recommendations: Recommendations should be reported in the manner specified in DA Pam 385-95, Page 8-13.

TECHNICAL REPORT OF U.S. ARMY AIRCRAFT ACCIDENT FOR CRM TEST PROJECT

PART IIIB - FINDINGS AND RECOMMENDATIONS

1. FINDINGS AND RECOMMENDATIONS (Attach additional sheet, if required)

FINDINGS 1 - PRESENT & CONTRIBUTING:

During a maintenance test flight autorotational RPM check, abnormal vibrations were encountered during power recovery. The *PF (a maintenance test pilot) made the decision to continue the autorotation due to the vibrations. The PNF, also a unit IP, was concerned that the *PF might pull too much collective during final deceleration and placed his hand on the collective. As a result, the collective movement of the *PF was restricted causing the aircraft to fall through and land hard. The PNF erred by the unannounced restriction of the *PF's control inputs. The *PF failed to properly prebrief the PNF on actions expected in the event an emergency situation was encountered during the test flight.

RECOMMENDATIONS:

- a. Unit Level Actions: Unit commander (1) ensure that all unit pilots are aware of the facts and circumstances surrounding this accident. (2) Ensure that adequate emphasis is placed on aircrew coordination throughout the unit.
- b. Higher Level Actions: Bn Commander (1) ensure that all pilots are aware of the facts and circumstances surrounding this accident. (2) Ensure that aircrew coordination techniques and procedures are periodically emphasized in unit monthly safety meetings.
- c. Army Level Actions: (1) TRADOC take action to improve and/or increase aircrew coordination training in aircrew courses. (2) USASC evaluate adequacy of aircrew coordination training taught in safety officers course. (3) USASC publish facts and circumstances surrounding this accident in Flight FAX.

2. SUMMARY OF CRM ACCIDENT CAUSES, SYSTEM INADEQUACIES AND RECOMMENDATIONS

	CONTRIBUTING FACTOR	DUTY POSITION	MISSION PHASE	AC TASK ERROR CODE	SYSTEM INADEQUACIES	REMEDIES		
CRM Error (Primary)	Y	PNF	K2038	06	CS101	U06	H02	A01 A06
CRM Error (Secondary)	Y	*PF	A1071	04	CS102	U06	H02	A01 A06
CRM Error (Primary)								
CRM Error (Secondary)								
CRM Error (Primary)								
CRM Error (Secondary)								

3. CASE NUMBER

a. DATE (YYMMDD)	b. TIME	c. AIRCRAFT SERIAL NO.	
90/06/25	0815	70-81042	

Figure 1

4.3 REPORTING PRESENT BUT NOT CONTRIBUTING AIRCREW COORDINATION TASK ERROR FINDINGS

Although present but not contributing findings may not have contributed to the specific accident under investigation, they have a high potential for causing future accidents. Therefore, present but not contributing findings will be reported and coded the same as present and contributing findings. "Possible" contributing findings will also be reported in the same manner.

4.4 INSTRUCTIONS FOR COMPLETING BLOCK 2, SUMMARY CODE FIELDS

Aircrew coordination task error and system inadequacy codes are listed below in paragraphs 6.3 and 6.4, respectively.

- (1) **Contributing Factor** - Enter "Y" for yes, "N" for no, or "P" for possible depending on role of the error in relation to the causation of the accident. Entries are required for both primary and secondary errors, if present.
- (2) **Duty Position** - Enter the duty position of the crewmember making the error. Use the duty position codes listed in paragraph 6.1
- (3) **Mission Phase** - A two-part, alphanumeric code consisting of one alpha and four numeric characters. The first character (alpha) is a code corresponding with the mission phase during which the aircrew coordination task error was made. These Alpha codes are listed in paragraph 6.2. The second four characters (numeric) correspond to the number of the ATM task that was being performed at the time the aircrew coordination task error was committed. ATM task numbers are listed in the applicable aircraft ATM. Entries are required for both primary and secondary errors, if present.
- (4) **Aircrew Coordination Task Error** - Aircrew coordination task error codes will be entered for both primary and secondary errors, if present. Codes are listed in paragraph 6.3. Aircrew coordination task error Code 10 (Other) will be used when the aircrew coordination task error is not adequately defined by aircrew coordination task error codes 01 - 09.
- (5) **System Inadequacies** - System inadequacy codes are listed in paragraph 6.4. If more than one system inadequacy exists for the aircrew coordination task error, enter all applicable codes in the block provided. System inadequacies are explained in Appendix B.
- (6) **Remedies** - Enter appropriate codes for Unit, Higher Level, and DA level remedial measures. Remedies should be reported in the same manner specified in DA Pam 385-95, page 8-16.

4.5 INSTRUCTIONS FOR COMPLETING BLOCK 3, CASE NUMBER

Enter the same case number used on the DA Form 2397-1-R.

5.0 AIRCREW COORDINATION NARRATIVE ACCOUNT OF INVESTIGATION (DA Form 2397-3-R

5.1 GENERAL

In addition to current requirements stated in DA Pam 385-95, paragraph 8-7, a specific aircrew coordination narrative will be completed for all aircraft accidents requiring a technical report in accordance with AR 385-40.

5.2 INSTRUCTIONS FOR COMPLETION

Aircrew coordination narrative will be included on DA Form 2397-3-R as follows:

(Note: Only additions to current instructions are given)

- (1) **History of Flight**
 - (a) **The Preflight Phase.** For accident investigation purposes, the preflight phase includes all activities from the time of mission notification until the crew begins the aircraft ENGINE START procedures. Describe aircrew coordination during the preflight phase, indicating the extent that distribution of workload, assignment of clearance responsibilities, and the mission plan were discussed.
 - (b) **The Flight Phase.** Flight phase includes activities from the time ENGINE START procedures are begun until termination of the aircraft accident sequence. State crew coordination procedures for entire flight. Include comments on aircrew situational awareness, decision making, workload distribution, and information management.
- (2) **Human Factors Investigation**
 - (a) **Personnel Background Information.** Indicate if individual aircrew member had received any aircrew coordination training and, if so, what training had been received. When explaining crewmember irregularities concerning personal and medical well being, state each crewmember's awareness as to other crewmembers' personal or medical problems that may have affected individual performance.
 - (b) **Personnel Management.** In reporting how the unit managed individual training and tasking, report in detail any unit training or other classes concerning aircrew coordination. If no unit training or classes were conducted on aircrew coordination, so state.
- (3) **Materiel Factors Investigation.** Not applicable to aircrew coordination task errors.
- (4) **Analysis.** Provide a detailed explanatin of all aircrew coordination task errors and system inadequacies identified during the investigation. Also indicate whether or not the pilot-in-command established an atmosphere conducive to good crew coordination.

6.0 CODES:

6.1 DUTY POSITION CODES:

*CODE	DUTY POSITION
PF	Pilot Flying
PNF	Pilot Not Flying
ADC	Approach/Departure Controller
AMC	Air Mission Commander
CE	Crew Chief/Flight Engineer
CET	Combat Equipped Troops/Jumpers
FCO	Flight Leader
G	Gunner
GCA	Final Controller
GC	Ground Guide/"Follow Me"
O	Aircraft Observer
OAY	Others Aboard Aircraft
TO	Technical Observer
TWC	Tower Personnel

* When using the codes "PF" and "PNF" an asterisk should be entered in front of the code for the individual who was the PIC.

Normally the PF, PNF, and the CE will be the individuals involved in committing aircrew coordination errors. The other individuals indicated in the above codes, while not an integral part of the aircrew, may commit coordination errors while interacting with the aircrew that influence the accident. While these errors are not considered to be aircrew coordination errors they will be reported in the same manner.

6.2 MISSION PHASE CODES:

A	Mission Planning	J	Approach
B	Aircraft Preflight	K	Autorotation
C	Taxi	L	Go-around
D	Takeoff	M	Landing
E	Hover, IGE	N	Low Level
F	Climb	O	Contour
G	Cruise	P	NOE
H	Combat maneuver	Q	OGE hover
I	Descent	R	After landing

6.3 AIRCREW COORDINATION TASK ERRORS

Aircrew coordination task errors and corresponding codes are listed below. Task error, "Other" (Code 10), is used for aircrew coordination task errors not covered by any of the other nine task errors listed below (Appendix B contains detailed definitions and examples of the aircrew coordination task errors).

- | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>01 Lack of positive communication technique (transmission, acknowledgement, confirmation) using standard terminology with specific qualifiers.</p> <p>02 Failure to announce decisions or actions that affect other crew members' duties or performance.</p> <p>03 Failure to appropriately assign clearance responsibilities during pre-mission briefing or to direct clearing assistance during a critical maneuver.</p> <p>04 Failure to properly distribute workload by directing a non-flying crew member to provide assistance in monitoring airspeed, altitude, engine power; to perform required actions inside the cockpit; or to assume a transfer of the controls.</p> <p>05 Failure to anticipate and offer assistance or information required by the flying crew member.</p> | <p>06 Assuming control of the aircraft or making control inputs without positive transfer of controls.</p> <p>07 Failure to allow sufficient time for another crew member to perform a directed action.</p> <p>08 Inappropriately directing a non-flying crew member to a lower priority task.</p> <p>09 Lack of assertiveness or excessive dominance; failure of a crew member to challenge or correct actions, taskings, and decisions which place the aircraft in marginal or unauthorized flight conditions. The crew is reluctant to offer assistance and, when assistance or information is offered, it may be ignored.</p> <p>10 Other: Aircrew coordination task errors not adequately defined by codes 01-09.</p> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

6.4 SYSTEM INADEQUACY

The aircrew coordination system inadequacy codes are listed below. A matrix identifying the most common relationships between aircrew coordination task errors and system inadequacies is provided in Table 2. While the relationships shown in Table 2 are not the only relationships possible, they are the most common. Appendix C contains detailed definitions and criteria for system inadequacies.

CODE	SYSTEM INADEQUACY
CSI01	- Inadequate mission information exchange
CSI02	- Inadequate workload prioritization/distribution
CSI03	- Inadequate cross monitoring of crew performance
CSI04	- Inadequate team relationships

6.5 REMEDIAL MEASURE

Use the remedial measure codes for aircrew coordination system inadequacies that are used for other types of system inadequacies (DA Pam 385-95, page 8-16).

SYSTEM INADEQUACIES

- TASK ERRORS**
- 01 Lack of positive communication technique (transmission, acknowledgement, or confirmation) using standard terminology with specific qualifiers
 - 02 Failure to announce decisions or actions that affect other crew members' duties or performance
 - 03 Failure to properly assign clearance responsibilities during pre-mission briefing or to direct clearing assistance during a critical maneuver
 - 04 Failure to appropriately distribute workload by directing a non-flying crew member to provide assistance in monitoring airspeed, altitude and engine power; to perform required actions inside the cockpit; or to assume a transfer of the controls
 - 05 Failure to anticipate or offer assistance or information required by the flying crew member
 - 06 Assuming control of the aircraft or making control inputs without positive transfer of controls
 - 07 Failure to allow sufficient time for another crew member to perform a directed action
 - 08 Inappropriately directing a non-flying crew member to a lower priority task
 - 09 Lack of Assertiveness or Excessive Dominance: Failure of a crew member to challenge or correct actions, tasks, and decisions which place the aircraft in marginal or unauthorized flight conditions. The crew is reluctant to offer assistance and, when assistance or information is offered, it may be ignored
 - 10. Other: Aircrew coordination task errors not adequately defined by codes 01-09

	CS101 Inadequate mission information exchange	CS102 Inadequate workload prioritization/distribution	CS103 Inadequate cross monitoring of crew performance	CS104 Inadequate team relationships
01	X			
02	X			X
03	X	X		
04		X		
05	X		X	X
06	X		X	
07	X		X	
08	X	X		
09	X		X	X
10	X	X	X	X

TABLE 2

TASK ERROR AND SYSTEM INADEQUACY MATRIX

APPENDIX A

CRM ACCIDENT INVESTIGATION CHECKLIST

The following checklist is provided to assist the investigator in determining what types of questions need to be answered as part of the process of identifying and categorizing aircrew coordination errors.

1. **Lack of positive communication technique (transmission, acknowledgement, or confirmation) using standard terminology with specific qualifiers.**

Were communications among crew members:

- a. Clear and concise, using standard terminology
- b. Specific, in terms of exact expectations
- c. Timely
- d. Verified
- e. Clarified when ambiguous
- f. Of a sufficient amount throughout all mission phases.

2. **Failure to announce decisions or actions that affect other crew member's duties or performance.**

Were decisions and actions:

- a. Announced by the PF (time permitting) if he performed a maneuver that was not expected by other crew members.
- b. Announced by crewmembers when they intended to divert their attention away from one mission critical task to another task.
- c. Announced by crewmembers to inform others of changes to their attention focus (especially during transitions between inside and outside the cockpit).
- d. Verified by affected crewmembers.

3. **Failure to properly assign clearance responsibilities during the pre-mission briefing or to direct clearing assistance during a critical maneuver.**

Were clearance responsibilities or clearance assistance:

- a. Anticipated, discussed and assigned during the context of the pre-mission briefing
- b. Anticipated, discussed and assigned so that crew members knew the details of the flight and knew when clearance responsibilities were critical
- c. Clearly requested by the PF during the flight
- d. Clearly assigned during night unaided, NVG conditions and other critical flight situations.

- 4. Failure to appropriately distribute workload by directing a non-flying crew member to provide assistance in monitoring airspeed, altitude and engine power; to perform required actions inside the cockpit; or to assume a transfer of the controls.**

Was workload distribution:

- a. Discussed during the pre-mission briefing.
- b. Clearly established during the pre-mission briefing so that inside and outside the cockpit responsibilities were clearly understood by the crew.
- c. Allocated so that the PNF provided the PF with in-the-cockpit information during the flight.
- d. Clearly transitioned throughout the flight, e.g., was positive control transfer accomplished prior to PF diverting his attention inside the cockpit.
- e. Reasonably allocated so that no one crewmember assumed an undue amount of the workload. (Was there any evidence of an "I can do this myself" attitude on the part of an individual crewmember.)
- f. Effectively re-distributed to avoid task saturation by any one crewmember.
- g. Effectively re-distributed to maintain situation awareness when a problem with a subsystem occurred, when a task required an unnatural reach, or attention was diverted to investigate a problem.

- 5. Failure to anticipate and offer assistance or information required by the flying crew member.**

Did the non-flying crew members:

- a. Anticipate requirements of the PF and offer assistance or information.
- b. Recognize PF task saturation and assist by providing information.
- c. Offer to perform lower priority tasks that might normally be within the realm of the PF.
- d. Communicate and offer information/assistance when an error or discrepancy was noticed.

- 6. Assuming control of the aircraft or making control inputs without positive transfer of controls.**

Did the pilots:

- a. Transfer control through two way verbal exchange prior to the PNF making control inputs.
- b. Visually confirm control transfer.
- c. Assume the controls simultaneously without announcement of intention by PNF.
- d. Experience any confusion as to who had control of the aircraft.

- 7. Failure to allow sufficient time for another crew member to perform a directed action.**

Did the crew:

- a. Allow sufficient time for other crew members to perform directed or procedural tasks.
- b. Respond in a timely manner to pre-planned or directed verification for clearance.

8. Inappropriately directing a non-flying crew member to a lower priority task.

Was task prioritization directed:

- a. By the PF for crew members to perform the most critical task for the situation.
- b. By other crewmembers so as to focus attention of a fellow crewmember on a task when he/she should have been performing a more critical task.
- c. So that all critical tasks were allocated and performed.
- d. So that nuisance events were deferred to a lower workload period.

9. Lack of Assertiveness or Excessive Dominance; failure of a crew member to challenge or correct actions, tasking, and decisions which place the aircraft in marginal or unauthorized flight conditions. The crew is reluctant to offer assistance and, when assistance or information is offered, it may be ignored.

Did:

- a. The PIC brief crew members to question the PF if they perceived a marginal or unauthorized flight condition.
- b. The crew practice the two challenge rule.
- c. The crew follow the most conservative response rule.
- d. A crew member demonstrate an anti-authoritarian attitude or blatant disregard for procedures while another crew member was aware of it.
- e. The crew demonstrate any of the following behaviors:
 - excessive professional courtesy
 - overconfidence in abilities
 - rank intimidation
 - lack of self-confidence
 - lack of assertiveness
 - impatience
- f. The pilot flying demonstrate a reluctance to consider information offered by other crew members.

10. Other:

Were there any task errors (present and contributing or present but not contributing) that fall within the parameters of crew coordination errors, but do not fall within one of the nine categories above?

APPENDIX B

TASK ERROR

DEFINITIONS AND EXAMPLES

1.0 AIRCREW COORDINATION TASK ERRORS

1.1 INTRODUCTION

The following problem areas have been identified from an in-depth analysis of U.S. Army rotary wing aviation accidents involving aircrew coordination errors. Each problem area is illustrated with brief narratives from the accidents to assist you in recognizing or distinguishing the types of errors which contribute to each area.

Please note that it is quite possible for the aircrews to be committing errors in the following areas throughout the entire flight. While such errors might reduce mission effectiveness, these errors would not necessarily translate into an accident. Such errors would translate into accidents only when there was insufficient time to identify and recover from the error and when the circumstances were unforgiving to the error. In general, however, an increase in the frequency of errors will reduce the aircrew's overall mission effectiveness and raise the potential for an accident.

Please note also that these problem areas refer to crew coordination errors, not individual flight skill deficiencies, poor individual judgement, or failure of an individual to follow established procedures. Such cases of individual error were excluded from consideration as aircrew coordination errors. The analysis of Army rotary wing aviation accidents revealed that a significant number of the accidents involved highly experienced aircrews. The problem areas arise because of interfering habit patterns and the failure of experienced aviators to effectively coordinate their actions in the cockpit.

1.2 DEFINITIONS AND EXAMPLES

TASK ERROR 01

Lack of positive communication technique (transmission, acknowledgement, or confirmation) using standard terminology with specific qualifiers

Definition:

Aircrew coordination requires positive communication among the crew members in order that each member has a common understanding of the state of the aircraft and the actions expected and required of each crew member. Variability in training and operational experience can lead individuals to interpret situations and procedures differently from one another. Failure to communicate in a positive manner can occur at any time of the flight; however, it is a particularly significant problem during maneuvers involving high workload. Misunderstandings can arise when one crew member either (1) assumes that the other crew members automatically understand what is happening or what is expected or (2) use incomplete, unfamiliar, or ambiguous phrases. Failure to verify that the other crew member has heard and correctly understood the communication can also contribute to this problem, particularly when the other crew members have focused their attention on other critical aspects of the flight. Likewise, habitual use of excessive professional courtesy (e.g., "you're a little fast") can lead to misunderstandings by not providing specific information needed to calibrate corrective actions. As seen from the accident examples, this type of problem is associated frequently with obstacle clearance tasks; however, it can arise with any aviator task requiring an exchange of information among crew members.

[Note: Where appropriate, PF indicates pilot on the controls at the time of the accident; PNF indicates pilot not on the controls. These designations are generally used instead of "pilot" versus "copilot" since control of the aircraft may be transferred at different times in the flight. PC indicates pilot in command of the flight or mission. CE designates crew chief and FE designates flight engineer.]

Examples:

1.1 PNF (left seat) saw a tree on left side of the approach path to a confined area, but misadvised PF through use of non-specific "Don't turn left" warning. Still unaware of the trees, the PF allowed the main rotor blade to strike the tree. [UH-1H]

1.2 After the PNF (left seat) had initially cleared the left side while descending into an extremely small confined area, the PF directed him to monitor torque. The PNF interpreted this command to mean that clearing assistance was no longer needed.

The aircraft struck a tree on the left side. [UH-1H]

1.3 While flying NOE along a river, the PC (PNF) was concerned about not yet acquiring wires marked on a hazard map. Just as he instructed the PF to stop the aircraft, the CE saw another set of wires and called out "Wires!" without giving distance, direction, or clearance. The PF overreacted to the ambiguous warning with abrupt aft cyclic, causing the tail rotor to strike the water. [UH-1H]

1.4 After experiencing whiteout conditions in a hover taxi over snow, the PC (PNF) directed the PF to increase altitude. When whiteout conditions persisted, the PC twice directed the PF to "Move forward." However, the PF did not realize that the PC specifically wanted him to move forward at a faster speed so as to outrun the blowing snow. As a result, the PC assumed controls and overtorqued the engine to escape the blowing snow. [UH-1H]

1.5 Just prior to landing, the PC (PNF) noticed a slope at the intended touchdown point and announced "Slope." The PF acknowledged with "Roger" without understanding what was intended in the warning. As a result, the aircraft landed on the skid toes, causing the PF to induce a cyclic oscillation and strike the upper wire protection system with the main rotor blades. [UH-1H]

1.6 While touching down on a concrete pad in a confined area, the CE noticed that the aircraft's skids extended excessively over the rear edge of the pad. He directed the PF to "Move forward"; however, this warning was given without sufficient reason or urgency to divert the PF's attention to the problem. As the PF lowered the collective, the aircraft rocked backwards off of the pad. Subsequent overcontrol of the cyclic by the PF resulted in a dynamic rollover. [UH-1H]

1.7 The PF assumed the controls on a NVG mission over water after the PC (PNF) announced "I've had it, you got it." Not realizing that the PNF was temporarily incapacitated and unable to assist with altimeter callouts, the PF continued a left descending turn with the intention to level off at 50 feet AGL. After passing below 50 feet AGL, the PNF quickly called out altitude at 38 feet and again at 20 feet AGL. Finally, the PNF applied collective; however, the aircraft was descending too fast to avoid impacting the water. [UH-60A]

1.8 While conducting a NVG landing approach as Chalk 2 in a flight of 2 aircraft, the PNF, as directed by the unit trainer (PF), advised that the aircraft had descended to 100 feet AGL. The PNF noticed the aircraft continuing to descend; however, he failed to call out any further altitude readings until the aircraft was at 25 feet AGL. This last warning was insufficient to divert the PF's attention from tracking the perceived formation lights from the lead aircraft. Actually, the PF had been tracking a reflection of the formation lights from the water's surface, and he continued the descent until the aircraft impacted the water. [MH-6B]

TASK ERROR O2

Failure to announce decisions or actions that affect other crew members' duties or performance.

Definition:

In addition to requiring positive communication among crew members, aircrew coordination requires that individuals keep other crew members informed whenever they are about to take an action which will affect the duties or performance of the other crew members. Performing unexpected maneuvers or taking unexpected actions temporarily can diminish the contributions of other crew members or, at worst, can set up a counterproductive set of behaviors. [Note: Because of its significance to rotary wing flight operations, making aircraft control inputs without positive transfer of controls is distinguished as a separate problem area.] In a related manner, aircrews frequently must balance the attention given to a number of competing tasks and responsibilities. There usually exists an ordered priority among the tasks at any moment in time. An error occurs when one crew member, without informing other crew members, unilaterally defers or abandons a high priority task (e.g., obstacle clearance) for a lower priority task (e.g., making a non-critical radio frequency change). Such unilateral and unannounced actions can potentially jeopardize mission effectiveness and flight safety not only by diverting limited cockpit resources from the most critical task, but also by temporarily upsetting the required coordination of crew task assignments.

Examples:

2.1 The aircrew was ground taxiing at 10 feet AGL over a snow-covered portion of airfield toward a refueling point. Instead of assisting the PF in maintaining altitude over terrain which lacked visual references, the PNF turned his attention inside the cockpit to make a radio frequency change and transmission. The PF lost visual reference and allowed the aircraft to descend into the snow, causing a dynamic rollover. [UH-1V]

2.2 While on an approach to a remote site, the PF noticed 4 feet high stakes in the landing area designated by the PC (PNF). Without informing the PNF, the PF brought the aircraft to a 35 feet AGL hover with the intention of sliding to the right and rear of the original site. Because the aircrew had also failed to properly confirm adequate power through an OGE hover check, the PF lost directional control of the aircraft and crashed. [UH-1H]

2.3 The PF was maintaining a low hover on sloping terrain since there was not sufficient main rotor blade clearance to land. Without informing the PF, the CE diverted his attention from terrain clearance duties to assist passengers in disembarking the aircraft --despite the availability of other personnel to assist the passengers. The PF subsequently drifted into the slope and struck the main rotor blades against the terrain. [UH-1H]

2.4 While in terrain flight, the PF (left seat) initiated a right turn without announcing his intention or requesting clearance assistance from the PNF (right seat). The PNF had his attention inside the cockpit for map navigation, and the CE was also seated on the left side of the aircraft. Subsequently, the aircraft's main rotor blades struck a tree on the right side of the aircraft. [UH-60A]

2.5 While initiating a climb-out after takeoff on a NVG mission, the aircrew saw the master caution light illuminate. The PF switched the panel lighting from NVG to DIM mode, while the PNF began to scan the instruments to identify the problem. Without announcing his action or requesting the copilot to assume control of the aircraft, the PF diverted his attention inside the cockpit to assist in the problem diagnosis. While both the PF and PNF had their attention diverted inside the cockpit, the aircraft descended and impacted the ground. [UH-60A]

2.6 During terrain flight over the desert (50 feet AGL and 90 knots), the PF noticed that the PNF's attention was diverted to the rear cabin. Without querying the PNF or informing him of his interest, the PF diverted his own attention from flying to investigate the distraction. When the PF again directed his attention forward, he noticed that the aircraft had lost considerable altitude. A subsequent aft cyclic control input caused the tail wheel of the aircraft to strike the ground. [UH-60A]

2.7 Flying as Chalk 1 in a night multi-ship mission, the PF was executing a 360 degree turn at 100 feet AGL in order to allow the other aircraft to join the formation. The PF directed the PNF to assist in clearing themselves from the rejoining aircraft. Hearing that their unit operations center was experiencing difficulty in making radio contact with the platoon leader, the PNF (without announcing his action) diverted his attention inside the cockpit and began to act a radio relay for the platoon. Subsequently, the aircraft descended and struck wires. [OH-58C]

2.8 During a NVG flight at 400 feet AGL, the aircrew experienced a low engine RPM warning signal. Without requesting the PNF to perform an engine cross check (required by the aircraft's technical manual), the PF erroneously assumed that an engine failure had occurred and began to set the aircraft up for a NVG autorotation. Without announcing his intentions, the PNF removed his goggles and turned on both the white landing light and the white cockpit lights. The landing light came on momentarily and burned out, leaving both crew members temporarily blinded. The subsequent autorotation was performed poorly because of degraded visual references and the aircraft struck the ground. [OH-58C]

TASK ERROR 03

Failure to properly assign clearance responsibilities during pre-mission briefing or to direct clearing assistance during a critical maneuver.

Definition:

A critical aspect of rotary wing operations is maintaining appropriate clearance from surrounding obstacles. The unique maneuverability of helicopters, combined with the high utilization of terrain flight tactics, frequently creates situations in which all available crew members must assist in obstacle clearance duties. Coordinated assistance is particularly required during night unaided or NVG conditions when visibility is severely degraded. Aircrew coordination requires that clearance responsibilities and procedures be clearly briefed to each crew member prior to takeoff. During the mission, it is also appropriate for the pilot on the controls to reiterate these responsibilities, to inform crew members of the relative demand for obstacle clearance assistance, and to direct specific clearance assistance in critical situations (e.g., approach to confined areas, taxiing near parked aircraft, slope operations). In some instances, it may become necessary also to direct the crew chief to occupy a specific seat location so that this individual is properly positioned to offer such assistance. Failure to properly assign clearance responsibilities can lead to situations in which the pilot on controls is relying exclusively upon his own limited visibility for avoiding nearby trees or aircraft. Accidents attributed to this type of error typically involve the aircraft striking an obstacle on the opposite side of the aircraft from the pilot on the controls. The frequency with which this aircrew coordination error occurs in rotary wing operations suggests that it be defined as a unique problem area.

Examples:

3.1 PF (right seat) was attempting to maintain a "wing" position in a 2-ship, 25 feet AGL flyover demonstration. The PF did not assign the PNF (left seat) any clearance responsibilities prior to takeoff, nor did he direct the PNF to assist in maintaining clearance with the other aircraft during the flyover. During this maneuver, the PF allowed the main rotor blade to underlap the main rotor blade of the other aircraft. The PNF advised the PF that they were too close to the other aircraft and the PF's subsequent right cyclic input caused the two rotor blades to mesh, resulting in the crash of both aircraft. [UH-1H]

3.2 Prior to a terrain flight mission to deliver troops and provide area orientation to the PNF, the PC (PF) failed to direct the PNF to provide any type of assistance. During the terrain flight, the PF became task saturated in a left turn maneuver and failed to use sufficient power for maintaining altitude. The aircraft subsequently struck a tree during the turn. [UH-1H]

3.3 Prior to practicing confined area landings as part of a 3-ship formation, the PC (PF) failed to assign any clearance responsibilities to the CE. During one of the approaches, the CE was occupied inside of the aircraft tuning a LORAN-C navigational radio and was not providing clearance assistance. The aircraft's main rotor blades subsequently struck a tree during the approach. [UH-1H]

3.4 Prior to approaching a sloped area with marginal clearance for the main rotor blade, the PF failed to advise the CE that continual assistance was required in clearing the main rotor blades. During the hovering off-load operations the CE ceased clearing assistance and started to assist the passengers in disembarking from the aircraft. The aircraft's main rotor blades subsequently drifted into the sloped terrain. [UH-1H]

3.5 Prior to practicing fast rope operations on a NVG mission, the PC failed to advise the CE of the proper procedure for insuring that troops were clear of the ropes prior to takeoff. During the actual operation, the CE improvised the procedure by looking underneath the aircraft to clear the ropes on the opposite side of the aircraft. The last troop was delayed leaving the opposite side of the aircraft and was hidden by the aircraft's structure when the CE announced to the PF "Ropes clear." The aircraft ascended with one troop still clinging to the rope. The troop subsequently fell from the rope and was killed. [UH-60A]

3.6 Prior to taking off at dawn on a terrain flight mission, the PC (PF) failed to assign clearance responsibilities to a newly rated PNF. Both pilots had noticed a tactical antenna near the intended flight path; however, the PNF did not provide any clearance assistance during the takeoff. During the takeoff, the antenna became obscured against the dark terrain and was struck by the aircraft as the PF initiated a right climbing maneuver. [OH-58A]

3.7 Prior to a search and rescue mission, the PC (PF) failed to brief a proper division of responsibilities for maintaining obstacle clearance while the other crew member performed ground search. Subsequently, the aircraft's tail rotor struck a tree while both the PF and PNF simultaneously attending to the ground search. [OH-58A]

TASK ERROR 04

Failure to appropriately distribute workload by directing a non-flying crew member to provide assistance in monitoring airspeed, altitude and engine power; to perform required actions inside the cockpit; or to assume a transfer of the controls.

Definition:

There exist a number of instances where the pilot on the controls requires assistance from another crew member in monitoring flight parameters or performing required actions inside the cockpit. The general requirement for such assistance should be discussed during the pre-mission briefing, while specific requirements should be reiterated prior to entering difficult maneuvers or flight phases. During night unaided or NVG missions (when the flying pilot's attention must be kept outside the cockpit), assistance is required in monitoring and calling out flight parameters during certain types of approaches or descent maneuvers. Failure to properly use the coordinated assistance of other crew members can produce a situation in which the flying pilot becomes task saturated, lacks critical information, or becomes overly reliant upon his own degraded visual system for maintaining aircraft control. Anytime during terrain flight, the flying pilot should first direct a positive transfer of controls to the other pilot before diverting his own attention to a problem or task inside the cockpit. Alternatively, there exist a number of instances in which other crew members should be utilized to investigate a problem or perform a required subsystem task –specifically, those requiring the flying pilot to extend themselves in an unnatural reaching position or those requiring the flying pilot to divert his attention from a critical flight control task. A characteristic attitude displayed in this type of crew coordination failure is "I can do this myself!" Consequently, pilots experienced in aircraft typically requiring only one rated crew member are susceptible to this problem when faced with unusually demanding circumstances (e.g., NVG flight, terrain flight).

Examples:

4.1 Prior to making a NVG steep approach to an intended landing area, the PC (PF) failed to direct the PNF to assist in monitoring and calling out airspeed and altitude. Relying only upon degraded visual references, the PF failed to establish an appropriate descent rate and closure rate and allowed his aircraft to strike a UH-60 parked near the intended landing site. [UH-1H]

4.2 The PC (PF) was attempting a NVG running landing on snow in order to join up with three other aircraft already in the landing zone. Instead of directing the PNF to assist in monitoring and calling out airspeed and altitude, the PF relied upon degraded visual references to control his approach. Landing with excessive speed, the PF was unable to arrest the skid before the main rotor blades struck one of the parked aircraft. [UH-1H]

4.3 The PC (PF) assumed the controls from the PNF after the PNF had experienced difficulty in correctly aligning a night, unaided approach to a poorly illuminated landing zone (landing zone was obscured by background lights from a nearby town). Instead of directing the PNF to assist in monitoring and calling out airspeed and altitude, the PC relied upon degraded visual references to control his approach. The PNF called out "Watch your closure," but was unable to provide sufficient warning before the aircraft descended into trees and crashed. [UH-60A]

4.4 After flying more than two hours under NVG conditions, the PNF announced that he was too tired to continue on the controls during a search and rescue mission. The PC (PF) assumed the controls, but failed to (1) determine if the PNF was able to provide further assistance and (2) direct the PNF to assist in terrain flight map navigation and obstacle avoidance. Continuing with the mission, the PF attempted a terrain flight approach along a valley to an intended landing site. Subsequently, the aircraft struck a set of high tension wires extending across the approach valley. [UH-60A]

4.5 Prior to attempting a "quick rope" troop off-loading demonstration, the aircrew had experienced several malfunctions of the aircraft's stabilator. This type of malfunction normally can be handled by the PNF assisting with a resetting of the stabilator control switch. Despite this recent sequence of problems, the PC (PF) did not direct the PNF to be prepared for additional malfunctions. The stabilator again malfunctioned in a downward position during the low altitude deceleration pitch-up required for the "quick rope" maneuver. The malfunction sufficiently distracted the PF such that he failed to properly control the collective during the 70 degree pitch-up. The aircraft's tail hit the ground and the aircraft subsequently struck a tree. [UH-60A]

4.6 On a night, unaided mission over water, the PC (PF) assumed the controls at 100 feet AGL and attempted to maneuver underneath a thunderstorm. Without directing the PNF to assist in monitoring and calling out altitude, the PC began to perform a number of tasks simultaneously: instrument cross checks, radio calls, aircraft control, and reset of the force trim switch. The PC subsequently became task-saturated and allowed the aircraft to descend unnoticed into the water. [OH-58C]

4.7 During a NVG flight at 400 feet AGL, the aircrew experienced a low engine RPM warning signal. Without requesting the PNF to perform an engine cross check (required by the aircraft's technical manual), the PF erroneously assumed that an engine failure had occurred and began to set the aircraft up for a NVG autorotation. Without announcing his intentions, the PNF removed his goggles and turned on both the white landing light and the white cockpit lights. The landing light came on momentarily and burned out, leaving both crew members temporarily blinded. The subsequent autorotation was performed poorly because of degraded visual references and the aircraft struck the ground. [OH-58C]

TASK ERROR 05

Failure to anticipate and offer assistance or information required by the flying crew member.

Definition:

Problem Areas 4 and 5 highlight the failure of a crew member to direct assistance from another crew member during a critical maneuver or flight phase. Conversely, a reciprocal error can be involved when the other crew member is in a position to recognize that assistance ought to be given, but fails to either anticipate or offer the required assistance. Good aircrew coordination requires that each aviator maintain a peripheral awareness of the tasks being performed simultaneously by other crew members. Anticipating that another crew member is becoming task saturated or is lacking in certain information permits the aviator to serve as a backup which increases both safety and mission performance. This type of mutual reinforcement is critical during periods of high task workload (e.g., hovering, approaches, target acquisition) when the attention of a crew member might occasionally be overly focused on a particular aspect of the mission or the aircraft's performance. Conversely, failure to provide this mutual reinforcement leads to situations in which the overall performance of the aircrew is only as strong as the capacity of the weakest crew member.

Examples:

5.1 The PF was attempting to maintain a Chalk 2 position in a 4-ship hover taxi formation when the lead aircraft stopped in a stationary hover. The PF then experienced difficulty in arresting his own forward motion because (1) the formation was taxiing with a 9 knot tail wind and (2) the PF's cyclic control was restricted by his forward seat position. To avoid striking the stationary lead aircraft, the PF made an abrupt climb to 50 feet AGL and lost control of the aircraft. The PC (PNF), without any announcement, took control of the cyclic, temporarily stabilized the aircraft, but then released the cyclic. Subsequently, the PF was still unable to effectively establish control of the aircraft and permitted it to crash. [UH-1H]

5.2 The PF was attempting to maintain a 25 feet AGL hover in adverse weather over snow-covered terrain while awaiting the return of the mission's lead aircraft. Instead of offering assistance to the PF in maintaining their position in degraded visibility conditions, the PC (PNF) concentrated his attention inside the aircraft. The PF fixed his attention on the returning aircraft and allowed the aircraft to enter a descending rearward drift. The aircraft subsequently struck the ground before either pilot could detect and correct the drift. [JUH-1H]

5.3 The PC (PF) was in the process of handing a target off to an accompanying gunship while attempting to maintain a stationary low-altitude hover over tall grass. The PNF noticed the aircraft drifting right, but he to notify the PF of this fact. The aircraft continued to drift right, struck a hidden tree stump with its skids, and rolled over. [OH-58A]

5.4 The PF was attempting to make a NVG landing to a small shipboard landing deck that already contained another OH-58 helicopter. The PF failed to request clearing assistance from either the PC (PNF) or personnel aboard the other aircraft. Similarly, the PC (PNF) failed to anticipate the PF's need for clearance assistance and did not offer such assistance. The PF subsequently allowed the aircraft to drift into the other aircraft while maneuvering onto the landing deck. [OH-58D]

TASK ERROR 06

Assuming control of the aircraft or making control inputs without positive transfer of controls.

Definition:

A critical aspect of aircrew coordination is a clear and positive understanding at all times as to who has control of the aircraft. The crew member flying will always remain on the controls and keep flying the aircraft until a positive transfer of controls has been made. Conversely, the crew member not flying will refrain from making any control inputs until the controls have been relinquished through a positive transfer of controls from the other crew member. Positive transfer of controls consists of a two-way verbal exchange, "You have the controls," "I have the controls," followed by the relinquishing crew member visually verifying that the receiving crew member has physical hold on the controls. Failure to make a positive transfer of controls may result in a destabilized situation in which two crew members unknowingly interfere with one another or, at a minimum, produce erroneous feedback cues. During excessive or non-standard maneuvers, unannounced control inputs can represent a type of habit response—particularly for aviators who have instructor pilot experience or who otherwise may be used to "guarding" the controls. Contrary to what might be expected, having two crew members on the controls simultaneously occurs most frequently in side-by-side seating arrangements (e.g., UH-1) where it is easiest for each pilot to visually observe the other.

Examples:

6.1 The PF was attempting to maintain a Chalk 2 position in a 4-ship hover taxi formation when the lead aircraft stopped in a stationary hover. The PF then experienced difficulty in arresting his own forward motion because (1) the formation was taxiing with a 9 knot tail wind and (2) the PF's cyclic control was restricted by his forward seat position. To avoid striking the stationary lead aircraft, the PF made an abrupt climb to 50 feet AGL and lost control of the aircraft. The PC (PNF), without any announcement, took control of the cyclic, temporarily stabilized the aircraft, but then released the cyclic. Subsequently, the PF was still unable to effectively establish control of the aircraft and permitted it to crash. [UH-1H]

6.2 While making an "airspeed over altitude" takeoff from a confined area, the PF drifted right and struck trees. Without announcing his intentions or actions, the PC (PNF) assumed the controls with the intention to land the aircraft. Unaware of the PNF's actions, the PF remained on the controls and continued to attempt a takeoff. The subsequent conflicting control inputs resulted in the aircraft striking additional trees and impacting a large rock upon touchdown. [UH-1H]

6.3 Upon approaching a snow covered landing zone, the PF began to experience whiteout conditions from the blowing snow. The PF perceived a rearward drift and added forward cyclic to arrest the aircraft's motion. The PNF then perceived a nose-low attitude and, without announcing his intentions or actions, added aft cyclic. The subsequent conflicting control inputs induced a rocking motion and resulted in the aircraft's main rotor blades striking the aircraft's Upper Wire Protection System. [UH-1H]

6.4 While attempting a landing at a field refueling point, the aircrew experienced a compressor stall at an altitude of 40 feet AGL. The PF responsively entered autorotation. The PF and PNF then recognized that a loss of engine power had occurred. Without announcing his intentions or actions, the PC (PNF) assumed controls. The subsequent conflicting control inputs resulted in a failure of the PF to successfully execute the autorotation, and the aircraft was damaged upon impact with the ground. [UH-1H]

6.5 The PF was practicing night unaided landings to an inverted Y without the use of landing lights. Several earlier landings had occurred with excessive approach speed. On the final landing attempt, the PF allowed the aft portion of the aircraft's skids to impact the ground at an excessive rate of descent. The PF immediately increased the collective in an attempt to make another approach. Without announcing his intentions or actions, the PC (PNF) simultaneously attempted to lower the collective upon hearing a loud noise. The subsequent conflicting control inputs, culminating with a sudden release of the collective by the PF, resulted in the aircraft striking the ground a second time. The second impact with the ground sheared the aircraft's aft cross-brace. [UH-1H]

6.6 The PNF had made several successful NVG approaches to a confined area. Increasing clouds then reduced visibility and caused the unit trainer (PF) to abort a subsequent approach. Without directing the PNF to assist in monitoring instruments (specifically engine power), the unit trainer (PF) attempted another approach. Likewise, the PNF failed to anticipate the PF's need for assistance in monitoring the engine instruments and did not offer such assistance. The PF saw the ground at 10 feet AGL, but did not apply sufficient collective to slow the descent because of his concern about engine over-torque. The hard landing subsequently damaged the aircraft's skids. [AH-1S]

6.7 On returning to a dusty parking area during a NVG mission, the PF aborted the initial approach after encountering brown-out conditions from the blowing dust. The brown-out conditions occurred because the PF failed to maintain sufficient airspeed to keep the dust cloud behind the aircraft during the approach. The PC (PNF) did not discuss the proper technique for making this approach either during the pre-mission briefing or after the PF's initial approach attempt. During a second attempt, the PF repeated the same error and again became enveloped in blowing dust. The PC (PNF) assumed the controls late and over-torqued the engine in his attempt to fly out of the brown-out condition. [AH-1S]

TASK ERROR 07

Failure to allow sufficient time for another crew member to perform a directed action.

Definition:

Good aircrew coordination requires that tasks requiring coordinated actions be positively directed and acknowledged among the involved crew members. It is equally important that crew members performing simultaneous actions allow for the proper sequencing and timing of those actions. The requirement for coordinated actions may be fully understood among the aircrew; however, impatience or disregard on the part of one crew member can serve to destroy the required sequencing or timing of the actions. The most frequently observed example of this type of crew coordination error occurs with obstacle clearance responsibilities. Pilots who maneuver their aircraft prior to receiving clearance verifications from other assigned crew members reduce the effective size of their aircrew and place the aircraft at potential risk. Conversely, non-flying crew members who delay their obstacle warnings leave the pilot with little or no time to react.

Examples:

7.1 The PF (right seat) was attempting to hover taxi near a refueling point. A deployed ground guide noticed that the hovering aircraft was approaching too close to another parked aircraft; however, his signals to the PF were obscured by blowing dust. The PF directed the PNF (left seat) to clear the left side (nearest the parked aircraft). The PNF, however, waited until he realized they were about to strike the parked aircraft before attempting to locate the floor microphone switch for the ICS. Experiencing difficulty in finding the floor microphone switch, the PNF could not warn the PF in time to avoid striking the parked aircraft with the aircraft's main rotor blades. [UH-1H]

7.2 The PNF was preparing to test the compatibility of NVGs with a new type of NBC mask during a night test flight. Only the PNF was wearing the NBC suit and was experiencing difficulty in climbing into the right seat. Without waiting for the PNF to be properly seated and in a position to assist with the engine start, the instructor pilot (PF)

attempted an engine start from the left seat, using the left collective throttle control and the right collective trigger. After an aborted start, the PF failed to fully close the throttle. A second start attempt was initiated by the PF, again before the PNF was connected to the ICS and in a position to assist in the start. The second start attempt resulted in a hot start and the subsequent destruction of the engine. [OH-58C]

7.3 After making a night landing to refuel at a small airfield with no taxiway markings, the PC (PF) ground taxied the aircraft to a point near a hanger and became concerned that there was inadequate clearance. The FE provided the PF with clearance to the right; however, the CE was unable to clear the left rear of the aircraft until he completed lowering the rear ramp. Without waiting for the CE to clear the left rear of the aircraft, the PF pivoted the aircraft and allowed the aft main rotor blades to move left and strike the hanger building. [CH-47C]

7.4 On a NVG mission to internally load an M102 howitzer, the PF brought the aircraft to a 20 feet AGL hover facing away from the M102. The PF requested clearance assistance and received left clearance. The CE (who was responsible for providing right and rear clearance) requested the PF to maintain the stationary hover until the CE could lower the rear ramp to provide rearward visibility. Instead of relying on the CE to provide rear clearance, the PF focused his attention upon a ground guide located to the front of the aircraft. When the ground guide signaled "down," the PF (without waiting for the CE's clearance) lowered the aircraft directly onto the top of the M102. [CH-47D]

TASK ERROR 08

Inappropriately directing a non-flying crew member to a lower priority task.

Definition:

Problem Area 3 refers to the failure of the pilot on the controls to appropriately request clearance assistance during critical maneuvers. Problem Area 4 refers to a similar type of failure in requesting appropriate assistance in monitoring flight parameters or in performing required actions inside the cockpit. In each of these instances, the crew coordination error involves a "I can do this myself" attitude in which the pilot on the controls fails to make use of other crew members. Problem Area 8 is distinguished from these two previously mentioned areas by virtue of the fact that the non-flying crew members are directed to provide assistance. The crew coordination error comes about in this instance because the non-flying crew members have not been directed to assist in the highest priority task. Thus, the error involves a failure to recognize task priority, rather than a failure to utilize all available crew resources.

Examples:

8.1 As the PF was ground taxiing toward a refueling point on the left side of the aircraft, the PNF (left seat) issued a warning that they were getting too close. Rather than requesting the PNF to provide continuing clearance information, the PF directed the PNF to lock the tail wheel. Since the PNF's attention was diverted inside the cockpit, he was no longer able to monitor their proximity to structures in the refueling area. Subsequently, the PF misjudged their clearance and allowed the aircraft's main rotor blades to strike a pole on the left side of the aircraft. [UH-60A]

8.2 The PF (right seat) was attempting an approach to a confined area. Instead of requesting the PNF (left seat) to assist in clearing the left side of the aircraft, the PF diverted the PNF's attention to obstacles on the right side. Having his attention diverted to the opposite side of the aircraft, the PNF failed to see a tree on the left side of the confined area. Subsequently, the aircraft struck the tree on the left side of the confined

area during the final portion of the approach. [OH-58C]

8.3 The PF was making a second attempted aft wheel landing to a 25 degree sloping terrain. Instead of directing the CE to provide rear clearance assistance with the aft main rotor blades, the PF directed the CE to "Call the wheels down." This action required the CE to lie face down with his head extended over the ramp. In this position, the CE was unable to properly judge main rotor blade clearance with the sloping terrain. Subsequently, the aft main rotor blades struck the sloping terrain as the PF lowered the aircraft. [CH-47B]

TASK ERROR 09

Lack of Assertiveness or Excessive Dominance; failure of a crew member to challenge or correct actions, tasking, and decisions which place the aircraft in marginal or unauthorized flight conditions. The crew is reluctant to offer assistance and, when assistance or information is offered, it may be ignored.

Definition:

Good aircrew coordination requires that each crew member have the authority and obligation to question the pilot on the controls whenever it is apparent that the aircraft is about to enter a marginal or unauthorized flight condition. When proper procedures have been implemented, such challenges can be made without subverting the command authority of the pilot in command (e.g., the "two challenge rule" and the "most conservative response rule"). Challenges by another crew member serve to safeguard against two types of problems: (1) the crew member who has jeopardized flight safety through the display of a hazardous attitude (e.g., impulsivity, machoism, antiauthority) or lack of experience and (2) the crew member who has become unaware of a critical flight condition because of overly focusing on another problem. A crew coordination error occurs whenever a crew member is in a position to issue an appropriate challenge, but refrains from making the challenge because of one of several reasons: professional courtesy, overconfidence in another crew member's knowledge and experience, rank intimidation, lack of self-confidence, or when the attitude and behavior of the PIC or PF is such that crew members are reluctant to offer assistance or information and, when offered, the pilot often ignores or rejects it. The dominant, authoritarian pilot is often overconfident in his own ability or lacks confidence in the crew.

Examples:

9.1 During the initial leg of a service mission to transport battalion staff members, the aircrew had encountered several hours of weather delay. During the return flight at night, the aircrew again began to encounter deteriorating weather while attempting to transit a mountain pass. Weather was forecast to be below VFR minimums for the mountain passes, and soon the aircrew experienced reduced visibility in darkness, light rain, and decreasing ceilings. Despite these conditions, the instructor pilot (PF) decided to continue the flight over the mountain pass and struck wires. The unit commander (flying in the rear of the aircraft as copilot) failed to challenge the PF's decision to continue the flight in below minimum weather. [UH-1H]

9.2 The unit trainer (PF) was conducting a mountain training mission. Of four attempted landings at a 10,000 feet MSL landing zone, two were successful and two were aborted due to excessive closure speed. An OGE hover check indicated that sufficient power was not available at this altitude. Despite the lack of power, the PF elected to continue the training with attempted landings at a 12,300 feet MSL landing zone. During the approach to the higher landing zone, the PF lost directional control and the aircraft crashed. The PNF failed to challenge the PF's decision to proceed to a higher altitude after experiencing inadequate power at the lower altitude. [UH-1V]

9.3 After arrival at a snow-covered tactical landing area, the copilot terminated the approach with a high hover to blow away loose snow. Upon landing, the aircraft broke through a thin crust of snow. The PC (PF) assumed the controls and picked the aircraft up to a 3 feet AGL hover in an attempt to reposition the helicopter. While moving to the right, the aircraft was enveloped in a snow cloud. Despite a warning from the copilot (PNF) that they were drifting into trees, the PF continued with the hover. After the tail rotor struck a tree, the PNF instructed the PF to set the aircraft down. The PF acknowledged the directive, but continued with the hover under whiteout conditions. Subsequently, the aircraft drifted forward another 235 feet before hitting the ground and rolling over. The PNF failed to take control of the aircraft after it became apparent that the PF did not have the aircraft under control in the whiteout conditions. [UH-1H]

9.4 Upon landing downwind to an upsloping terrain, the inexperienced PF failed to perform a required stability check before lowering the collective. As the aircraft settled off of the front portion of the skids, it rocked backwards. The PF reactively lowered the collective full down and applied full forward cyclic. This abrupt control input resulted in the main rotor blades striking the Upper Wire Protection System. The PC (PNF) failed to challenge the less experienced PF in his selection of an approach direction and touchdown point. The PNF also failed to direct that a stability check be performed prior to lowering the collective to the full down position. [UH-1H]

9.5 Despite the fact that neither crew member was mountain qualified, the PC (PF) attempted to demonstrate mountain flying tactics on a training mission. In addition, the PC failed to properly complete the PPC for the anticipated flight conditions. Finally, the PC considered the OGE hover check conducted at 6,000 feet MSL to be adequate for predicting available power at the mission

altitude of 9,180 feet MSL. While attempting an NOE masking/unmasking maneuver at this higher altitude, the PF lost directional control of the aircraft and permitted it to crash into wooded terrain. The PNF failed to challenge any of the PF's actions or decisions during this mission. [UH-1H]

9.6 Enroute from an intermediate refueling stop to home base, the instructor pilot (PF) deviated from the planned and briefed route and overflowed a large mountain range at an altitude of less than 500 feet AGL. Spotting the wreckage of a previously downed aircraft, the PF decided to reduce airspeed and circle the wreckage for positive identification. During the first pass, the PF permitted the airspeed to drop below ETL limits and experienced loss of directional control. Recovering the aircraft, the PF made a second attempted pass over the wreckage. During the second pass, the PF again lost directional control and the aircraft subsequently crashed. The PNF failed to challenge or alter the PF's decision to make a second pass after experiencing inadequate power on the previous attempt. [UH-1H]

9.7 After taking part in a troop transport mission, the flight of three aircraft joined in a "V" formation and flew over the area at 500 feet AGL to provide a "goodby" salute. After passing over the review area, the air mission commander directed the flight to change to a tactical trail formation. At this time, the PC (PF) of the mishap aircraft left the formation unannounced, descended to an altitude of 50-75 feet AGL, and began to perform "return to target" maneuvers over a nearby lake. During the second attempted maneuver, the PF was unable to control the rate of descent and the aircraft impacted the ground. The PNF of the mishap aircraft failed to challenge or alter the PF's unauthorized maneuvers. [UH-1H]

9.8 During the preflight briefing phase and the flight phase of a NVG training mission the *PF failed to brief, assign, or direct any crew coordination duties to other on-board aircrew members with the exception of transfer of controls and basic emergency actions. The *PF had a low opinion of his flight crew; an opinion not supported by other unit personnel. Approximately 3 seconds prior to touchdown in an unimproved PZ the *PF ignored the crewchief's warning to pull up. The main gear of the UH-60 touched down. When the collective was lowered the aircraft started to roll backwards due to the steep slope of the terrain. Attempting to compensate, the *PF abruptly applied collective. At a high hover the *PF perceived a nonexistent emergency (tail rotor failure), then bottomed the collective causing a hard landing resulting in extensive damage to the aircraft. [UH-60A]

APPENDIX C

SYSTEM INADEQUACY DEFINITIONS AND CRITERIA

1.0 SYSTEM INADEQUACIES

The four system inadequacies, based on the aircrew coordination behaviors are defined below along with the criteria which each area normally manifests itself.

1.1 DEFINITIONS AND CRITERIA

Definition:

CSI01 Inadequate Mission Information Exchange: Represents poor intra-crew communication techniques and patterns the cockpit. Both the amount and type of communication may be deficient. Inadequate performance in this area manifests itself along the following criteria:

Criteria:

- Statements/directives are not clear, timely, relevant, complete, and/or verified. Crewmembers use non-standard terminology or fail to speak clearly.
- Inquiry/questioning is not practiced. Crewmembers do not raise questions during the flight regarding plans, revisions to plans, actions to be taken, or the status of key mission information. Crewmembers do not adequately contribute to decision making by presenting alternative actions, and, likewise, the PC does not adequately consider crew input.
- Advocacy/assertion is not practiced. Crewmembers do not advocate a course of action they consider best when it is in disagreement with others.
- Decisions are not communicated and/or acknowledged. Crews may be confused as to whether a decision has been made and not know what they are supposed to do - often leading to uncoordinated action. Likewise, when a decision has been made and communicated, the crew fails to acknowledge and the pilot fails to insist on acknowledgement.
- Actions are not communicated and/or acknowledged. Unannounced actions are implemented. Consequently, crewmembers do not respond verbally or with an appropriate adjustment to their actions or control inputs.
- Aircraft, personnel, and mission status are not reported. The crew does not keep one another informed of the status of the aircraft and mission information, thus fails to maintain a high level of situation awareness. The elements of situation awareness include:
 - Aircraft position/orientation
 - Environmental/battlefield conditions
 - Equipment status
 - Personnel status
 - Changes to mission status
- Crewmembers may use excessive professional courtesy when an error is detected.

Definition:

CSI02 Inadequate Workload Prioritization/Distribution: Represents the mismanagement and poor distribution of workload during the mission including redistribution as mission situations change. Inadequate performance in this area manifests itself along the following criteria:

Criteria:

- Distractions are not avoided nor correctly prioritized. Essential activities may be dropped by the crew. Crew attention may be focused on minor tasks when critical tasks require immediate attention. Someone is not always "outside" the aircraft when they should be. A malfunction or nuisance draws attention of all crew members to the problem, thus other tasks are dropped.
- Workload is not effectively distributed or re-distributed. Individual task overload may occur in circumstances where other crewmembers were in a position to assist. Crewmembers may be *unaware of the build up of other's workload*. Workload is not re-distributed even though mission requirements change. Previously unassigned, but emerging tasks may not be assumed. One crewmember may be assuming an inordinate amount of the workload.
- The crew mismanages an abnormal/emergency situation. The crew becomes disorganized and flustered. Communications break down. PC requests for information elicit inadequate responses. Crewmembers may focus on the wrong issues. Often these crews may focus on only one solution to an event, and not consider other plausible alternatives, or they may choose an inappropriate solution. Lack of coordination of actions adds to the confusion. The pilot and crewmembers make poor use of resources available to them to resolve the problem. Situation awareness significantly decays during the abnormal/emergency condition.
- Support information/actions are not *sought from* the crew by a crew member. The PNF does not request support. He may not even alert the crew that he is in the process of making a decision. Decision making and planning are accomplished by one individual with little or no discussion. The PNF may not ask for crew assistance with tasks even when he is overloaded to the point where he may fail to properly execute his tasks. Such overloads are particularly critical when the pilots are attempting to clear obstacles, takeoff, land, or are operating in confined areas.
- Support information/actions are not offered by the crew. The crew does not offer information to support decision making. The crew does not volunteer assistance to support actions. The crew may not even realize that support is necessary. Support, when offered by the crew, may be inappropriate to the situation. Crewmembers may fail to offer obstacle clearing support.

Definition:

CSI03 Inadequate Cross-Monitoring of Crew Performance: Represents the lack of cross-monitoring by crewmembers of each other's actions and decisions. Thus increasing the likelihood of errors that negatively impact mission performance or safety. Inadequate performance in this area manifests itself along the following criteria:

Criteria:

- Crewmember actions are not mutually cross-monitored to detect errors. This condition may be worsened when fatigued. Crewmembers may show a lack of concern for effective task execution on their part or on the part of other crewmembers. Crewmembers may be insulted if they are corrected by another crewmember.
- The crew does not perform self-critiques of decisions and actions during or following a flight segment or during the post flight debrief. Where discussions of previous actions or decisions occur, they may focus on "finger pointing." There is no effort to learn from previous decisions or actions. Crewmembers fail to use the "two challenge" rule. Crewmembers do not call for a decision review even when poor judgments are suspected.

Definition:

CSI04 **Inadequate Team Relationships:** Represents that the crew has not established positive working relationships thus discouraging or preventing them from communicating openly and freely and operating in a concerted manner. This area is extremely important because it influences the quality of performance in the areas of information exchange, workload distribution, and cross-monitoring. Inadequate performance in this area manifests itself along the following criteria:

Criteria:

- Crewmembers do not have good interpersonal relationships. In these circumstances, the following factors may be present:
 - The crew does not like or respect each other.
 - Interactions are awkward and uncomfortable; the crew is curt and even impolite to each other.
 - Informal conversations do not occur even during low workload periods.
 - Crewmembers do not advise the PIC of stresses or fatigue that may effect individual capabilities.
 - Crewmembers do not freely critique one another since they may be fearful of censure or sanctions.
 - The PIC attempts to dominate the crew.
 - There is a dominance factor present stemming from rank, crew position, or experience factors.
- The crew is unable to effectively resolve conflicts. The crew fails to directly confront the situation-at-hand. There are personal attacks on each other. Senior crewmembers are highly resistant to recommendations from junior crewmembers. Crewmembers do not explore the range of possible solutions. One crewmember may decide (given the personal "put-downs") to retreat to a hostile silence. The crewmembers show very little respect for one another with the exception of deferring to formal rank. A "win-lose" situation develops where one crewmember is shown to be right and the other to be wrong.