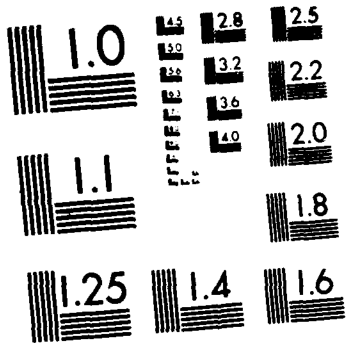
AD-A191 869 COGNITIVE PERFORMANCE DECREMENT IN US ARMY AIRCREWS(U) 1/2
SCIENCE APPLICATIONS INTERNATIONAL CORP MCLEAN VA HUMAN
PERFO.. J I PETERS ET AL. 31 AUG 85 SAIC-85/1787

UNCLASSIFIED DNA-TR-85-269 F/G 6/7 NL



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AD-A191 869

DNA-TR-85-269

COGNITIVE PERFORMANCE DECREMENT IN U.S. ARMY AIRCREWS

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31 August 1985

Technical Report

CONTRACT No. DNA 001-84-C-0215

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SECURITY CLASSIFICATION OF THIS PAGE

AD-A191 869

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188 Exp. Date: Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY N/A since Unclassified 2b. DECLASSIFICATION / DOWNGRADING SCHEDULE N/A since Unclassified	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
4. PERFORMING ORGANIZATION REPORT NUMBER(S) SAIC-85/1787	5. MONITORING ORGANIZATION REPORT NUMBER(S) DNA-TR-85-269
6a. NAME OF PERFORMING ORGANIZATION Science Applications International Corporation 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Director Defense Nuclear Agency
6c. ADDRESS (City, State, and ZIP Code) P. O. Box 1303 McLean, VA 22102-1303	7b. ADDRESS (City, State, and ZIP Code) Washington, DC 20305-1000
8a. NAME OF FUNDING / SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER DNA 001-84-C-0215
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO: 62715H; PROJECT NO: RM; TASK NO: RH; WORK UNIT ACCESSION NO: DH008398

11. TITLE (Include Security Classification)

COGNITIVE PERFORMANCE DECREMENT IN U.S. ARMY AIRCREWS

12. PERSONAL AUTHOR(S)

Peters, J. I.; Archer, M. A.; and Moyer, M. J.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Technical	FROM 840521 TO 850831	850831	174

16. SUPPLEMENTARY NOTATION

This work was sponsored by the Defense Nuclear Agency under RDT&E RMC Code B3510844662 RM RH 00004 25904D.

17. COSATI CODES

FIELD	GROUP	SUB-GROUP
6	18	
5	5	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

Radiation Effects, Helicopter Tasks, Task Taxonomy, Performance Decrement, Human Performance, Radiation Sickness, Time Estimation

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This study investigates the use of subjective estimates to assess the cognitive effects of intermediate doses of radiation on helicopter crew performance. A mission analysis was performed across several aircraft with scenarios developed for the CH-47 and AH-1 followed by detailed task analysis and classifications. Thirty-four CH-47 crews performed 9 tasks on a CH-47 simulator and their task times were measured. An analysis was made of the task times including a comparison of actual times against pilot estimates of times for each task. Pilot estimates of radiation effects were analyzed and methods for predicting such estimates are discussed. The primary study recommendation was for validation of questionnaire techniques for predicting radiation induced performance decrement.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Sandra E. Young	22b. TELEPHONE (Include Area Code): (202) 325-7042 22c. OFFICE SYMBOL: DNA/CSTI

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

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A-1

PREFACE

This report was prepared by the Human Performance Technology Division of Science Applications International Corporation (SAIC) for the Biomedical Effects Directorate of the Defense Nuclear Agency under contract number DNA 001-84-C-0215. Included in this report for the purpose of continuity is a section on task definition and task taxonomy (Section 2-1 and associated references and appendices) performed at the same time as this contract and reported separately under DNA contract number DNA 001-84-C-0290. The contract was monitored by Dr. Robert Young. The program manager was Dr. Michael L. Fineberg and the principal investigator was Dr. Joseph I. Peters.

The authors wish to express thanks to the many individuals who contributed to this effort. Dr. Robert Young provided continual support through his technical insight, patience and understanding of the challenges associated with large-scale data collection. Inputs from members of the Intermediate Dose Program aided significantly in early program definition. From the U.S. Army Nuclear and Chemical Agency, Dr. C.N. Davidson and Captain James Davis proved instrumental in their constructive review of our finalized approach and in securing troop support through FORSCOM.

Of particular note is the outstanding support provided by pilots of the U.S. Army. Major David Kellogg and personnel of the Combat Development Directorate at the U.S. Army Aviation Center, Ft. Rucker, Alabama, were invaluable in initial steps to defining high workload helicopter missions. Personnel of the 101st Airborne Division, Fort Campbell, Kentucky and Ft. Rucker, Alabama provided extensive support through the entirety of this effort - from early mission definition through rigorous schedules of data collection. Special thanks go to the pilots at Ft. Campbell who dedicated their time and sweat to answering numerous questions and flying in difficult circumstances.

We are particularly indebted to Mr. George E. LeFavor (CW4). As the Supervisor of the CH-47 Flight Simulator, Mr. LeFavor demonstrated outstanding initiative and provided invaluable insights on CH-47 operations. Moreover, Mr. LeFavor personally supervised the CH-47 simulation for data collection on each of the over thirty-four missions which were flown. We can't imagine having made it without him!

Special thanks go to Dr. Michael L. Fineberg, who, as the SAIC Program Manager, formulated the initial conceptual approach and fostered an environment for innovation and technical excellence to occur. Any short-comings in that domain, however, are solely the responsibility of the authors. We are also greatly indebted to other members of our SAIC staff: to Ms. Robin Ely for her literature review and analysis of factors pertinent to time estimation; to Ms. Kiran Chadda, for her help in the data analysis phase; to Dr. Eleanor Criswell for advice on task taxonomies; and, to Ms. Brenda Frady for her expertise in graphics and report management.

The views expressed herein are solely the responsibility of the authors and are not to be taken as representing the position of the Defense Nuclear Agency, the U.S. Army or any other government agency.

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SECTION 1

INTRODUCTION

1.1 STATEMENT OF PROBLEM.

The Defense Nuclear Agency needs to know how performance of Army helicopter crew members is affected by exposure to intermediate doses of nuclear radiation. Obvious moral and ethical considerations preclude exposure of humans to radiation, and animal studies preclude insight into the effects of such radiation on human cognition. The problem then, is how to predict the cognitive performance decrement of Army aircrews in a fashion which is accurate and reliable and, at the same time, free of undue hazards to such crews. This study investigates the use of pilot estimates to assess the cognitive effects of intermediate doses of radiation on helicopter crew performance.

1.2 BACKGROUND.

1.2.1 Intermediate Dose Program.

The Defense Nuclear Agency's Intermediate Dose Program (IDP) assesses the impact of radiation sickness on individual, crew, and unit performance. The result of the IDP will improve the Army's ability to fight on an integrated battlefield by providing a predictor of the amount of performance degradation that could be expected as a result of troop exposure to nuclear radiation. Such predictors will be of value to commanders and planners in determining missions and how best to employ their forces. Predictors are also valuable in the targeting of nuclear fires in order to assure that friendly troops have the desired amount of safety from nuclear weapons effects.

Techniques for assessing radiation effects on helicopter crew proficiency are based on (1) the identification of symptoms of radiation sickness based on animal and accidental or medically related human exposures and (2) the ability to relate these symptoms to helicopter crew performance effectiveness. These factors are discussed in the following paragraphs.

1.2.2 Identification of Symptoms.

As part of the Intermediate Dose Program, Glickman et al. (1983) have described a methodology for describing various symptoms of radiation sickness. This methodology produced symptom complexes characterized by the combination of symptoms from six syndrome components:

(1) Upper gastro-intestinal
(2) Lower gastro-intestinal
(3) Fatigability/weakness
(4) Cardiovascular
(5) Hemotological (bleeding and infection)
(6) Miscellaneous symptoms (fluid loss and electrolyte imbalance)

Each syndrome component was described by five alternate symptoms which varied in degree of severity (e.g. the "fatigability" component varied from "1- No effect" to "5- Exhausted with almost no strength"). Table 1 lists the symptoms comprising each syndrome. The total number of combinations of the five severity levels of the six syndrome components is 5^6 or 15,625. Not all of these combinations, however, make logical sense because the components are not orthoginal. Instead, they are related such that, for example, high fluid loss and fatigability are more likely to occur together than not. From the 15,625 combinations, a group of subject matter experts identified a total of 40 symptom complexes which represent the full range of severity levels of radiation sickness and could be associated with specific radiation dosages and times after exposures.

1.2.3 Relating Symptoms to Performance Decrement.

After radiation symptoms are well defined and related to dosages and times after exposure, the research method for determining effects of these symptoms on crew performance is to recreate in some way the symptoms of radiation sickness in crew members and in some way to assess resultant performance effectiveness. Asymptomatic, baseline performance can then be compared to symptomatic performance in a qualitative and quantitative way.

One method for relating symptoms to performance is through the use of suggestion by means of symptom complex descriptions incorporated into a

Table 1. Levels of radiation sickness severity for Army questionnaire (from Glickman et al., 1983).

Upper GI Distress (UG)
1. No effect
2. Upset stomach; clammy and sweaty; mouth waters and swallows frequently
3. Nauseated; considerable sweating; swallows frequently to avoid vomiting
4. Vomited once or twice; nauseated and may vomit again
5. Vomited several times including the dry heaves; severely nauseated and will soon vomit again

Lower GI Distress (LG)
1. No effect
2. Feels uncomfortable urge to defecate
3. Occasional diarrhea, recently defecated and may again
4. Frequent diarrhea and cramps, defecated several times and will again soon
5. Uncontrollable diarrhea and painful cramps

Fatigability and Weakness (FW)
1. No effect
2. Somewhat tired with mild weakness
3. Tired, with moderate weakness
4. Very tired and weak
5. Exhausted with almost no strength

Hypotension (HY)
1. No effect
2. Slightly light-headed
3. Unsteady upon standing quickly
4. Faints upon standing quickly
5. In shock: breathes rapidly and shallowly, motionless, skin cold, clammy, and very pale

Infection and Bleeding (IB)
1. No effect
2. Mild fever and headache--like starting to come down with flu
3. Joints ache, considerable sweating; moderate fever; doesn't want to eat; sores in mouth/throat
4. Shakes and chills and aches all over; difficulty in stopping any bleeding
5. Delirious, overwhelming infections; cannot stop any bleeding

Fluid Loss and Electrolyte Imbalance (FL)
1. No effect
2. Thirsty and has dry mouth; weak and faint
3. Very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion
4. Extremely dry mouth, throat, skin and very painful headache; has difficulty moving; short of breath, burning skin and eyes
5. Prostrate

questionnaire. This was done in recent DNA-sponsored studies of crew performance in the M-60 tank, the M-109-155 Howitzer, M-901-ITV and the Fire Direction Center (Glickman et al., 1983). In each of these studies a questionnaire was given to system crew members. Table 2 presents a sample of the questionnaire structure. For each system, the questionnaire presented a scenario including a detailed list and description of tasks occurring within a brief (1-2 minute) segment of the mission scenario (e.g. loading and firing a Howitzer). Next to each task on the list was the "usual time" taken to perform the task. Respondents were required to read the description of a radiation sickness symptom complex and then estimate what effect the particular symptom complex would have on the time it takes "a crewman" to perform each task. The response could be either "no effect", "could not do it at all" or an estimated time (presumably longer than the "usual time" already provided).

The results of the above study showed that crew judgements did indicate that symptoms associated with nuclear radiation exposure would degrade crew performance. In addition, the expected radiation effects were found to be generalized across tasks, positions and crews which were sampled by the questionnaire. Nevertheless, the authors did conclude that, although still somewhat imprecise, quantitative prediction of performance degradation is feasible.

The next section discusses the approach taken in the present study. First, the study objectives are discussed followed by a discussion of how the tasks were selected for the study and how they were defined. A discussion of differences between the methodologies of the current study and those of Glickman, et al. (1983) is followed by some hypotheses which conclude the section.

Table 2. Example of questionnaire given to M901 crew members.

SYMPTOMS: NAUSEATED; CONSIDERABLE SWEATING; SWALLOWS FREQUENTLY TO AVOID VOMITING; OCCASIONAL DIARRHEA AND CRAMPS, DEFECATED SEVERAL TIMES AND WILL AGAIN SOON; VERY TIRED AND WEAK; SLIGHTLY LIGHT-HEADED; JOINTS ACHE, CONSIDERABLE SWEATING; MODERATE FEVER; DOESN'T WANT TO EAT; SORES IN MOUTH/THROAT.

CREW TASKS

TASKS CREW MEMBER	THE USUAL TIME FOR EACH TASK IS ABOUT:	HOW LONG DO YOU THINK IT WOULD TAKE A CREWMAN TO DO EACH TASK IF HE HAD THESE SYMPTOMS?		
		NO INCREASE IN TIME	AMOUNT OF TIME (SEC)	COULD NOT DO IT AT ALL
SQUAD LEADER DESIGNATE AZIMUTH AND TARGET	4 SEC			
COMMAND DRIVER TO FIRING POSITION	2 SEC			
GUNNER SET SUPERELEVATION, ERECT, SIZE 170° TO 10° AZIMUTH	17 SEC			
ADJUST MAGNIFICATION, ACQUIRE TARGETS, IDENTIFY, ARM, AND FIRE	7 SEC			
DRIVER FROM STANDSTILL, DRIVE FORWARD 40 FT. AND STOP	20 SEC			
LOADER RELOAD	60 SEC			
REARRANGE READY RACK	60 SEC			

SECTION 2

STUDY APPROACH

2.1 STUDY OBJECTIVES.

The primary objective of this study was to assess the effects of intermediate radiation doses on the performance of U.S. Army helicopter crews. A major supporting objective was to obtain questionnaire data comparable to those already obtained for other Army weapon systems. As such, task times were the primary measure of concern; however, the methodology for obtaining these and other data differed from that used in prior studies. This change in methodology was because of differences in weapon systems as well as due to an effort to improve the overall reliability and validity of the questionnaire technique.

All written materials (including instructions and questionnaires) which were provided to each crew member in the current study are reproduced and provided in Appendix A. Because the original questionnaires were distributed to the respondents on legal size paper (to improve readability), there may be some difficulty in reading some items in the reduced version of Appendix A. Therefore, Appendix A should be reviewed merely for the purpose of obtaining an overall picture. Pertinent parts of these documents will be reproduced in the main body as appropriate for aiding discussion.

2.2 TASK DEFINITION PROCESS.

The basic unit of human peformance measurement used in the Intermediate Dose Program is the task. Examples of tasks analyzed in prior studies are:

- Designate azimuth and target,
- From standstill, drive forward 40 feet and stop,
- Reload,
- Command driver to firing position.

These tasks ranged in nominal time from about two seconds to one minute.

The objective of the current study was to focus in on the performance of helicopter crews. Tasks measured in prior studies (tanks, Howitzers, etc.) focused largely on the firing of weapons and lacked the degree of cognitive and precise physical coordination which is required of helicopter crews. As a result, particular interest was expressed by the Defense Nuclear Agency (DNA) in assessing the impact of radiation on the high level of cognitive and precise visual-motor skills of helicopter pilots.

More specifically, the DNA expressed special interest in an analysis of helicopter crew performance in an attack mission. Attack helicopters were preferred primarily because, although the flying task was different, they shared many tasks which were in common with those analyzed in most prior studies, i.e., arming, aiming and firing of a weapon.

An analysis of the attack helicopter missions of interest highlighted several points which made helicopters considerably more difficult to study than ground-based systems. These points included the following:

- Helicopters have more operational degrees of freedom
- Continuous control versus discrete tasks predominate
- Crew size is generally smaller
- Confined on-board space precludes in-flight observation of tasks

A brief discussion of each of the above points follows.

The fact that helicopters operate in three dimensional space significantly complicates the accuracy and reliability of measurements of system performance. The fact that pilots are always flying the helicopter as long as it is airborne makes it very hard to define the beginning and ending points of tasks. Because there are two pilots on board with their hands and feet almost continuously on the controls, it becomes impossible to differentiate the flying tasks of one pilot versus those of the other unless the observers interfere with the pilot's natural procedures. In an effort not to interfere with in-flight procedures, all tasks measured in this study rendered task times for each "crew".

Therefore, separate times for pilot vs. copilot duties were not measured for the particular tasks observed in this study.

Perhaps the biggest constraint in performing a task timeline analysis of an attack helicopter crew was the fact that it is impossible to fit an observer with a stopwatch into the helicopter. There is not enough room! An attractive and still viable alternative, however, was the use of a high-fidelity helicopter simulator where there is enough room for an observer. Increased capacity of a simulator to hold more people was but only one, albeit major, advantage. Section 3 of this study discusses the other advantages and some disadvantages.

One major disadvantage of having to rely on a simulator for observation of tasks is the limited number, if any, of those available - especially for such purposes as task timeline analysis of high workload tasks. Due to the uncertainty in availability of simulators, the study approach taken was to perform a mission analysis which was both unconstrained by the availability of hardware and yet identified enough mission segments of interest, that a high probability of success in measuring at least one aircraft would be achieved.

In summary, the process leading to task definition involved several steps. They were:

1. Mission Analysis
2. Mission Segment Identification
3. Task Definition
4. Task Classification

The evolution of these steps are reported in the subsections to follow.

2.2.1 Mission Analysis.

The mission analysis phase of this study involved visiting with operational helicopter crews and reviewing literature pertinent to helicopter operations. Numerous field manuals, training circulars and technical manuals (See Reference Section) were consulted for the latest available information on the operational environment. From these sources, four separate mission were identified:

- Attack
- Observation
- Utility
- Transport

The attack mission is currently peformed primarily by two helicopters, the AH-1 "Cobra" and the AH-64 "Apache". Observation and scouting are performed by the OH-58 "Kiowa". The utility mission is performed by the UH-1 "Huey" and the UH-60 "Blackhawk" helicopters, and the transport mission is peformed primarily by the CH-47 "Chinook".

Given DNA's interest in the attack mission and an increasing knowledge of the availability of CH-47 simulators, scenarios were written for both the Attack and the Transport missions. These scenarios served as an initial baseline or "straw men" for presentation to operational pilots at Ft. Rucker, Alabama and Ft. Campbell, Kentucky. These pilots commented on the authenticity of the scenarios, assisted in refining them and contributed to the identification of high workload mission segments. Copies of the scenarios are reproduced in Appendix B.

2.2.2 Mission Segment Identification.

Although the primary missions of Army helicopters is rather clear, an analysis shows that when missions are broken down into segments, all aircraft share some common functions. Table 3 portrays those mission segments performed by aircraft under the four mission specialty areas.

The general attack mission scenario developed in Section 2.2.1 (Appendix B) was biased toward a Cobra helicopter mission; however, to increase flexibility in being able to collect task and task timeline data, separate scenarios were developed for several mission segments. Some of the scenarios were robust enough to apply to more than one aircraft. These scenarios are provided in Appendix C.

Table 3. Mission segments of various Army helicopters.

Mission Type / Mission Segments	Attack (AH-1)	Transport Observation (CH-47)	Utility (UH-1) (UH-60)	Observation (OH-58)
Take Off & Hover Check	X	X	X	X
Sling Load Pick-Up		X	X	
NOE/Contour Navigation	X	X	X	X
Fire Suppression	X			
Sling Load Drop-Off		X	X	
Target Handoff	X			X
Pop-Up and Tow Launch	X			
Evade Threat	X	X	X	X
Perform Emergency Procedures	X	X	X	X
Land Aircraft	X	X	X	X

A brief discussion of each segment in Table 3 and the related crew skills, knowledges and abilities required for each segment follows:

Take-Off and Hover Check. This a highly proceduralized segment of the missions of all aircraft. It requires sophisticated eye-hand coordination refined by means of intensive training. In addition, it requires a thorough knowledge of how the engine and transmission function. Pilots are required to know which parameters to check on their instrument panels and the tolerance levels for safe and acceptable operation before making a decision to proceed in the flight regime.

Sling Load Pick-Up. This mission segment applies to only those aircraft equipped with hardware for attaching lines to cargo for hauling by means of a sling hanging beneath the helicopter. To peform this mission segment, pilots are required to have gooa eye-hand coordination, stamina and good crew coordination. Eye-hand coordination supplemented by good depth perception is required to control the aircraft within fine constraints defined by cargo size, shape and location on the terrain. Stamina is required to some degree in order to maintain position of the helicopter in a relatively stable position while compensating for the effects of wind. Crew coordination is especially required in the CH-47 where the cargo to be picked up cannot be seen by the pilot. Coordinatioon between the pilot and flight engineer therefore is esential and takes the nature of brief height and altitude directions from the engineer such as "Up 2 feet, Left 2, Down 1", etc. in response to pilot adjustments.

NOE Navigation. Nap-of-the-earth (NOE) navigation involves both map reading and crew coordination skills. NOE flight is the type of flight which occurs at or below tree-top level and takes maximum advantage of the concealment provided by the local greenery and terrain. It is characterized by slow, often stop-and-go movement. Contour flight, on the other hand, is characterized by continuous movement but with emphasis on lowest possible altitude. NOE flight is quite typical of Scout, Attack and Utility missions;

however, Transport missions due to CH-47 system dynamics and size, typically go only as low as contour flight allows.

As the altitude of flight missions decreases, there is increased dependency on the skills of the crew in map reading. This is true because the lower altitudes deny the crew of the same broad perspective from which their map was created. Therefore, the numbers of cues become less and the crew is more dependent on mental imagery of their location based on contour lines in the map and map-terrain associative skills.

The need for good crew coordination is emphasized in NOE navigation tasks. This is largely true because the workload involved with keeping the helicopter from hitting obstacles precludes the pilot from looking at a map. The copilot, therefore, is continually comparing his perceived position on the map with his actual position and simultaneously issuing instructions to the pilot.

Fire Suppression. Fire suppression is the employment of weapons to suppress enemy fire. The best equipped for this segment is the Attack helicopter because of the versatility of weapons aboard, its firepower and the fact that it was designed for the purpose of enemy engagement. Other aircraft, however, can and do perform fire suppression. The UH-1 can be equipped with rockets and guns for fire suppression.

Overall, Utility and Attack aircraft are the primary aircraft performing fire suppression. However, anyone carrying a rifle or machine gun on any helicopter can perform fire suppression. The distinction is that between "mission" versus "activity". Therefore, Table 3 designates Attack and Utility helicopters as having a fire suppression mission even though other aircraft may do fire suppression when they have to.

The skills associated with fire suppression are largely eye-hand coordination. These are associated with aiming and firing the weapon while siumultaneously flying the aircraft.

Sling Load Drop-Off. The characteristics of sling load drop-off are very similar to those for picking up a sling load. The only noticeable difference is that, for obvious reasons, the accuracy of placement is usually not as critical as that for pick-up. Associated eye-hand and crew coordination requirements therefore are also slightly less stringent.

Target Handoff. Target handoff involves the sighting of a target, conversion of target location into communicable coordinates and the follow-through communicatin of target location either to another aircraft or ground based communications mode. This activity is usually peformed by attack or observation aircraft. Requirements for target handoff are target detection ability, map-terrain associative skills, map reading abilities to convert map location into coordinates, short-term memory, good articulation and proper communications procedures.

Pop-Up and Tow Launch. This mission segment is unique to attack helicopters. Performance of a pop-up and TOW launch maneuver involves a sudden rise in altitude from a concealed position, location of target and considerable crew coordination in aiming, firing and tracking a wire-guided missile into the target. Tasks associated with executing this maneuver require considerable knowledge of proceduralized steps for weapon selection, arming, aiming and firing. Crew coordination is essential for hitting the target. Both pilot and gunner require good eye-hand coordination as they maintain the aircraft and missile respectively, within constraints.

Evade Threat. Being able to evade a threat system is paramount to the survivability of any helicopter. It involves either visually detecting a tank or SAM site through the helicopter windscreen or receiving an audio or visual warning that enemy radar is scanning your aircraft. The appropriate response for evading a threat is to break visual and radar contact as quickly as possible. This usually occurs by means of a combination of driving and turning maneuvers. The major characteristic of this situation is uncertainty and is handled best through abilities of crews to react quickly and safely while maintaining their orientation.

Perform Emergency Procedures. As the title suggests, this type of activity is highly proceduralized and is associated with a well trained set of responses. As in "evading threat", the uncertainty factor is very high here, and likewise, the desirable crew characteristic is speed and accuracy of response. Because the population of possible system emergencies and associated responses is limited, the use of well trained standard procedures has been the traditional method for handling them. In that vein, the amount of uncertainty to be reduced for a system-related emergency is potentially far less than in a threat evasion situation in which an unknown or little-known threat is encountered. Therefore, a pilot's consistency in following procedures is a more desirable characteristic for handling system emergencies, and proficient flying skills become more desirable for handling evasion of threats.

Land Aircraft. The pilot skills associated with landing a helicopter are similar to those for dropping off a sling load. Good eye-hand coordination and depth perception is paramount. Some dependency on established procedures exists, and some crew coordination may be required, especially for the larger aircraft such as the CH-47.

2.2.3 Task Definition.

2.2.3.1 AH-1 Tasks. The initial Cobra task analyses were peformed by 13 helicopter pilots from Fort Rucker, Alabama. Six of the pilots were from a FORSCOM attack helicopter company; the seven others had previous operational experience and were assigned at the time to TRADOC's Combat Development Center. Their operational experience is summarized as follows:

7 - Attack Pilots/Gunners (AH-1 "Cobra")
5 - Observation Pilots (OH-58 "Scout," O-2)
    3 - Armor
    2 - Artillery
1 - Utility Pilot (UH-1, "Huey")

Each of the pilots was given those scenarios in Appendix C which were appropriate for his particular aircraft. Deficiencies in the scenarios were refined accordingly.

Pilots were taught the basics of task identification with the objective being the ability to time each task. Emphasis therefore was placed on identifying discrete, observable start and stop points as anchors for later timeline analysis. Emphasis was also placed on ensuring tasks were defined at the "micro" level. For example, pilots were told that "starting the engine" did not comprise a sufficient breakdown of the activity and that there were discrete and observable actions which comprised steps in starting the engine. Their task was to define these steps. The AH-1 technical manual (TM 55-1520-236-10) was provided as an aid to the Cobra pilots in helping them to remember some of the tasks, particularly in the "Takeoff and Maintain Hover" mission segment, where the checklist formalizes many of the steps.

The individual pilot accounts of each of the mission segments were compared for consistency, and inconsistencies were resolved through majority rule. In a few cases, phone calls were made to some pilots to clarify certain points. Appendix D includes the results of integrating pilot accounts of three mission segments of interest for the Cobra attack helicopters.

2.2.3.2 CH-47 Tasks. The CH-47 task analysis was quite revealing with regard to differences in aircraft mission. The weapons-related tasks of the Cobra were, as expected, very similar to the firing of ground-based weapons. As such, they were discrete as opposed to continuous tasks and thus amenable to short-term, fairly reliable timing procedures which could be applied against each crew position. Tasks analyzed for the CH-47, however, were fundamentally based in the "flying" aspects of the tasks. The start and stop times of such tasks were therefore anchored more on system observables versus crew behaviors. This resulted in generally longer tasks which did not differentiate separate crew member roles.

The basis for CH-47 task analysis was repeated observations of pilots in the CH-47 simulator. These observations were converted into lists of tasks which were then discussed with several CH-47 pilots. Task definitions were then modified based on pilot inputs. When a proposed secnario for task-timeline data collection was presented, tasks were further refined with inputs from two seasoned CH-47 simulator operators/instructor pilots.

2.2.4 Cognitive Task Taxonomy.

The study by Glickman et al. (1983) demonstrated that the estimated effects of symptom complexes were fairly generalized across tasks. There was one exception in which estimated symptom effects exagerated the decrement of those crew members performing physically demanding tasks. From this, one might hypothesize that physically demanding tasks in general are more vulnerable to the effect of low dose nuclear radiation than are less physically demanding tasks. This section discusses the need for taxonomy, reviews the current literature and applies a taxonomy to several helicopter tasks.

2.2.4.1 The Need for a Taxonomy. One limitation in the methodology employed by the Intermediate Dose Program is that there is currently no method for systematically generalizing radiation effects on one task to those on similar tasks in other hardware systems. A system therefore is needed which will provide a classification of tasks, including aspects such as physical demand, so that when empirical data are available for one member of the class, accurate generalizations can be made to all tasks belonging to the same classification.

The need for a task classification system, or a taxonomy, is presumed only if a measurement system is available which can discriminate radiation sickness effects across various tasks. The Glickman study indicates that the time estimation methodology employed by them did a minimal job of discriminating tasks. However, the current study has adopted some of Glickman et al's recommendations as well as encorporated some new methodologies intended to reduce error variance. These changes in methodology are discussed in detail in Section 2.3. It is hoped that such changes will improve the sensitivity of task time estimates to various radiation sickness conditions.

A major reason for DNA's attention to helicopter crew performance analysis is the concern over the potential for increased vulnerability of aircrews to radiation sickness. This concern is based on the perception that there are more workload demands on helicopter pilots than on ground crews and that the nature of the workload is more oriented to tasks involving cognitive processes rather than sensation or physical strength requirements. As such, emphasis in the development of a taxonomy was initially placed on discriminating among various cognitive functions such as long and short term memory, attention, and information coding and processing.

2.2.4.2 Review of the Literature. The seminal document on the topic of taxonomies of human tasks is a recent book by Fleishman and Quaintance (1984). Although numerous taxonomies and variants are discussed, it appears that there are three basic and distinguishable approaches to classifying tasks:

- Behavior Description
- Behavior Requirements
- Ability Requirements
- Task Characteristics

These approaches are the best developed taxonomies with an already substantive body of studies which support, in varying degree, the reliability and validity of their tenets. A brief discussion of each follows.

Behavioral Description

This form of classification is based solely on overt behaviors of the person performing a task. As such, the taxonomy is insensitive to why a particular action is occurring and focuses on quantitative measurement of the task. The overall strength of this approach is that it is comprehensive in describing activities. The weakness of the approach however is that because it is so comprehensive of behaviors it lacks meaningful discriminability across tasks.

Behavior Requirements Approach

The behavior requirements approach goes a step beyond observed behavior only and introspects the requirements for successful performance. This approach might have appeal to the development of a cognitive task taxonomy in that many cognitive processes are seen as requirements for tasks (i.e. memory, decision-making, etc.). As is the drawback for the field of cognitive psychology, however, the behavioral requirements approach falls short in its ability to quantify the behavior being required.

Ability Requirements Approach

Unlike the behavioral descriptive approach, the ability requirements approach can discriminate among tasks based upon the abilities that they require of the person performing them. As such, this approach works well in a factor analytic environment where the person defining abilities is also exercising the taxonomy. Use of the ability requirements approach usually lacks objectivity in the definition of tasks and thus reliability across classifiers suffers. This approch would appear to be useful in manpower modeling activities.

Task Characteristics Approach

This approach attempts to divorce itself from introspective techniques of projecting what human requirements or abilities are demanded by the task. Instead it focuses largely on the stimuli which characterize the environment in which the task is performed and the task responses which affect the environment. This approach appears the most promising for one interested in high inter-rater reliability and the ability to generalize to equivalent types of tasks. This approach is unique in that it is not dependent upon human abilities or requirements to classify tasks.

2.2.4.3 Taxonomy Applied to Helicopter Tasks. Of the four basic types of taxonomies discussed, two are particularly attractive for application to military weapon system tasks. The Behavioral Requirements approach appears to be the one most appropriate for defining categories of cognitive activities; however, as mentioned in the preceding sections, its biggest drawback is an inability to be quantitative. The task characteristic approach, on the other hand, appeared to be more measurement oriented with an objective method of rating tasks. A complete set of scales has already been developed including those which assess decision making, workload and degree of muscular effort.

Because these scales appear to address those factors which have demonstrated at least some task discrimination in prior studies and because on overriding concern was the ability to generalize from one military task to another, the task characteristic approach was selected for further study.

2.2.4.4 Application of the Task Characteristic Approach to Helicopter Tasks. Scales provided by Fleishman and Quaintance (1984) were used independently by two raters to evaluate the helicopter tasks listed in Table 3, of the preceding section. Each rater filled out 21 scales evaluating each of the 13 tasks listed. Each of the 21 scales had a rating range from 1 to 7. Table 4 is a blank version of the matrix required to be filled out by each rater and Appendix E includes the filled in matrices along with an example of a scale from Fleishman and Quaintance.

An analysis of agreement between raters was conducted using the standard formula:

$$\frac{\#\ \text{Agreements}}{\#\ \text{Ratings}}$$

An agreement was taken to mean that the distance between the two ratings was less than or equal to 2. Thus if one rater scores a "4", an agreement would be scored if the other rater's score was 2, 3, 4, 5, or 6. Exact matches accounted for about 1/3 of the agreements. Given the degree of subjectivity involved in using the rating scales, this definition of agreement was acceptable for our purposes.

Results of the inter-rater agreement analysis are presented in Table 5. The scores appear to cluster together with the exception of only

Table 4. Task characteristic ratings applied to U.S. Army helicopter missions.

RATING SCALES / TASKS	NUMBER OF OUTPUT UNITS	DURATION OUTPUT UNIT MAINTAINED	NUMBER OF ELEMENTS PER OUTPUT UNIT	WORKLOAD	DIFFICULY OF GOAL ATTAINMENT	PRECISION OF RESPONSES	RESPONSE RATE	SIMULTANEITY OF RESPONSES	DEGREE OF MUSCULAR EFFORT INVOLVED	NUMBER OF PROCEDURAL STEPS	DEPENDENCY OF PROCEDURAL STEPS	ADHERENCE TO PROCEDURES	PROCEDURAL COMPLEXITY	VARIABILITY OF STIMULUS LOCATION	STIMULUS OR STIMULUS COMPLEX DURATION	REGULARITY OF STIMULUS OCCURRENCE	OPERATOR CONTROL OF THE STIMULUS	OPERATOR CONTROL OF THE RESPONSE	REACTION TIME/FEEDBACK LAG RELATIONSHIP	FEEDBACK	DECISION MAKING
TAKE-OFF TO HOVER																					
HOVER POWER CHECK																					
CARGO HOOK-UP																					
DEPART WITH CARGO																					
CARGO DROP-OFF																					
DEPART																					
LOW-LEVEL NAVIGATION																					
EVADE THREAT																					
ENGINE FIRE																					
FIRE SUPPRESSION																					
TARGET HAND-OFF																					
POP-UP & TOW LAUNCH																					
RUNNING LANDING																					

Table 5. Inter-rater agreement analysis.

Tasks	Agreement
Take off to Hover	.71
Hover Power Check	.76
Cargo Hook-Up	.62
Depart with Cargo	.76
Cargo Drop-Off	.76
Depart	.71
Low Level Navigation	.67
Evade Threat	.71
Engine Fire	.52
Fire Suppression	.76
Target Hand-Off	.81
Pop-Up and Tow Launch	.81
Running Landing	.81

two tasks: engine fire and cargo hookup. There, scores suggest that the nature of the task did not affect the difficulty in using the scales. The results do show, however that application of some scales was more difficult than others. Further analysis revealed that agreement scores were under .70 for 10 of the 21 scales. It might have been the case that raters had trouble applying those scales to any task.

It may be desirable to use these scales in the future as the basis for a generalization model. As mentioned earlier, these scales have been validated in other work. If the scales are used in the future, however, one of two general approaches should be taken. One, raters might undergo more extensive training in the application of the scales, or two, the raters could discuss all ratings, arrive at a consensus, and use the consensus figure as the value in the generalization model. This second approach appears warranted for future efforts.

2.3 COMPARISON WITH PRIOR STUDY APPROACHES.

The study of Glickman et al. (1983) served as a benchmark of the Intermediate Dose Program in that it was the first of its kind and assessed four different systems with analyses of each broken down to task and crew position level. The current study adopted much of Glickman's methodology; however some changes were made. Of these, some were done to improve control of extraneous variance. Because these changes were applied to the entire data collection process, the value of these changes is not testable through analysis of the data collected. Other changes were made to test research hypotheses about the validity of using subjective estimates of time. A discussion of the changes follows.

2.3.1 Use of Normative Versus Nominal Task Times.

There are two types of timeline analyses, nominal and normative. A nominal task timeline analysis uses the performance of a single individual, or a small number of individuals, to establish the "usual" time it takes to perform a given task. A normative task timeline analysis however, establishes a representative distribution of task times from which characteristics of the total population of task times can be inferred. The minimally acceptable size for a normative timeline analysis is 30 measurements from 30 individuals. Sample size can be comfortably reduced if each individual (or team of individuals) is measured more than once on each task performed.

The data used by Glickman et al. (1983) for portraying "normal task times" as anchor points for task estimates in their questionnaire were nominal. They came from the literature and were "suspect because of age, non-comparable methods of analysis, and lack of task commonality" (Moyer, O'Donoghue and Fineberg, 1984). It was therefore difficult to reliably evaluate the impact of estimates of performance decrement on mission effectiveness. This conclusion was supported by SAIC's experience in questionnaire administration whan volunteers questioned the accuracy of the "normal task time." In the present study, the time each crew took to finish each task was measured. The large number of crews (N=32) measured in this study and the use of repeated measurements on many of the same tasks certainly characterize these data as "normative."

2.3.2 Use of Personal Versus "Average Person" Baseline.

In the Glickman et al. study (1983), people were asked to project effects of radiation sickness symptoms on the performance of the "average person" (based on nominal times provided) as opposed to projecting their own performance decrement. However, in the present study, people projected what their own personal decrement would be. As such, the anchor time used for each task was each crew member's estimate of the "normal time" associated with being healthy and feeling fine. In essence then, each estimate of degredation was baselined against each crew member's estimate of normal operating time.

It is hoped that projecting one's own performance as was done in this study added to the internal validity in a way similar to that of repeated measures experiments, i.e. the person serves as his own baseline in projecting degraded performance, or performance under different environmental conditions. This procedure should add to the validity of individual reports, and the ability to generalize (i.e. external validity) should be strengthened by averaging across individuals who project their own performance in various tasks.

2.3.3 Familiarity of Crews.

Glickman et al. (1983) noted in their study that there was a lot of variance in the responses of the crew members. In their concluding remarks they state that "...it should be recognized that the results are unrefined estimates of military personnel who were given relatively little time or background in making complex judgments" (p. 75). In their study, training classrooms and conference rooms were used for administering their questionnaire to groups ranging in size from four to forty-four.

The present study attempted to improve the ability of crew members in estimating task times. This was done in a number of ways. First, each crew member had intimate knowledge of each task being studied because he flew each task at least once in the simulator before estimating task-time decrements. This economy and improved validity was achieved by obtaining normative task times and questionnaire decrements from the same pilots during the same "sitting." Each pilot, therefore, knew the exact nature of each task because he had just flown it.

In addition to having intimate knowledge of each task, pilots were given two practice trials in estimating task times. The first practice was before the simulator flight. After having read what their mission and route would be, pilots were asked to estimate how long it would take to perform each of the nine helicopter tasks. Estimates were based on a written summary of each task. The second practice in task time estimation occurred after each crew had flown the simulator mission. The first question handed to each crew member after the simulator run was, "How long did it take you to perform these tasks?". This procedure forced each pilot to relive in his mind each task in detail. Lastly, as compared to Glickman's procedures involving as many as 44 crew members in one room, the procedure of this study provided for a direct question and answer relationship between each 2-person crew and the person administering the questionnaire in a room directly adjacent to the simulator.

2.3.4 A Test of General Performance Decrement Estimators.

A major conclusion of Glickman et al. was that "the expected effects of radiation sickness on performance were very general across the types of tasks, positions and crews sampled by the questionnaires" (p. 71). In addition, the authors conclude that "The analyses indicated that a sizeable portion of the expected decrement could be predicted or explained through knowledge of the scale values of the six symptom components used to construct symptom complex descriptions." These results suggest several things - first, that if the scale values of the symptoms within each complex were clearer, the predictors of decrement would be even stronger; and second, that if pilots were asked to rate the percentage of overall performance resultant from each sickness condition, that one rating across all tasks might account for the same if not more variance in individual task estimates of performance decrement.

To test the utility of obtaining a generalized estimate of overall performance decrement, this study added two questions to the basic questionnaire format. To each of the 37 different sickness conditions, each pilot answered the following: "How sick are you? Scale 1-20", and "Overall performance? What percent?". The answers to these questions would be analyzed with respect to the amount of variance they would explain compared to separate estimates for each task.

2.3.5 Symptom Estimates Versus Symptom Complex Estimates.

Glickman et al. (1983) noted that in their study, "...only a small subset of the possible 7,776 symptom complexes were selected for study" (p. 74). From this, they concluded that "More representative sampling of the symptom complex domain with larger sample sizes would increase predictability and precision of the expected effects of radiation" (p. 74). Although the practical significance of increasing the sample size of respondents is debatable, the fact that not all levels within each syndrome were equally represented in their questionnaire was of concern.

Another concern with procedures in the Glickman study is that the presence of syndromes within a complex was never randomized. The same order was always maintained such that if a symptom within a syndrome were present, the order from first to last was always: Upper GI distress (UG), then Lower GI distress (LG), then Fatigability and Weakness (FW), then Hypotension (HY), then Infection and Bleeding (IB) and then Fluid Loss and Electrolyte

Imbalance (FL). This procedure introduces the potential for systematic error caused by a "position effect."

A demonstration of the potential for position effect is provided in the following two symptom complexes:

> Vomited several times including the dry heaves; severely nauseated and will soon vomit again; exhausted with almost no strength; slightly light-headed; mild fever and headache-like starting to come down with the flu; very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion. (Glickman et al. (1983) symptom code = 515223)
>
> Slightly light-headed; exhausted with almost no strength; vomited several times including the dry heaves; severly nauseated and will soon vomit again; very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion; mild fever and headache-like starting to come down with the flu. (Not used on the Glickman study.)

These complexes portray exactly the same symptoms but in different order. Using a code which indicates the syndrome and severity levels within each complex might be helpful in visualizing what the differential effects of the complexes might be. Such a code would convert Glickman's code (515223) to:

$$UG_5\ LG_1\ FW_5\ HY_2\ IB_2\ FL_3$$

The same code applied to the reorganized version reads:

$$HY_2\ FW_5\ UG_5\ FL_3\ IB_2\ LG_1$$

By focusing in on the number sequences and ignoring the letter codes, one can see that the first complex (515223) portrays very serious problems first and ends with a moderately serious condition. The second complex (255321), however, starts off with a very moderate condition, builds rapidly to very serious conditions and tapers off with decreasingly serious conditions. As a result, it is quite possible that people's estimates based on these two complexes could be substantively different as a result of primacy effects (i.e. what the person reads first) or recency effects (i.e. what the person reads last). Moreover and independent of primary versus recency, there is a whole body of literature which deals with how people's impressions are formed. Such literature shows that when a series of adjectives are presented to people, the first adjective can place a cognitive set or impression which significantly affects how the other adjectives shape the initial impression.

This study considered the issue of position effect to be significant in that it significantly compounds the number of possible combinations. As such, obtaining a representative sample of all symptom combinations escalates from 15,625 (i.e. 5^6) complexes to 11,250,000 complexes (i.e. 6! x 5^6) when considering the added factor of syndrome ordering. The methodological challenge therefore grows by a factor of 720!.

Before discussing how this study proposed to handle the problem of representing all viable symptom complexes, a final comment is needed on the questionnaire administration process. SAIC's experience in administering the Glickman et al. questionnaire was that many crew members criticized the credibility of the questionnaire. Criticisms included:

- the questionnaire was too long
- "usual times" were inaccurate
- symptom complexes were too long (i.e. people had difficulty in assimilating and projecting what it sould be like to have a combination of six different syndromes as portrayed in the questionnaire)
- differentiating between complexes was difficult.

Although research techniques were applied to account for some of the problems encountered (e.g. randomizing the presentation order of symptom complexes), many of the respondents' criticisms appear to have been valid, thus contributing to overall error variance in estimates.

The current study was structured to avoid many of the problems discovered in previous studies. As such, in addition to procedural changes, the questionnaire was redesigned for ease of understanding, speed of completion and utility as a tool for predictive modeling. The most significant change was the decrease in number of symptom complexes presented and an up-front estimation of effects of singular symptoms which were presented in rank order of severity within each syndrome. This approach took all of the guess-work (or error variance) out of the mental process of having to discriminate such symptoms when they were combined into a "complex." This approach also allowed for analysis of scaling differences among the severity levels within each syndrome. In addition, the format of the questionnaire allowed for the listing of sickness conditions along the left column of the pages such that simultaneous viewing of prior answers was easily provided. This was significantly different from the Glickman approach whereby only one symptom complex was listed per page of the questionnaire.

The value of obtaining estimates on every symptom used by Glickman is that it provides a comprehensive baseline for predicting estimates of any combination of symptoms which might form a complex. Such predictions can be based on a model which, through multiple regression, determines the relative weights of symptoms as contributors to the total effectiveness of a symptom complex. To provide this capability, 12 symptom complexes were included in the questionnaire so that a series of simultaneous equations could be evaluated.

2.3.6 "Time Estimates" as a Research Variable.

The value of having pilots give simulator task time estimates before and after their mission "flights" was discussed in Section 2.3.3 as a method of reducing error variance by providing practice to the questionnaire respondents. Another value of this process is that pilot estimates can be validated against their actual task times as measured in the simulator. In other words, the ability to compare pre and post flight estimates with actual task times, as was done in this study, allowed for the answering of some very basic questions pertinent to the validity of the IDP approach:

- How well can pilots estimate task time?

- Can they estimate task times better after having just performed the tasks?

The answers to these questions will add to the confidence placed in the IDP time estimation methodology used. Although the questions don't directly address how well people can predict performance decrement as a result of sickness conditions, they do allow for a better understanding of human performance in the time estimation domain.

In pursuit of a better understanding of human abilities to estimate time, a review of the relevant literature was performed (Ely, 1985). this review plus an annotated bibliography is provided as Appendix F. The results of this review provided valuable insights as to the hypotheses concerning pilot estimates as well as methodologies for controlling extraneous variance. The following are hypotheses which were derived from the review:

- The most accurate estimates will be on those tasks which take longer than one minute.

- Pilots will be accurate in estimating task times that are work related.

These hypotheses were tested in this study and the results and conclusions discussed accordingly. The next section however, discusses the specific methodology for obtaining normative task times and pilots' estimates of radiation induced performance decrements.

SECTION 3

METHODOLOGY

The data collection effort consisted of two-person helicopter crews flying cargo transport missions in a CH-47 Chinook simulator. Crews were introduce to the study and were given materials and time so they could flight plan for two cargo missions. Prior to flying the missions, subjects completed a pre-flight questionnaire that requested biographical data, simulator fidelity ratings and time estimates for a series of tasks that divided the two missions into well-defined flight segments. The crew, consisting of a pilot and copilot, then flew the missions in the CH-47 simulator. During the flights, the actual times required to accomplish the flying tasks were recorded. Upon completion, the pilots recorded in a post-flight questionnaire estimates of how long they took to complete the flying tasks and how various types and levels of sickness might affect the time to complete these tasks.

3.1 SUBJECTS.

Fifty-two U.S. Army CH-47 pilots from the 101st Airborne Division (Air Assault) participated in this study. These pilots formed 32 two-man crews, with six of the pilots participating in more than one crew. The sample included both relatively new (with only 150 flight hours) and highly experienced (up to 6200 hours) pilots. In general, however, the participants were quite experienced (an average of 1580 flight hours) and relatively mature, with an average age of 32. The majority (65%) were warrant officers (see Tables 6 and 7) and the remainder commissioned officers. Only two of the pilots had less than two years of military service, and the majority (55%) had served more than ten years.

The participants were familiar with CH-47s and the CH-47 flight simulator. All of the participants were currently assigned to a unit that used CH-47s and most had a breadth of experience in other aircraft (see Table 8). A third (17) of the participants had combat experience, 12 as combat aviators (see Table 9). Only one pilot had less than 10 hours in the CH-47 simulator, and most had logged over 50 hours (with a mean of 84

Table 6. Grade of participating crew members.

Grade	Frequency	%
Warrant Officer (W1)	8	15.4
Chief Warrant Officer (W2)	9	17.3
Chief Warrant Officer (W3)	10	19.2
Chief Warrant Officer (W4)	7	13.5
First Lieutenant	5	9.6
Captain	10	19.2
Major	2	3.8
Lieutenant Colonel	1	1.7
Missing Data	1	

Total = 59

Table 7. Military occupational specialty of participating crew members.

Military Occupational Specialty	Frequency	%
Warrant Officers:		
100 C - CH-47 Pilot	8	15.4
100 CB - Safety officer	4	7.7
100 CC - IP	9	17.3
100 CG - Maintenance	4	7.7
100 CO - Pilot	9	17.3
100 CF - Instrument Examiner	1	1.9
Commissioned Officers:		
15	2	3.8
15 A	7	13.5
15 A00	1	1.9
15 A001G	1	1.9
15 A41	1	1.9
15 A42	1	1.9
15 A48	1	1.9
15/54	1	1.9
15 S	1	1.9
71 A00	1	1.9

Table 8. Participant flight experience.

Type of Aircraft	Number of Pilots	Percentage (N = 52)
UH-1	38	73.1
AH-1	3	5.8
OH-58	17	32.7
CH-47	48	92.3
CH-54	4	7.7
OH-6	6	11.5

Table 9. Participants' combat flight experience.

Type of Aircraft	Number of Pilots	Percentage (N = 52)
UH-1	11	21.2
AH-1	1	1.9
CH-47	8	15.4
OH-6	4	7.7

hours). Lack of familiarity with CH-47s, or the CH-47 simulator, should not have been a problem in this study.

3.2 FACILITIES.

Based on several considerations, it was decided to use a simulator rather than an actual helicopter. By using a simulator, the reliability of the data would be enhanced since the device could be configured prior to each flight to be exactly as it was for the previous flight. In addition, the simulator would not only permit the control of variables such as aircraft gross weight and weather but these items could be degraded to the level required by the scenario. The safe environment of the simulator afforded the opportunity to examine pilot performance of difficult tasks requiring advanced flying skills under degraded weather conditions. Crew workload could be further increased through simulator-induced emergencies such as engine fires or warnings of anitaircraft threats. Finally, the use of a simulator versus that of an actual CH-47 Chinook helicopter greatly reduced the amount of time required for data collection.

3.2.1 Simulator Description.

The flight missions for this study were performed in a flight simulator produced by Singer Link. This device was designed for training pilots in the use of a CH-47C Chinook helicopter. The primary components of this simulator, as shown in Figure 1 are:

- trainee station
- instructor operator station (IOS)
- visual display system
- motion system
- a digital computer system.

The flight compartment, as shown in Figure 2, contains the trainee station. This cockpit section represents a 100 percent replication of a CH-47C helicopter from the rear of the pilots' seats to the wind shield frames. For purposes of simulations, however, loud speakers and seat vibrators have been included to provide aural and kinesthetic cues to the pilots.

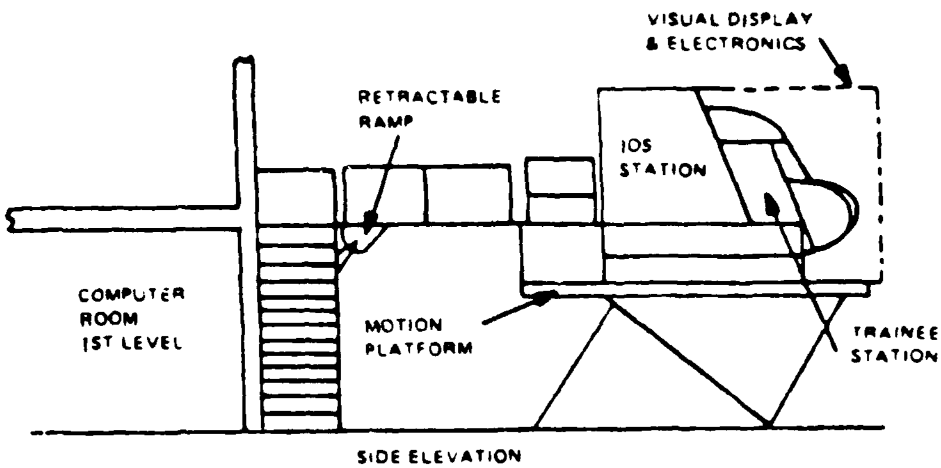


Figure 1. CH-47 flight simulator components.

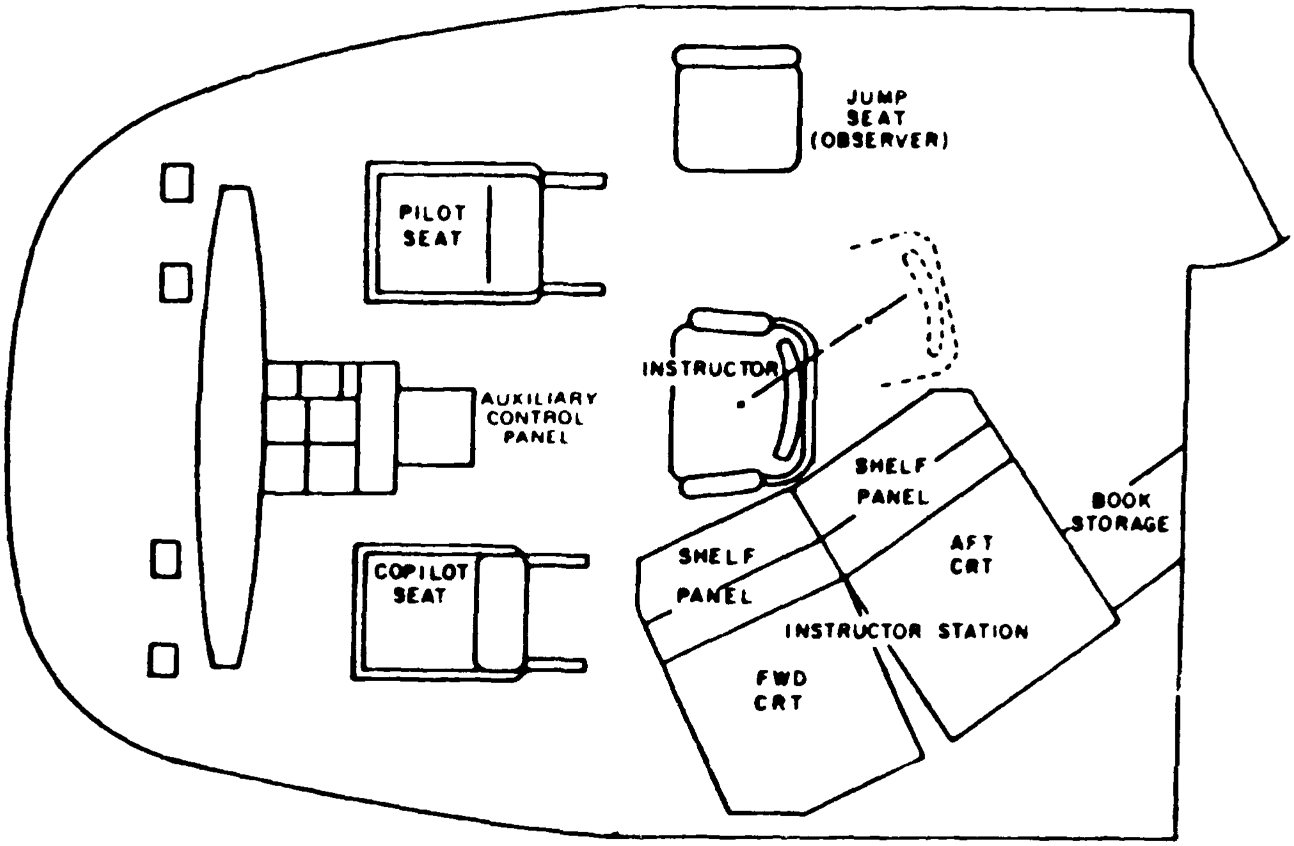


Figure 2. CH-47 flight compartment layout of CH-47 flight simulator.

The instructor operator station is situated behind the cockpit area of the simulator from which the instructor controls and monitors the simulator. This arrangement permits the simulator operator to observe the pilots' actions while assuring correct and safe operation. To assist the operator the station contains two CRTs that display a variety of indications including various weather and aircraft conditions as flight progresses. Behind the pilots' seat is the observer's chair that is elevated to permit the occupant to see the crew's actions as well as monitor the progress of the flight on the instructor's CRTs.

The visual display system provides both pilots with color television images in their front and chin windows. In addition, the right side pilot's door window provides a similar television image. The two forward windows and the command pilots' right side window CRT images are provided by two closed circuit television cameras which are mounted at right angles to each other on gantries that move over two identical model boards in a manner corresponding to the pilots' cockpit inputs. This provides the pilots with a front window and a right side window image of their progress as they "fly" over the three dimensional model boards. The 1:25,000 scale maps of the terrain board are part of the simulator and were provided to the crews. The two chin window displays below the pilots' feet do not contain images from the three dimensional model boards. However, a CRT-generated graphic provides visual cues of motion and altitude change through these windows in the form of a checker board.

The entire flight compartment is mounted on a six-degree-of-freedom motion system that is capable of providing pitch, roll, yaw, lateral, longitudinal, and vertical movement or any combination of these. An additional function of the control computer is its ability to store up to twenty data points for simulated flight.

3.2.2 Differences Between Simulator and Actual Aircraft.

Although a very high degree of fidelity is incorporated into the simulator, there remain some differences between this training device and the actual helicopter that should be considered when examining the flight performance data and the crews' questionnaire responses.

The pilots who participated in this study were assigned to units that used a more recent version (CH-47D) of the Chinook helicopter while the simulation replicates the older CH-47C. While controls and displays are laid out in the same general pattern for both the C and D versions, there are some notable differences. First the two engine condition levers, used to select the condition (stop, ground, flight) at which the respective engines will operate, are located on the center console on the C model while on the overhead panel on the CH-47D. Secondly, both the C and D versions have identical external cargo hook release buttons, but the master hook panels are different. Finally, the D model helicopter also has improvements to reduce pilot workload such as a radar altitude hold system and an upgrade of the cargo hook system to accomodate a sling loaded cargo better.

Since the simulator was designed for training and proficiency, the flight controls are generally more sensitive to pilot input than the actual aircraft. This sensivity of the controls appeared to be most apparent while performing a hovering maneuver. In addition to sensitive controls, the visual display system which is overall quite good, does have some anomalies not typical of the real world. For example the computer-generated synthetic terrain is an artificial cue that is based on seven foot squares which expand, contract and move to correspond with changes in altitude and lateral movement. Although artificial, it appears to be quite helpful especially after the pilots have used it a few times. Another anomaly is that while cruising, the image from the model board can blur as the pilot approaches the ground or executes rapid turns. Furthermore, the visual displays create a perception that the simulated helicopter is at a slightly higher altitude than it actually is. This resulted in the crews clipping a few of the terrain features such as trees. While some details such as windows on buildings and railroad track ties were included on the model board, some pilots indicated that additional visual cues such as power lines and cars along roads would enhance their ability to fly low-level missions. Some pilots remarked that the computer generated clouds unnaturally restricted visibility; however, most crews agreed that the affect was very similar to poor European weather that they had previously experienced. Finally, a few pilots indicated that interior cockpit lights produced glare on the visual display CRT.

The map used in the simulator was on a scale of 1:25,000. The pilots indicated they more commonly used 1:50,000 scale maps while flying. This difference had the affect of the simulator covering a greater distance on the simulator map than normal, however, the level of detail on the map of the model was increased.

3.2.3 Pilot Ratings of Simulator Fidelity.

The pilots involved in the study were asked to respond to questions regarding simulator fidelity and its affect on the time to accomplish the mission tasks. After flying the simulated study missions, the pilots were asked to provide an overall rating of the simulator realism. The pilots indicated that they felt the simulator was moderately realistic with a mean score of 2.8 on a five point scale where "1" represented "very unrealistic" and "5" meant "very realistic".

The pilots were also asked to indicate how simulator fidelity would affect the time it took them to perform the mission tasks. Figure 3 displays the mean pilot ratings of similarity between the times needed to accomplish the mission tasks in an actual aircraft versus the simulator. Pilot ratings were made on a five point scale with "1" meaning "the same" and "5" being "very different". Using this same scale, Figure 4 shows the pilot ratings of the similarity between actual aircraft and simulator times for performance of each of the nine flight tasks. The means of these tasks are what is represented in the preceding figure (Figure 3).

The pilot ratings tended to indicate that cargo hook up and drop off were the flight tasks which would be most affected by using the simulator instead of a real aircraft. Both of these tasks are heavily dependent upon the visual display system and the pilot's ability to hover the simulator. It should be noted that, unique to cargo pickup, there is an approximately seven foot visual misalignment between where the pilot visually perceives the cargo to be and where the simulator operator, who assumes the role of the flight engineer, verbally directs the pilot to center his aircraft. This is due to a software problem and as a result, the simulator requires a higher degree of skill than the actual aircraft.

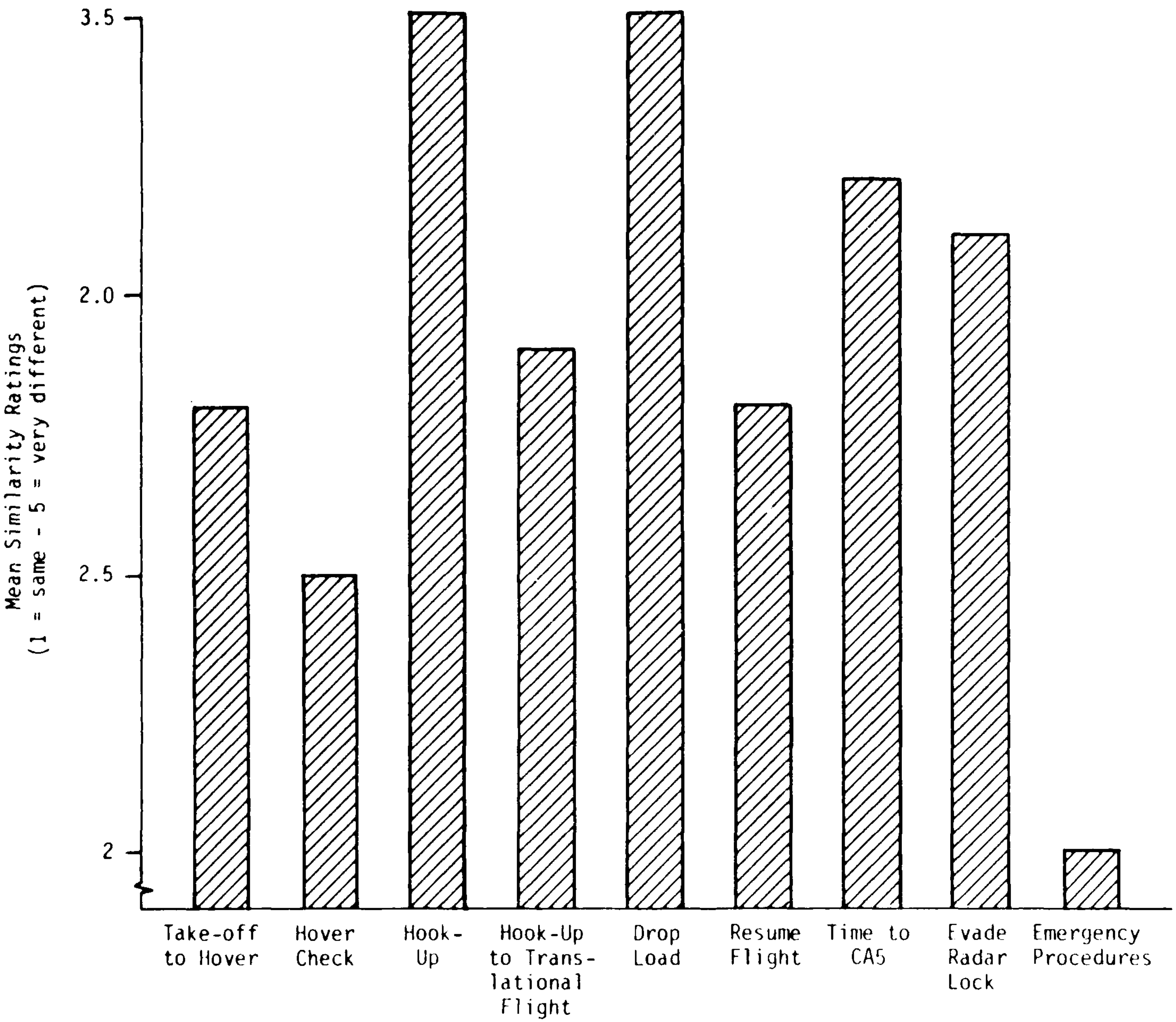
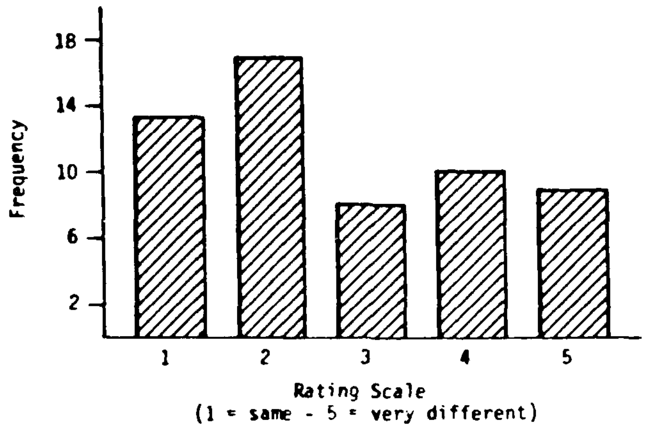


Figure 3. Mean ratings of simulator differences from actual aircraft.

TASK 1. Take-Off to a Hover (no cargo)

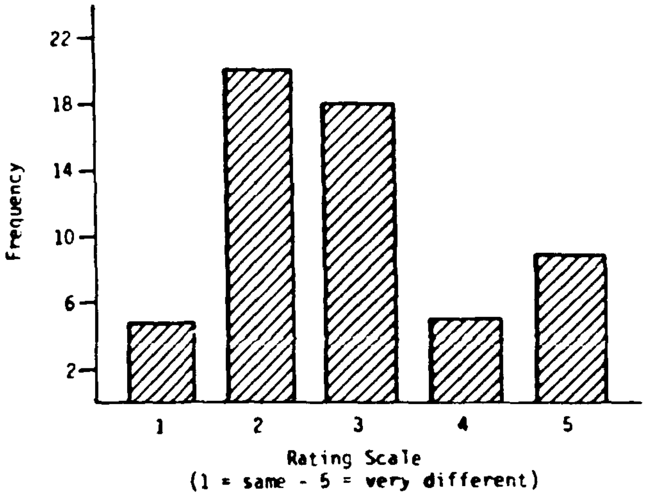


TASK 2. Perform Hover (power) Check

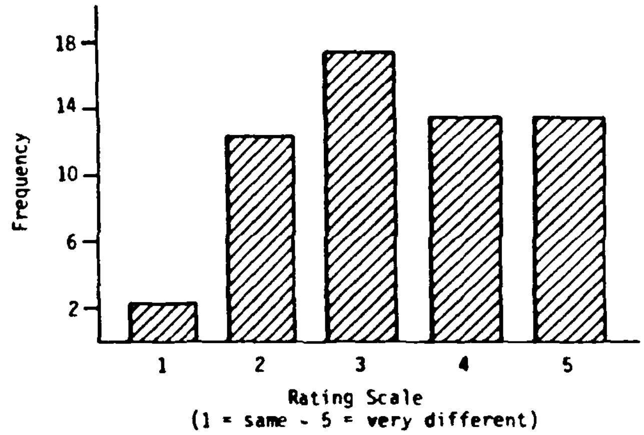
TASK 3. Load Under the Nose to Cargo Hooked-Up

Figure 4. Crew ratings of simulator similarity to real flight task times.

TASK 4. Cargo Hooked-Up to Translational Flight



TASK 5. Load at 100 AGL to Load on the Ground



TASK 6. Load on the Ground to Translational Flight

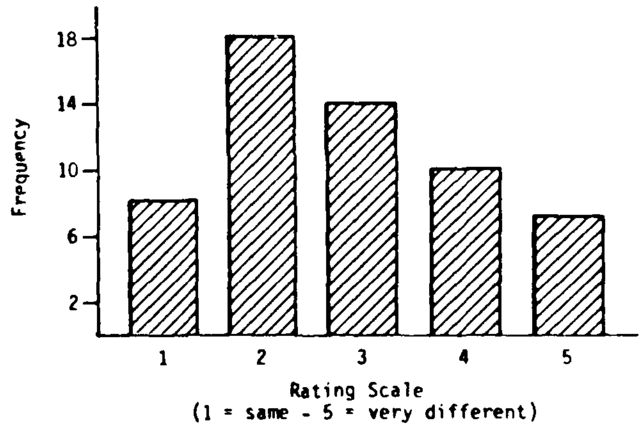
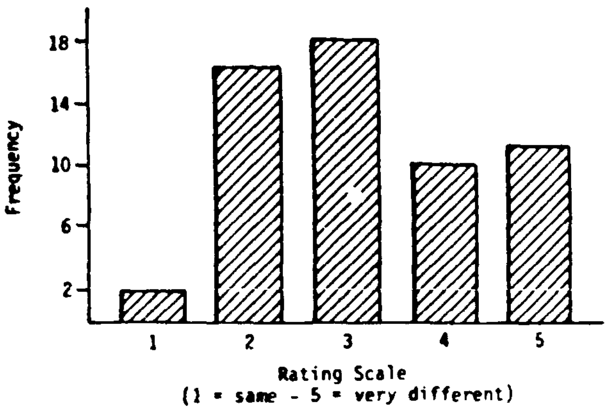
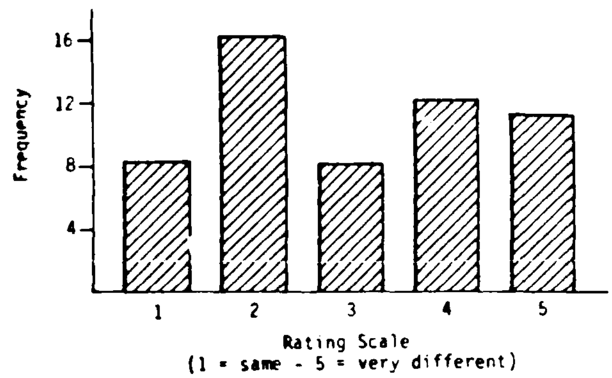


Figure 4. Crew ratings of simulator similarity to real flight task times (Continued).

TASK 7. Enroute Time (with sling load) to Confined Area



TASK 8. From Radar Warning Until Flight Route is Resumed



TASK 9. Time to Accomplish Required Emergency Procedures

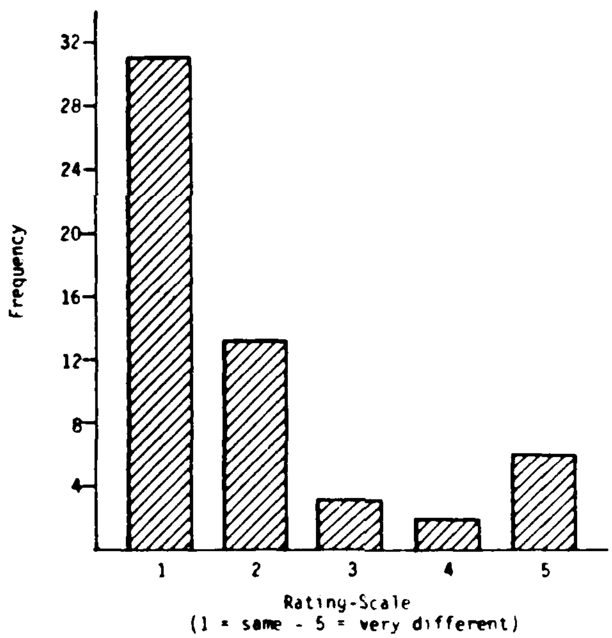


Figure 4. Crew ratings of simulator similarity to real flight task times (Continued).

Also shown by Figure 3 is that emergency procedures and hovering checks were the two tasks that pilots tended to rate as least affected by being performed in the simulator. These two tasks are characterized by memorized procedures that are dependent upon the cockpit layout. These results are not surprising since a major use of the CH-47 simulator is for training such procedures.

3.3 PROCEDURES.

Each crew of two pilots completed the study during one session of two and a half-hours. The sessions were divided into three periods: pre-flight, flight mission, and post-flight.

3.3.1 Pre-Flight Activities.

The crew members reported to the simulator building briefing room that provided the necessary documents and work space for performing pre-flight planning activities. Additional printed materials for the study were provided along with written instructions for them to begin (Appendix A). The printed study materials were:

- Part 1 - Introduction
- Part 2 - Flight Plans
- Part 3 - Simulator Pre-Flight Questionnaire, and
- a map of the model board indicating the routes for the two flights.

3.3.1.1 <u>Briefing</u>. During the briefing period, the data collector introduced the crew to the study, briefed them on the two missions to be flown in the simulator, and walked them through Part 3 explaining the flight tasks to be timed and how the questionnaire should be filled out. The crews were given time to read the materials, complete their flight planning and fill out data required in Part 3.

Selection of pilot and co-pilot positions for the missions was left to the subjects. However, subjects remained in the same role for both flights and if a subject was repeating the study, he was required to switch to to the alternate position. The flight plans for the missions provided the scenario, all data required by the flight crews, and descriptions of the flights.

Prior to starting the simulation, crew members completed the pre-flight questionnaire. The first part requested biographical data about the crew member's military and aviation experiences. Secondly, the questionnaire introduced the subjects to the list of flight tasks to be timed during the missions. Subjects were informed that task definitions were based on the missions presented in the flight plans. The tasks were identified and defined as follows:

- Takeoff to a Hover (No Cargo) - With before-takeoff check completed, takeoff to a hover of 10 ft. ± 3, maintaining heading, and eliminating any drift, assuming that there is no cargo involved.

- Perform Hover Power Check - Perform a hover power check using appropriate checklist and checking predicted hover torque with required torque. Check hover torque, N1, and rpm, and determine if power needed to fly is available.

- Load Under the Nose to Cargo Hooked-Up - From the pilot's announcement that the 18K lb high density load of cargo is under the nose of the helicopter until the flight engineer announces that the load is hooked-up.

- Cargo Hooked-Up to Translational Flight - From the time that the flight engineer announces that the load is hooked and cleared until the load is at 10 ft above ground level and the pilot initiates translational flight.

- Load at 100 ft AGL to Load on the Ground - From the time that the 18K lb high density load is 100 ft above ground level during your approach to land until the cargo is on the ground.

- Load on the Ground to Translational Flight - From the flight engineer's announcement that the load is on the ground, the hook will have to be released and an additional announcement made that the aircraft is cleared for flight. This task ends when the pilot initiates translational flight.

- Enroute Time (With Sling-Load) to Confined Area 5 - This task is defined as the time enroute from takeoff at the airfield with an 18K lb high density load until the final barrior is cleared at Confined Area 5. The planned route should be used for this estimate.

- From Radar Warning Until Flight Route is Resumed - While contour flying along a predetermined route, the radar warning receiver indicates a threat radar. This task starts from the moment the radar warning receiver indicates a threat until the planned flight is resumed after evading the threat.

- Time to Accomplish Required Emergency Procedures - This task is from the first indication of an abnormal engine condition to include the time it takes the crew to recognize the emergency, determine a suitable action, and accomplish the required procedures for an in-flight engine fire.

For each task, pilots were asked to indicate in seconds how long it would take for them to perform these tasks in the simulator.

3.3.2 Flight (Simulator) Activities.

Each crew had a map of the model board (Figure 5) with the flight route marked and a CH-47 in-flight check list in the simulator. The crew would preflight the cockpit while the simulator operator set up for the first mission. When everyone was ready, the operator made a few statements concerning the layout of a CH-47C cockpit and the conduct of the mission. He further clarified his roles as both simulator operator and flight engineer. For consistency, all missions were flown using the same person in the role of simulator operator.

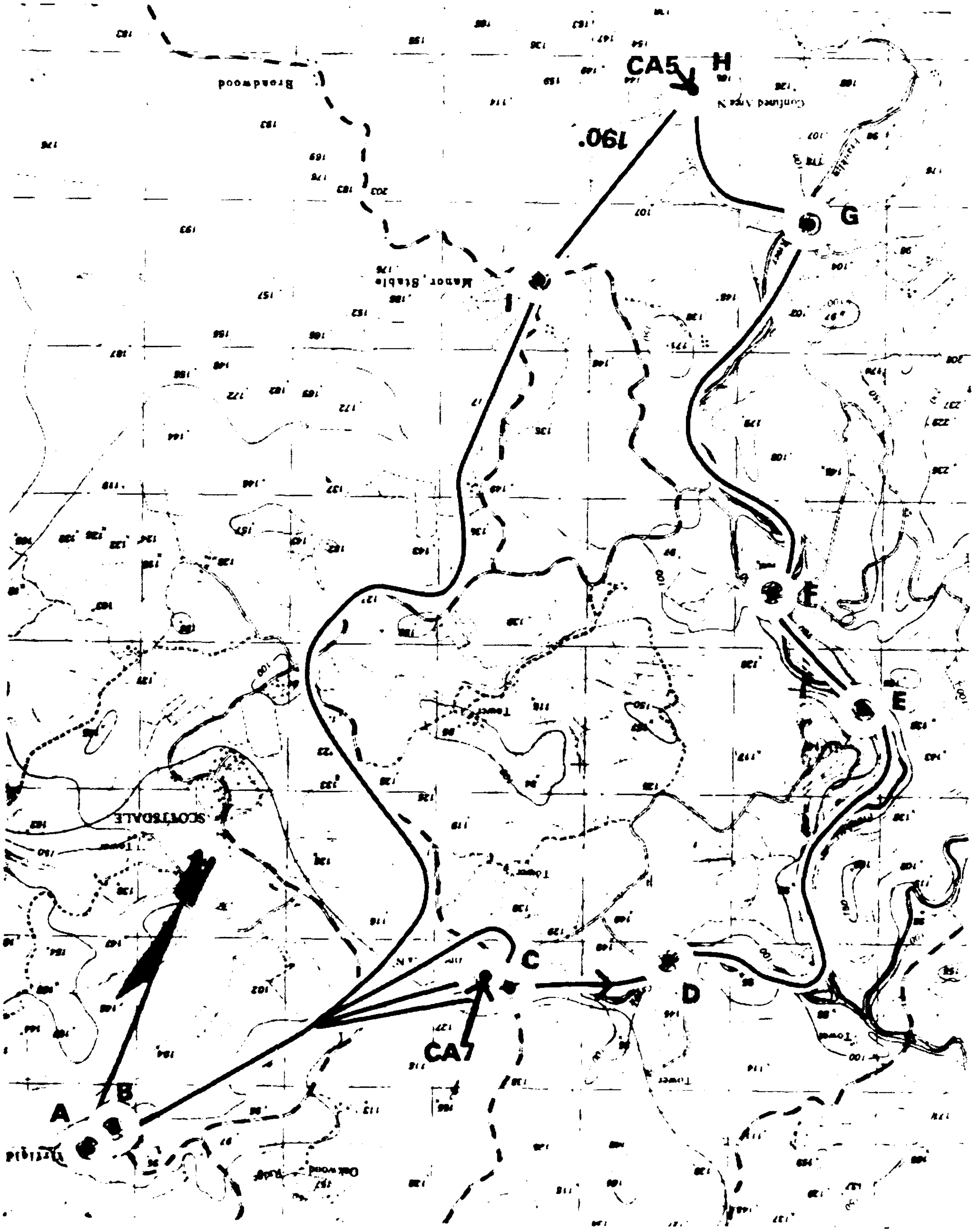


Figure 5. Mission flight map.

3.3.2.1 Mission CA5. The first mission in the sequence involved picking up a very heavy, high density sling load at the airfield and delivering the cargo to a landing zone on the model board designated Confined Area 5. Contour flying techniques were used enroute. The outbound leg of the mission as shown in Figure 5 indicates that the crew followed a river bed to a bridge where the crew executed a left turn up a hill to Confined Area 5 (H). The sling loaded cargo was placed in the landing zone. Leaving Confined Area 5, the crew resumed their low level flying and returned to the air field by following a road bed. A radar directed anti-aircraft attack took place when the crew was a third of the way back to the airfield. Shortly after the attack, the engine fire sequence was initiated by having cockpit instruments indicate a drop in engine #1's oil pressure followed by a rise in the engine's temperature. When the crew was in sight of the airfield, the engine fire light illuminated. The mission ended when all four wheels were on the air field runway.

Flight events were categorized for all missions flown to Confined Area 5. Categories were based on navigation performance and pilot maintenance of aircraft control. Figure 6 presents frequency distributions of events as recorded outbound to Confined Area 5 and the return trip inbound. Below is a summary of each category:

Normal Flights: These were crews who located the air check points and returned to the field without getting lost.

Temporarily Disoriented: These were crews who became noticeably disoriented but regained their bearings unassisted.

Lost and Received Help: These were crews who were becoming lost and recovered based on indirect remarks by the simulator operator (also "flight engineer") who gave cues as to probable landmarks.

Lost and Machine Stopped: These were crews who were becoming lost and did not respond to hints as to landmarks. Their disorientation led to a definite and uncorrected wrong turn causing the operator to stop the machine and reorient the crews.

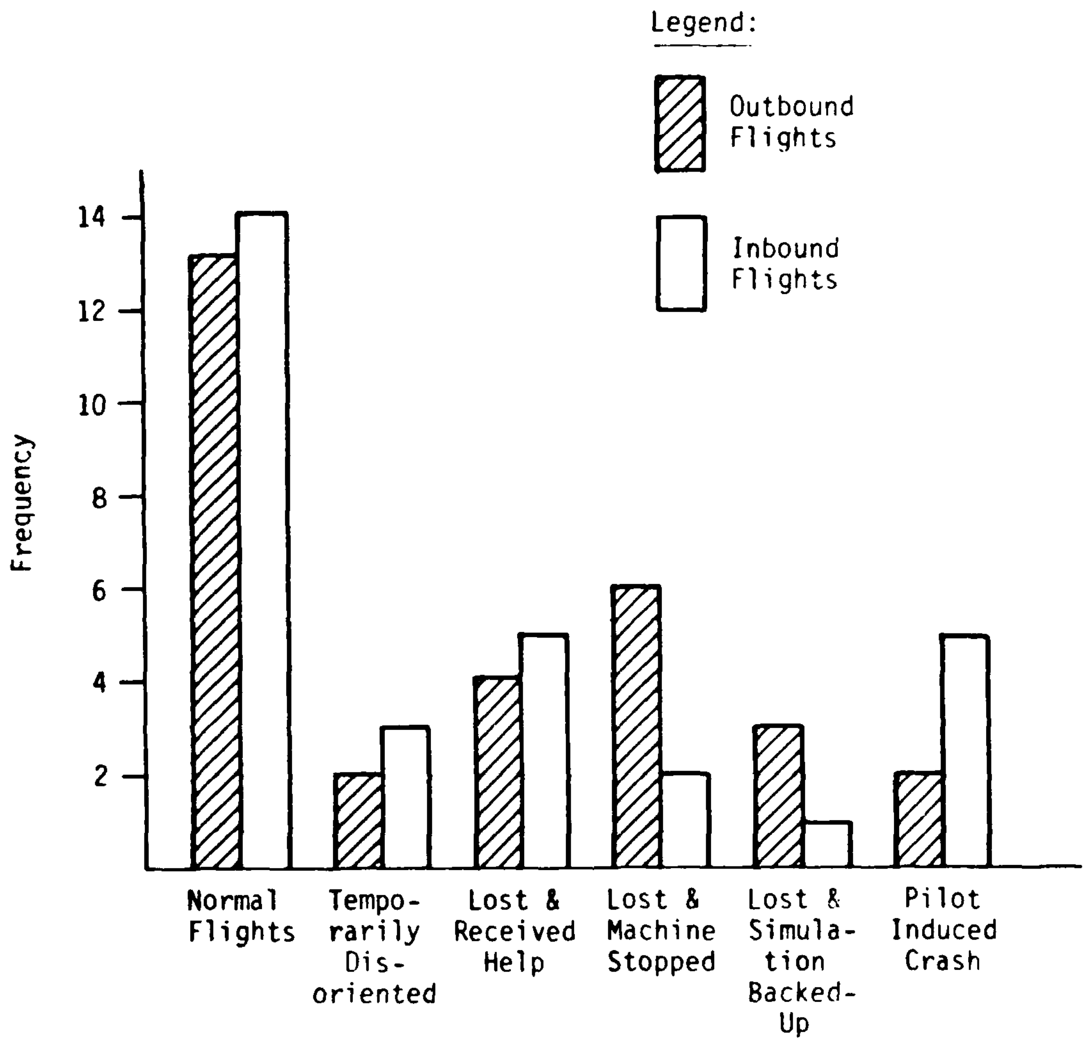


Figure 6. CA5 mission flight events.

Lost and Simulation Backed-Up: These were crews who became noticeably disoriented, responded to hints unknowingly in the correct direction and never really knew where they were going. As such, the simulator operator was required to stop the simulator, back it up and reorient the crew.

Pilot Induced Crash: These were crews who experienced a simulator crash which was induced by the pilot (i.e. due to pilot error as opposed to simulator malfunction). Crashes due to machine failure were not included.

Figure 6 shows that just under half of the crews had normal flights with the rest having been disoriented to varying degrees. This fact attests to the success of the simulator in creating, through low visibility and high gusty winds, an overall condition of very high workload. There were some differences between outbound flights (i.e. carrying cargo to Confined Area 5) versus inbound flights (i.e. returning home and getting radar warnings and engine failures along the way). These differences show that more pilots got lost trying to find Confined Area 5 and more crews crashed upon returning from Confined Area 5. Getting lost was probably because Confined Area 5 was much harder to acquire visually than an open airfield. The fact that slightly more than twice as many crews crashed on the return flight than on the outbound flight is probably due to the extremely high workload and channelized attention associated with evading threats and handling the engine fire.

Simulator device failures were recorded during the mission to Confined Area 5. Figure 7 shows that the majority of mission legs flown (39) were not hampered by simulator failures. An equal number of inbound (8) and outbound (8) flight legs experienced one flight interruption due to difficulties with the device. Five flight legs were interrupted by two or more machine failures. Generally, the simulator performed very well considering the demands placed on the device by the high speed, low level flying performed during the study. Machine failures should not be considered as having a significant impact on the results of the study.

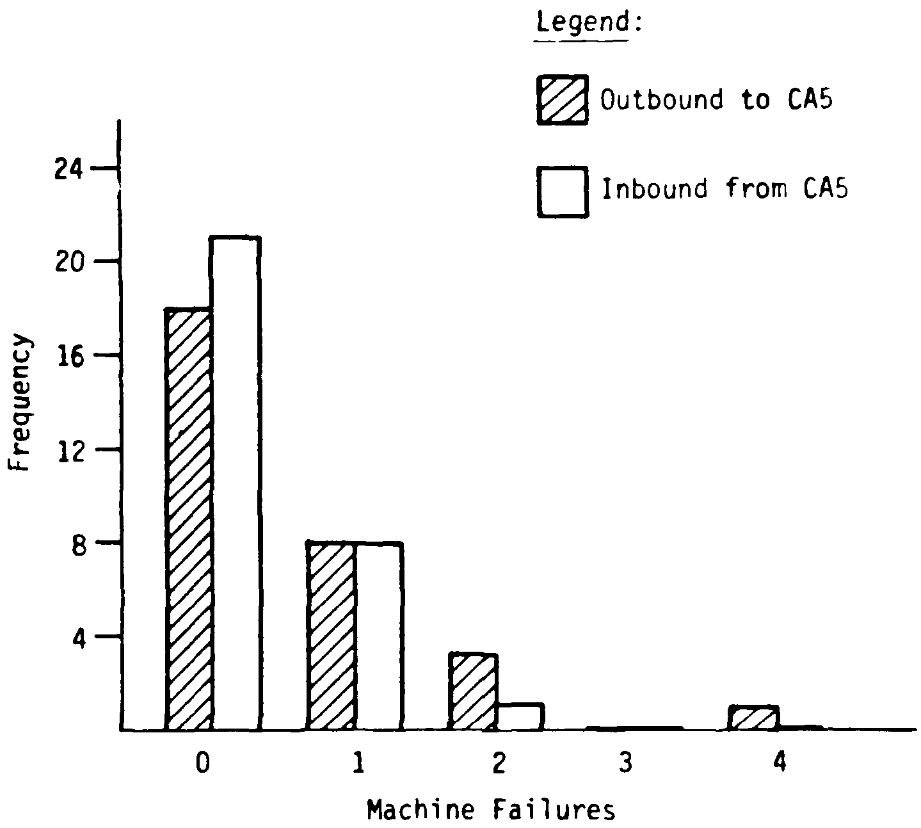


Figure 7. CA5 mission machine failures.

3.3.2.2 Mission CA7. As for the mission to Confined Area 5, the mission to Confined Area 7 began with cargo pick-up from the airfield. After departing the airfield with the sling loaded cargo, the crew was required to turn a few degrees right (as shown by Figure 5) and fly into Confined Area 7, located approximately three miles off the end of the airfield. Upon unloading the cargo the crew could then pedal turn the helicopter and return to the airfield and land.

The same six categories used to examine crew performance during the mission to Confined Area 5 were applied to the mission to Confined Area 7. Due to the short duration of the CA7 mission, outbound and return leg flight events were combined. Figure 8 shows that all but four crews were able to complete the CA7 mission successfully with three crews requiring navigational help and one crew not completing the mission due to a pilot induced crash. Two crews experienced one simulator failure each during the mission to Confined Area 7.

3.3.2.3 Measuring Task Times. During the two missions flown in the simulator, both the simulator operator and the data collector recorded times to complete the nine flight tasks. A Pearson Correlation Coefficient was used to examine the relationship between the task times separately recorded. The in-flight recorded times for the task to detect and evade the anti-aircraft attack (radar warning threat) were selected for examination (N=22). The calculation of the Pearson r for the simulator operator's and the data collector's recordings for the radar warning threat task is $r=0.948$ ($df=20$, p. 01) indicating a very high correlation between the two sets of data collected.

3.3.3 Post-Flight Activities.

After completing the two simulated flights, each individual was presented with a Post-Flight Questionnaire (Appendix A). All crews were briefed on the questionnaire using a walk-through method to explain the various questions and examples. The individuals completed the questionnaires after which they were debriefed and thanked for their cooperation.

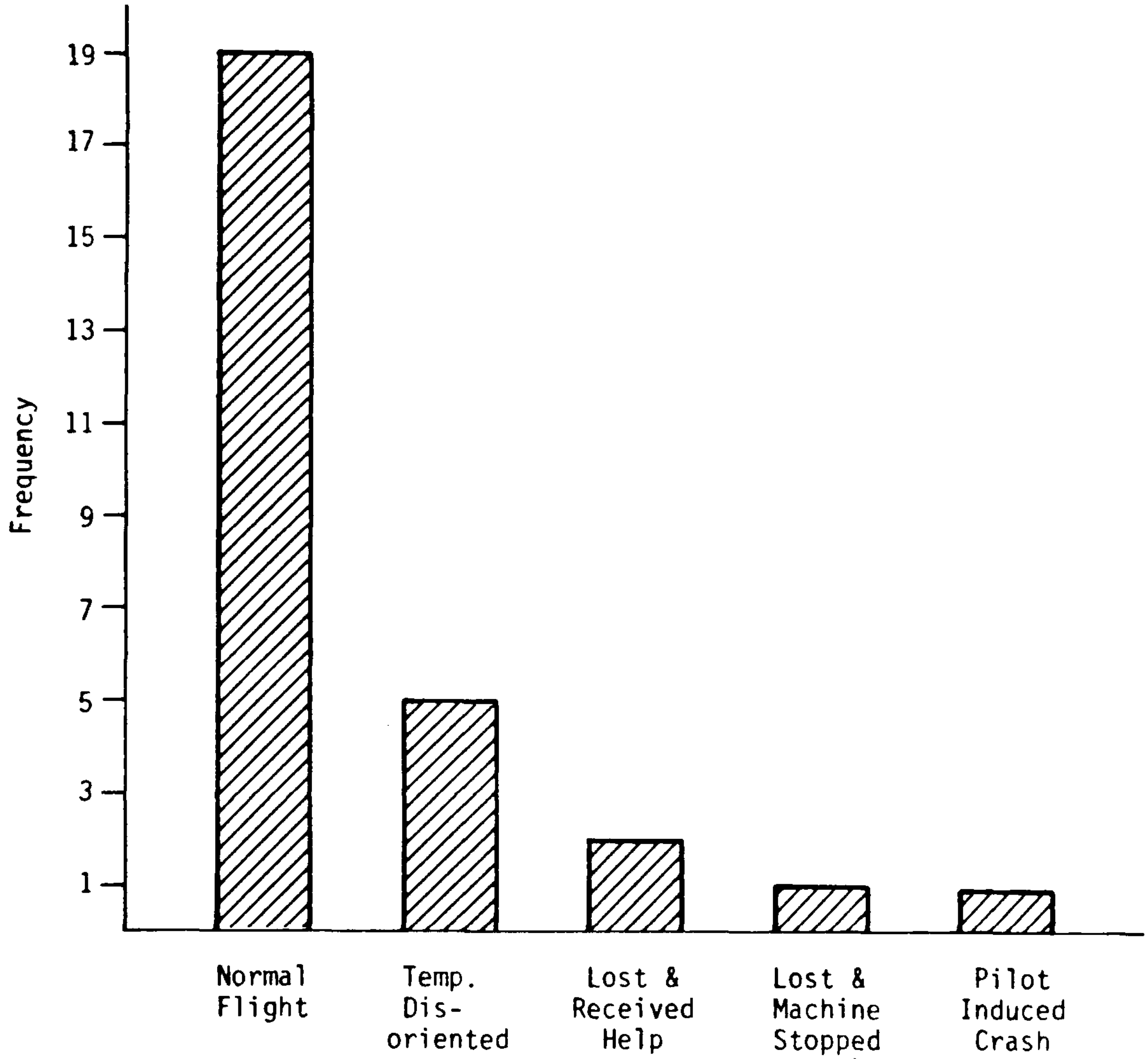


Figure 8. CA7 mission flight events.

3.3.3.1 Post-Flight Questionnaire. The Post-Flight Questionnaire consisted of three sections: crew estimates of task times for the tasks flown; examples of estimates of health effects on task times; and crew estimates of task times under varying conditions of health. Provided with the list of nine tasks and definitions, individuals were asked to estimate accurately how many seconds it took to perform each of the tasks in the simulator. Next, on a five point scale, where "1" means "the same" and "5" means "very different", subjects were asked to rate how similar the simulator task times were when compared to the times required in the actual aircraft. Finally, on a five point scale where "1" means "the same" and "5" means "very different", subjects rated how realistic the simulator was, the results of which were discussed under section 3.2.3 Subject Ratings of Simulator Fidelity.

The second section in the questionnaire required the pilots to estimate how certain symptoms might affect performance in terms of task time. An example together with an explanation was provided to the pilots to acquaint them with the format and procedures for completing the questionnaire. Column one listed various physical conditions. The pilots were asked to draw on past experiences and to imagine how they would feel if they had these symptoms. Having developed a mental frame of reference for certain symptoms, the subjects were instructed to make ratings and time estimates. Column two asked the question, "How sick are you?". Imagining the level of sickness listed in column one, the individual was required to relate this to a 20 point scale where:

1 is completely incapacitated - cannot move or talk,
10 means fairly ill, and
20 represents feels good, a good nights sleep the night before.

For each symptom listed in column one, the subject was instructed to imagine how the physical condition would affect his total capacity to perform his duties as a pilot. The response to this question was based on a 100 point scale, meaning 100% ability to do the task. The remaining columns define a series of tasks. Considering each physical condition listed in the first column, the subjects estimated how many seconds it would take for them to perform each task individually.

Using the same procedures shown in the example, subjects completed Section Three of the Post-Flight Questionairre. In this final section, the subjects were instructed to consider 37 different physical conditions arranged into six syndromes and twelve symptom complexes (Appendix G). Each of the six syndromes had five levels of physical symptoms (the first one always being healthy, feeling fine). Physical symptoms were combined to produce twelve symptom complexes. Columns two and three posed the questions: "How sick are you?" (Scale 1-20); and "Overall performance? What percent?". Both of these questions were answered in relation to the physical condition listed in column one. The remaining columns listed the original nine flight tasks. Considering the varying conditions of health listed in column one, subjects estimated in seconds the time to complete the flight tasks just completed in the simulator missions.

Of the 2 1/2 hours of data collection, the pre-flight questionnaire and mission briefing took approximately 15 minutes. The actual simulator mission took between 30 minutes to an hour. Answering the post-flight questionnaire was definitely the most tedious and took about 1 1/2 hours to complete.

SECTION 4

RESULTS

This chapter describes the basic findings of this research effort. These findings are divided into four areas. The first section presents the normative task times measured during the flight simulation missions. The second section examines the ability of the participating pilots to estimate the time it takes to perform tasks. Section three describes the pilots' estimates of the effects of the symptoms and symptom complexes on task times. The final section examines how the pilots arrived at their estimates of these effects.

4.1 NORMATIVE TASK TIMES.

One of the major goals of this research was to establish the normal time it takes helicopter crews to perform a number of basic tasks. The times required for these tasks was recorded during the simulator flight missions. Table 10 gives the mean task times for the various tasks in the two missions.

Not all the task times were recorded in both missions. Some tasks were not performed in both missions, and methodological limitations prevented repeated timing of others. For those task times that were repeated in both the CA5 and CA7 missions, the two mean task times were averaged. These averages are reported in the last column in Table 10.

4.2 ACCURACY OF PILOTS' TIME ESTIMATES.

The simulator crew members participating in this study were asked to estimate how long it would take them to accomplish nine different tasks. They made these estimates before their simulator flight missions, and immediately after the flight. Table 11 presents both the mean pre and post flight estimates of task times. This table also shows the actual times it took to accomplish these tasks in the flight simulation missions. Figure 9 compares these three variables graphically.

Table 10. Mean task times for CH-47C flight simulator missions.

Task Descriptions	CA5 Mission	CA7 Mission	Average
Take-off to hover (no cargo).	24.07 (28, 8.98)	23.32 (28, 10.40)	23.70
Perform hover (power) check.	38.00 (24, 18.76)	29.54 (26, 17.98)	33.77
Load under the nose to cargo hooked-up.	78.11 (28, 34.03)	68.54 (28, 89.64)	73.33
Cargo hooked up to translational flight.	62.57 (28, 31.50)	52.39 (28, 13.69)	54.48
Load at 100 ft. AGL to load on the ground.	65.50 (28, 62.61)	--	NA
Load on the ground to translational flight.	--	49.29 (21, 54.95)	NA
Enroute time (with sling load) to CA5.	767.00 (29, 288.80)	--	NA
From radar warning until flight route is resumed.	37.39 (26, 16.45)	--	NA
Time to accomplish required emergency procedures.	27.26 (23, 9.26)	--	NA
Total time for mission.	1650.25 (24, 503.30)	707.04 (27, 214.34)	NA NA

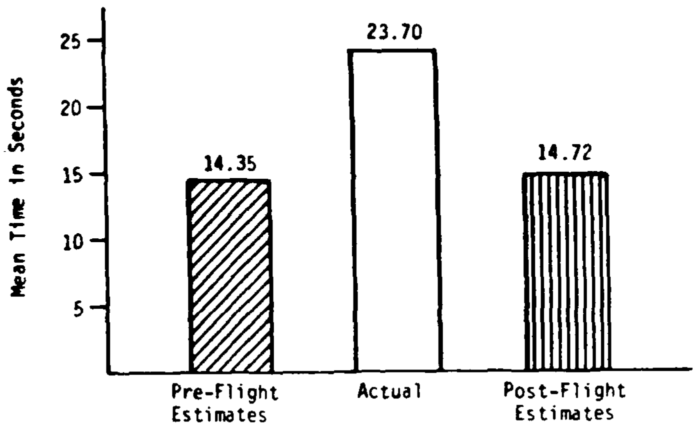
Note: Mean time in seconds; N and std. dev. in parenthesis

Table 11. Crew estimates and actual times for CH-47C flight simulator tasks.

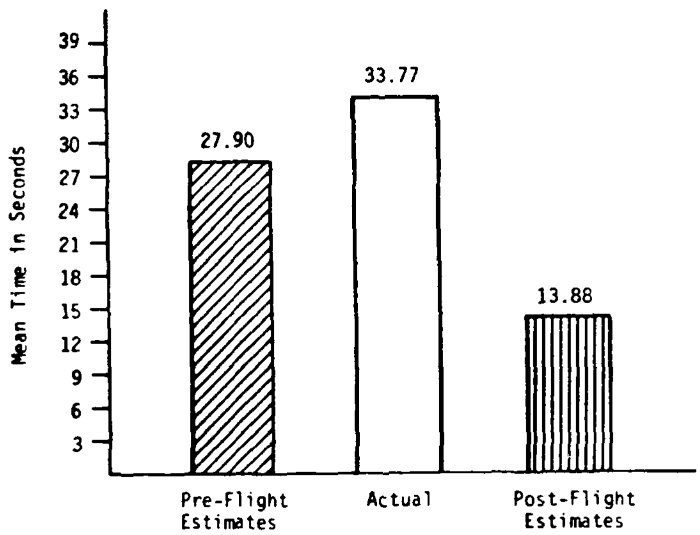
Description of Tasks	Pre-Flight Estimate	Actual Task Times	Post-Flight Estimate
Take-off to hover (no cargo).	14.35 (51, 9.46)	23.70*	14.72 (50, 13.43)
Perform hover (power) check.	27.90 (51, 36.39)	33.77*	13.88 (50, 13.01)
Load under the nose to cargo hooked-up.	58.45 (51, 51.16)	73.33*	82.02 (50, 77.90)
Cargo hooked up to translational flight.	40.08 (51, 28.98)	54.48*	34.34 (50, 31.03)
Load at 100 ft. AGL to load on the ground.	58.47 (51, 41.29)	65.50 (28, 62.61)	48.54 (50, 41.64)
Load on the ground to translational flight.	27.00 (50, 24.96)	49.29 (21, 54.95)	28.94 (50, 29.60)
Enroute time (with sling load) to CA5.	653.60 (50, 299.99)	767.00 (29, 288.80)	709.86 (50, 391.24)
From radar warning until flight route is resumed.	101.98 (50, 95.61)	37.39 (26, 16.45)	126.41 (48, 142.24)
Time to accomplish required emergency procedures.	41.76 (50, 36.26)	27.26 (23, 9.26)	25.23 (48, 30.84)

Note: Mean time in seconds; N and std. dev. in parenthesis
* Average of CA5 and CA7 task times

TASK 1. Take Off to a Hover



TASK 2. Time Required to Perform Hover (Power) Check



TASK 3. Time From Load Under the Nose to Cargo Hooked-Up

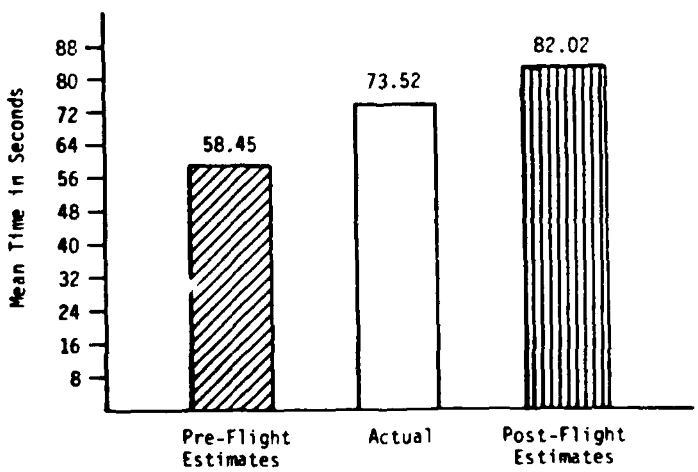
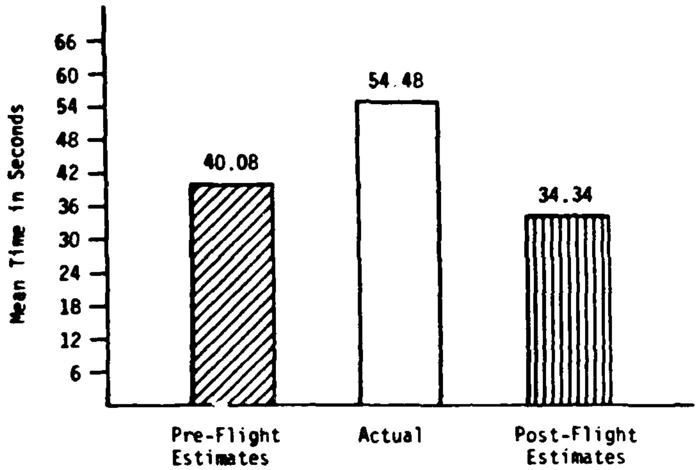
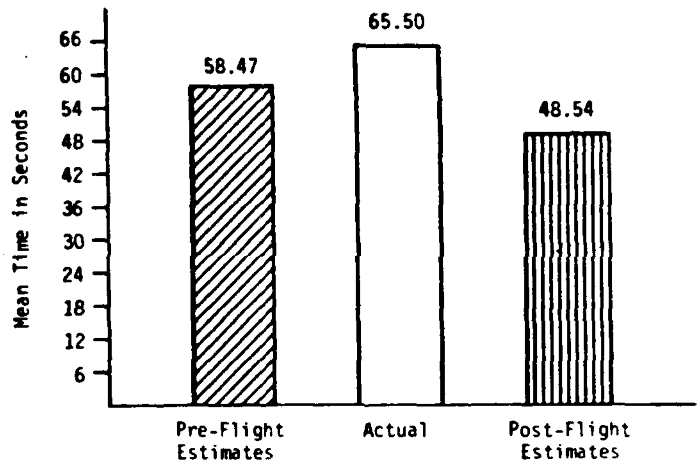


Figure 9. Estimated and actual task times.

TASK 4. Time From Cargo Hooked-Up to Translational Flight



TASK 5. Time From Load at 100 ft. AGL to Load on the Ground



TASK 6. Time From Load on the Ground to Translational Flight

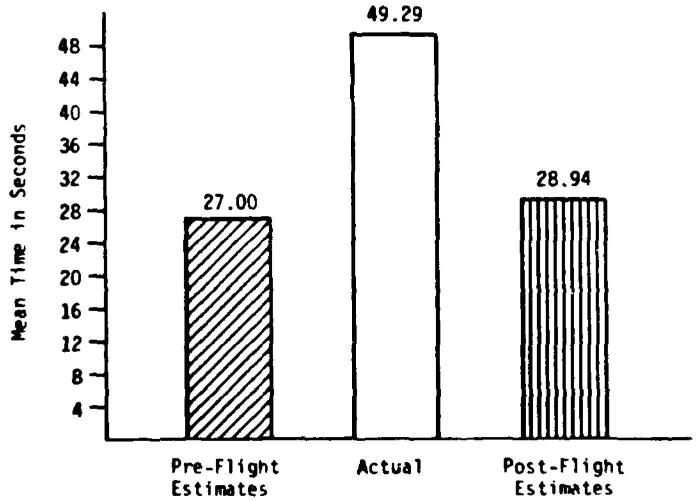
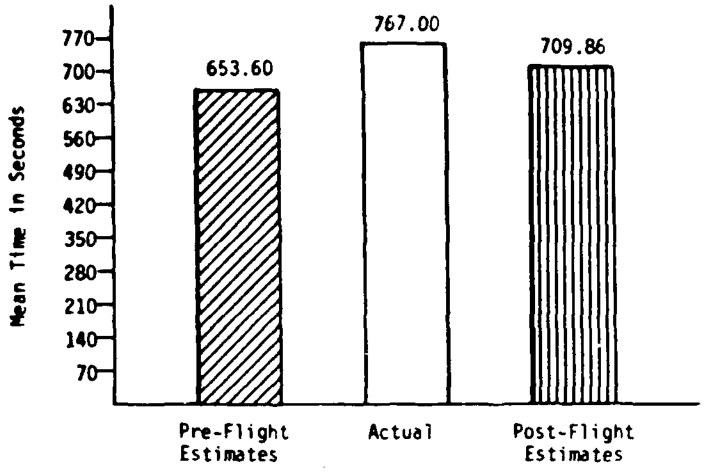
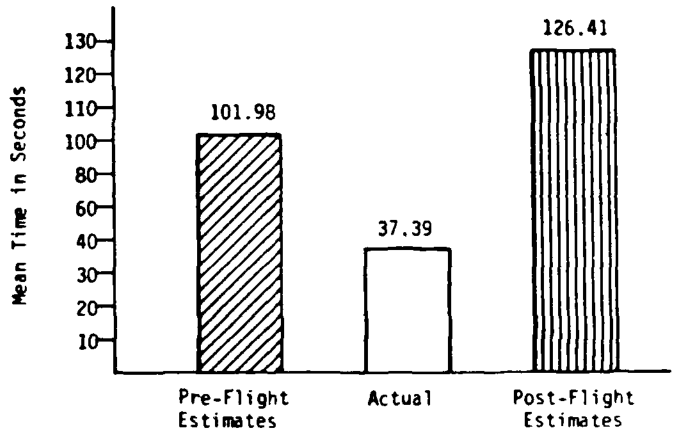


Figure 9. Estimated and actual task times (Continued).

TASK 7. Enroute Time to Confined Area: 5



TASK 8. From Radar Warning Until Flight is Resumed



TASK 9. Time to Accomplish Required Emergency Procedures

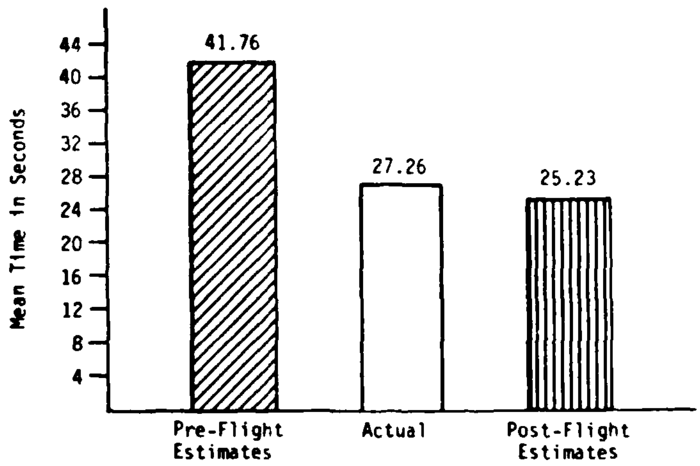


Figure 9. Estimated and actual task times (Continued).

To ease comparisons of pilots' ability to estimate task times for different tasks, the time estimate scores were converted into accuracy scores. The accuracy scores indicate the percentage the time estimate was above (+) or below (-) the actual task times. This was computed by subtracting the actual task time from the time estimated for the task, dividing the difference by the actual task time, and multiplying by 100. A value near zero indicates an accurate estimate, a high positive value indicates that the pilots overestimated the time required for the task, and a high negative accuracy score indicates they underestimated how long it would take them to complete the task. Accuracy scores for both the pre and post flight task time estimates are shown in Figure 10.

The pilots were most accurate at estimating the enroute time to confined area 5. Both the pre and post flight estimates for this task are essentially equal, and do not differ significantly from zero. That these estimates are most accurate is not too suprising; pilots have a good deal of experience estimating flight times and may never have tried to estimate the other eight tasks previously. It is also interesting to note that enroute time was the task that took by far the most time and that time estimates were not nearly as accurate for the shorter tasks.

Accuracy was so poor for two tasks that they could not be reported in Figure 10 on the same scale as the other tasks. The gross overestimation of the times required for evading a radar lock and the pre flight estimate of the time required for emergency procedures may be caused by experimental artifacts. The time required to break a radar lock was measured as the time from the radar warning to the indication that the radar lock was broken. Many of the pilots, however, may have thought that the task did not end until they resumed their previous course, which could take much longer than simply breaking the lock. Limitations in the simulator necessitated the use of the former task definition, while written instructions on the questionnaire indicated the latter. The participants were verbally instructed about this modification, but many subsequently expressed their confusion on the definition of this task, and asked for clarification. The inaccurate time estimates for this task may say more about the importance for clearly defining and communicating task definitions than about the pilots' ability to estimate task times.

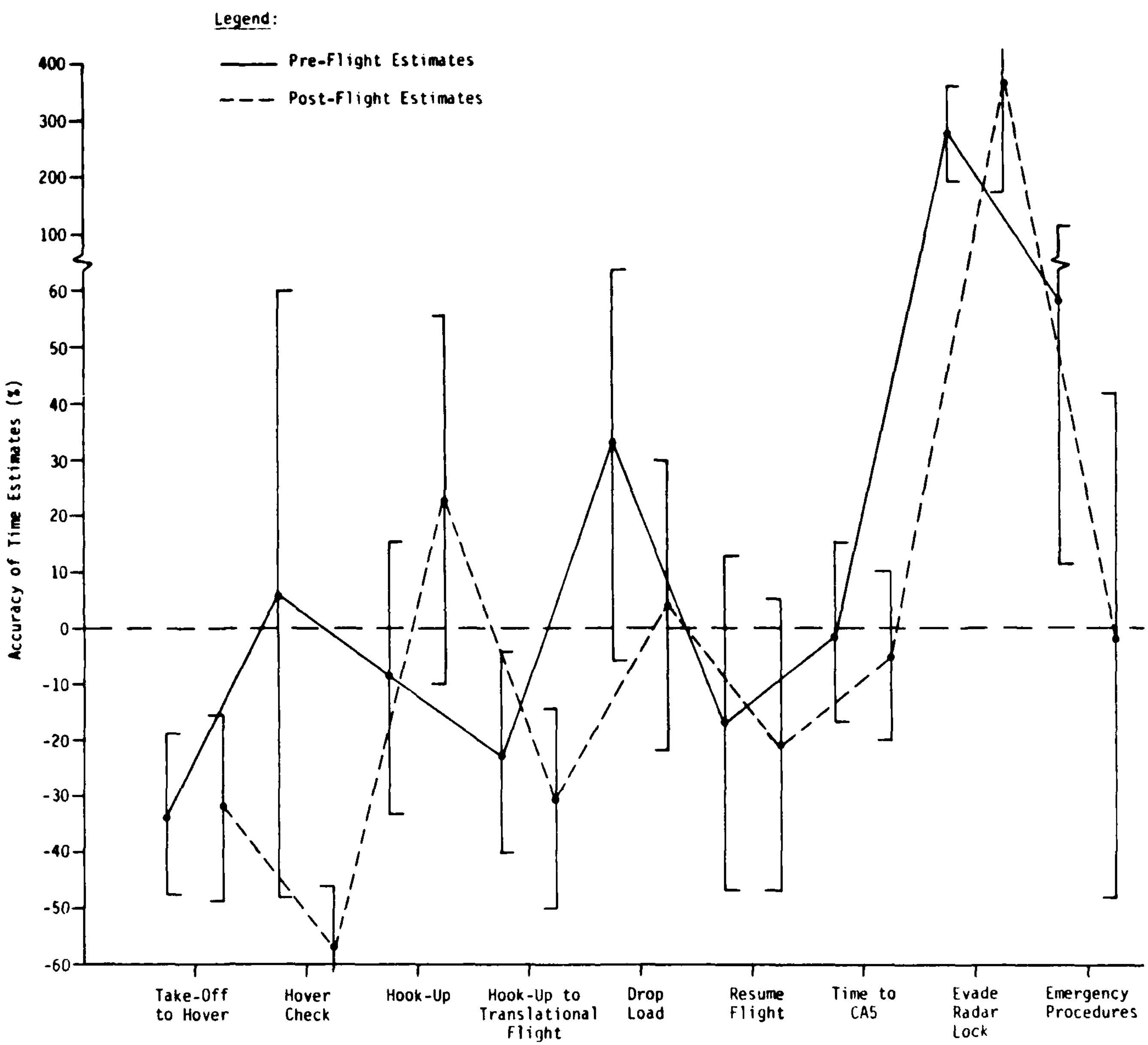


Figure 10. Accuracy of crew estimates of task times.

Poor preflight estimates of the time required to perform emergency procedures may also have been caused by confusion about the task definition. Before the flight simulation, helicopter crews could only be told about the emergency in general terms. Not knowing exactly what would happen, the pilots may have assumed more would have to be done to respond to the emergency than was actually required in the simulaion. After having actually performed the emergency procedure during the simulation, the crew members may have had a clearer understanding of the task, and hence their post flight estimates were much more accurate.

Two major conclusions can be drawn about pilots' ability to estimate the six remaining tasks. First, they do not seem to be particularly accurate at estimating the times for these shorter duration tþsks. In general, their estimates vary ±30%, with no real consistent pattern. These results cast real doubt on the ability of pilots to accurately estimate times for tasks other than enroute flight times

The second major generalization that may be made from these results is recent experience from doing the tasks in the simulator does not appear to improve accuracy. Despite being sensitized to the tasks in the preflight questionnaire, and then performing them in the simulation, post flight task time estimates were worse than preflight estimates for most tasks. So while the simulator missions were important for collecting normative data about task times, they do not appear to have caused any real improvement in accuracy of task time estimates.

4.3 ESTIMATES OF RADIATION EFFECTS.

How well will helicopter crews be able to perform after receiving different doses of radiation? To help estimate how performance will be degraded if their crews are experiencing different physical symptoms, the participants were asked to estimate what the nine task times would be if they were feeling each of 37 different physical conditions.

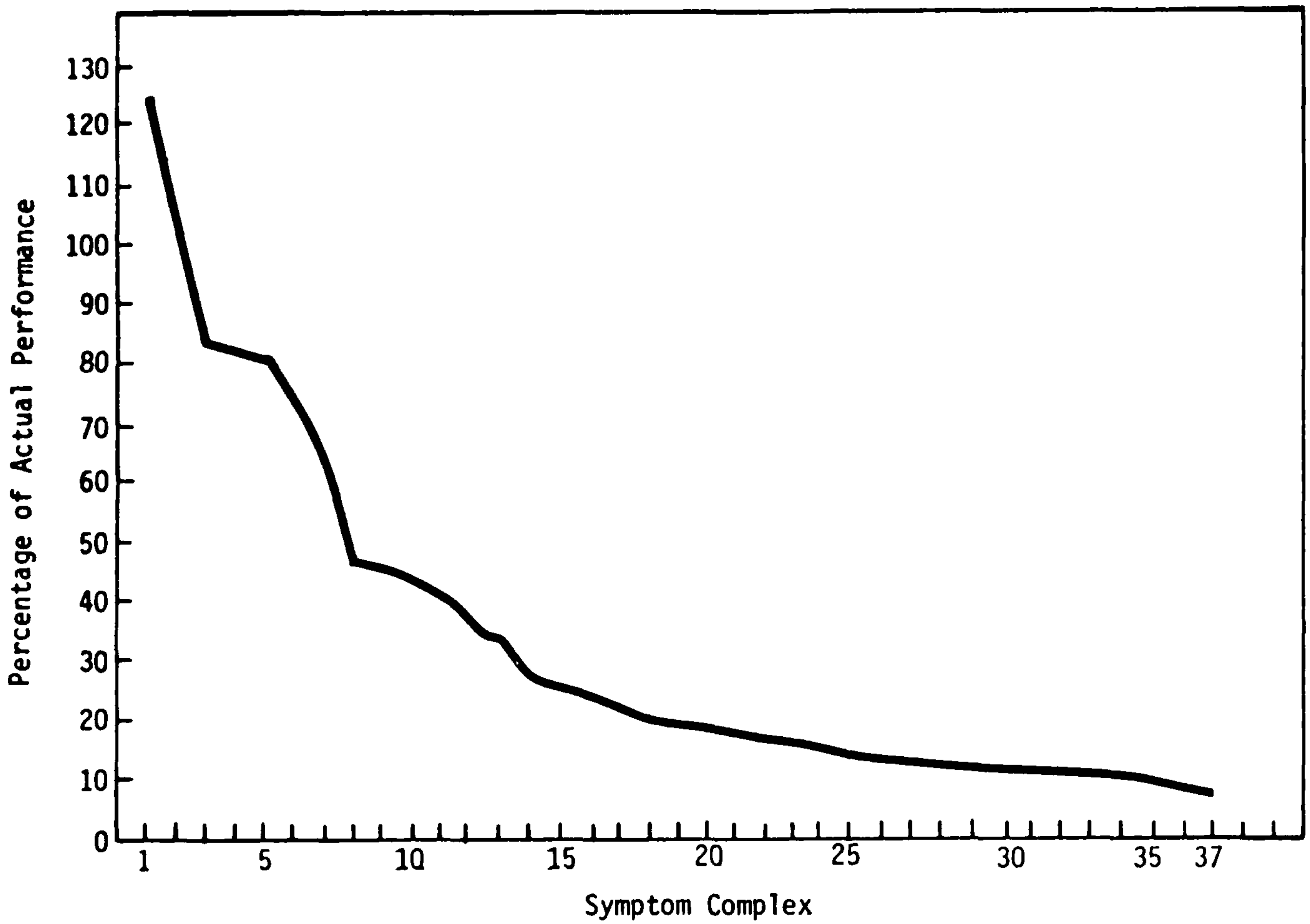
The mean task times for each of the nine tasks, under all physical conditions, are reported in Appendix H. For computational purposes, all scores indicating that someone feeling so sick that he would not be able to do a task at all were considered equal to a score of 9999 seconds (27 hours and 45 minutes). Because of this, any unreasonably high time estimates (such as 10 times the Healthy - Feeling Fine condition) should be considered to indicate incapacitation.

The severity of the different physical conditions is determined by the percent of normal performance indicated on the tasks. Since pilots were most accurate at predicting enroute time to CA5 (and there is no evidence that pilots discriminated between the tasks, see below), this time estimate was used to rank order the 37 physical conditions. The percent of normal performance was calculated by taking the ratio of the actual enroute time measured in the flight simulation to the mean times estimated for each of the physical conditions. This ratio was then multiplied by 100 to indicate the percent of normal performance estimated for each physical condition. Figure 11 shows the rank orders of the different physical conditions, and plots the percent of normal performance for each condition.

4.4 PREDICTING ESTIMATES OF RADIATION EFFECTS.

How did the pilots participating in this study make their estimates of performance degradation? The validity of this methodology, and the choice for future approaches to estimating radiation induced performance degradation depend upon the answer to this question. Two major issues involved in this question are addressed by this analysis. The first is whether the pilots did discriminate between tasks, or whether performance estimates were degraded similarly for all tasks. The second issue is whether asking for estimates of task times are the best way of determining performance degredation.

The pilots did not discriminate between tasks when estimating the effects of the symptom complexes. All tasks were decremented by approximately the same percentage for a given physical condition. The correlations between time estimates (by physical condition) for the nine tasks were remarkably high (Table 12). The lowest correlation between task times is .85 (p .0001), and most of the correlations are above .90. It appears that pilots made a single determination of how performance would be degraded for a given physical condition, and applied the same relative amount of degradation for all tasks.



Order of Symptom Complexes

1. 111111	21. 111141
*2. 112111	*22. 514111
3. 111211	23. 344231
4. 121111	24. 511111
*5. 211111	*25. 535111
*6. 113111	*26. 515311
7. 111121	27. 111114
*8. 114111	*28. 314113
9. 111311	29. 515223
*10. 311111	30. 151111
11. 131111	*31. 515431
12. 111112	*32. 525111
13. 111131	*33. 315113
14. 111113	*34. 415314
*15. 411111	35. 111151
16. 111411	36. 111511
17. 115111	37. 111115
*18. 314112	
19. 141111	
*20. 414112	

*Symptom complexes used by Glickman, et al., 1983.

Figure 11. Mean percentage of actual performance as a function of perceived symptom complex severity.

Table 12. Correlations between task time estimates.
(n = 2146)

	1	2	3	4	5	6	7	8	9
1. Take-off to hover	1.00								
2. Hover check	.96	1.00							
3. Load hook-up	-.93	.89	1.00						
4. Hook-up to trans-lational flight	.94	.91	.97	1.00					
5. Drop load	.93	.90	.98	.98	1.00				
6. Resume flight	.93	.91	.96	.98	.97	1.00			
7. Time to CA5	.92	.89	.94	.94	.95	.94	1.00		
8. Break radar lock	.89	.87	.91	.92	.92	.92	.92	1.00	
9. Emergency procedures	.88	.85	.89	.89	.90	.89	.88	.86	1.00

If pilots did make a single estimate of performance degradation and apply it across tasks, what was this single estimate? This questionnaire asked two questions about the effects of physical conditions across tasks. The first question asked the pilots how sick they would feel (where 20 = feeling good, and 1 = completely incapacitated) if they had the symptoms described in that physical condition. The second question asked them to estimate their overall performance for each physical condition, where 100% equaled maximum performance and 0% equaled completely unable to perform.

The two questions were highly correlated (r = .94, df = 2145, p the individual task times than the "how sick" estimates. Overall performance ratings were correlated around the .70 level with each of the nine task time estimates (see Table 13, all correlations are based on 2146 observations, and are significant at the .0001 level). Correlations for the "how sick" ratings are also high, but are consistently about .06 lower than the overall performance ratings.

Overall performance ratings, then, are the best candidate for the single metric that pilots appear to be using to determine their estimates of task times for the different physical conditions. This was further confirmed by a series of stepwise regressions done on each of the nine task times, using either or both "how sick" and overall performance estimates as predictors. For each of the nine tasks, overall performance alone accounted for slightly more of the variance than "how sick" judgements, and including both variables did not account for significantly more of the variance. It does not appear to be necessary to use both these variables to predict task times.

Estimates of overall performance are very good predictors of the individual task times. Regression models using overall performance to predict estimates of task times under the different physical conditions explained approximately 50% of the variance for each of the nine tasks (Table 14). This represents a substantial improvement over the use of individual symptom levels as predictors reported in Glickman, et al. (1983), which only accounted for about 35% of the variance in time estimates. If anything, the power of the overall performance ratings are underestimated

Table 13. Correlations between estimates of "How Sick" and overall performance and estimated task times (n = 2146).

Task	"How Sick"	Overall Performance
Take-off to hover	- .64	- .70
Hover check	- .64	- .70
Load hook-up	- .66	- .72
Hook-up to translational flight	- .65	- .71
Drop load	- .65	- .72
Resume flight	- .65	- .71
Time to CA5	- .69	- .74
Break radar lock	- .64	- .70
Emergency procedures	- .61	- .68

Table 14. Results of regression analysis of estimates of overall performance on task time estimates (df = 1,2142).

Dependent Variable	Intercept	Slope	F	R^2
Take-off to hover	7037.91	- 99	2114.77	.50
Hover check	7129.30	- 98.98	2044.5	.49
Load hook-up	7508.28	-103.05	2350.09	.52
Hook-up to translational flight	7324.10	-101.58	2239.02	.51
Drop load	7415.52	-102.66	2328.25	.52
Resume flight	7269.77	-101.19	2218.24	.51
Time to CA5	7866.85	- 97.03	2709.33	.56
Break radar lock	7537.61	- 99.47	2020.86	.49
Emergency procedures	7438.54	- 98.16	1817.45	.46

here. Since all time estimates indicating incapacitation were converted to 9999, some non-linearity was introduced as an artifact, which would result in slightly underestimated F, p, and R^2 values. For psychological variables, being able to predict 50% of the variance indicates a very strong relationship between estimates of overall performance and times to perform individual tasks.

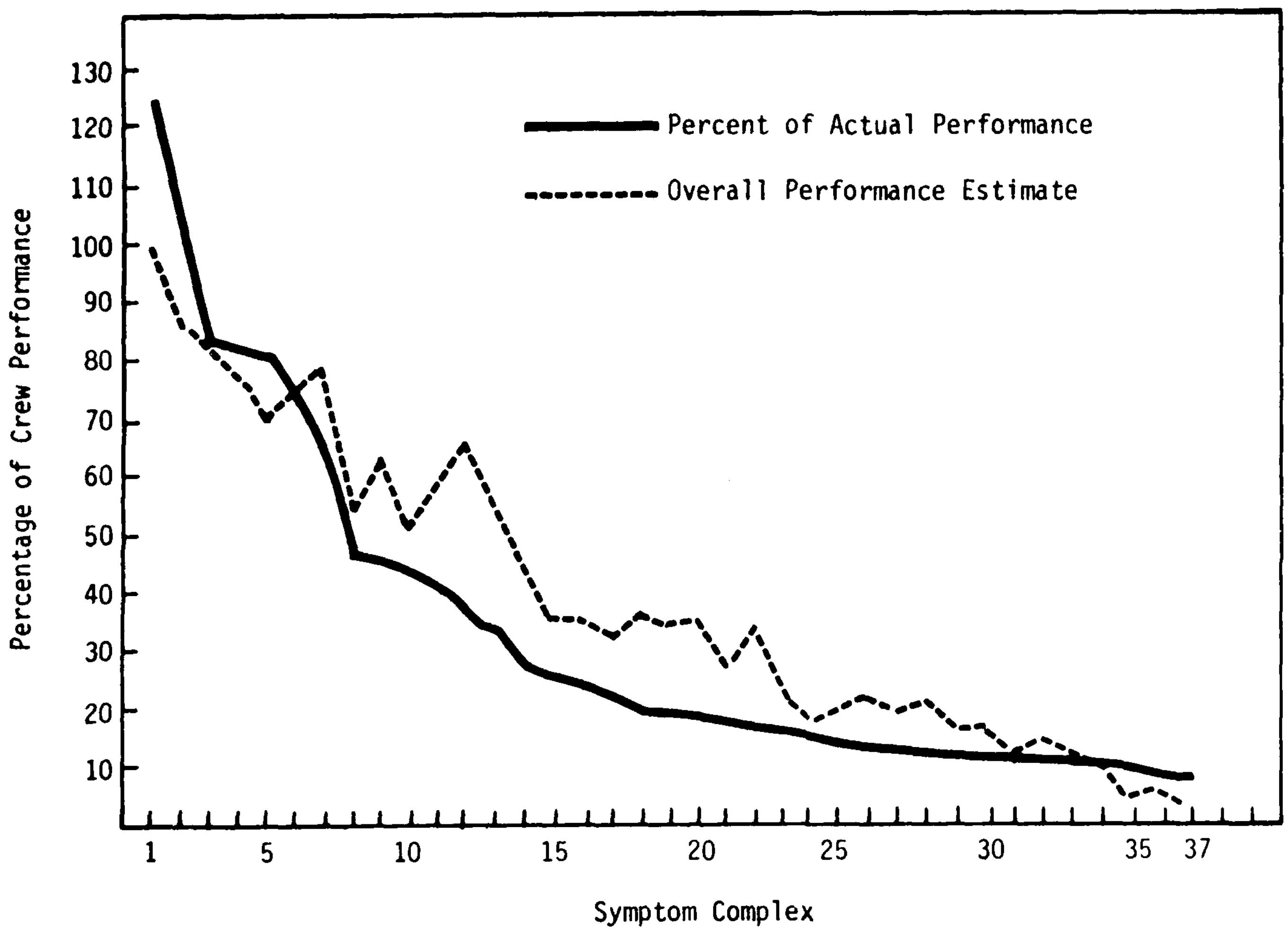
This regression analysis also confirms the lack of differentiation between the nine tasks. Table 14 indicates that while the intercepts for the regression equations are different (as would be expected for tasks normally taking different times) the slopes are virtually identical (-100 ± 3). The relationship between estimates of overall performance and time estimates does not change from task to task.

Asking pilots to estimate the effects of symptoms on their overall performance is an alternative to asking them to estimate task times. The two approaches appear to yield quite similar results. Figure 12 plots the mean estimates of overall performance for the 37 physical conditions along with the percent of actual performance computed from task time estimates. This table is identical to Figure 11, with the addition of the mean overall performance estimates. The ordering of the symptom complexes is based on the percent of actual performance. This is responsible for the more jagged appearance of the overall performance line. If overall performance were used to rank the symptom complexes it would slightly reorder them, and make its line more regular than the percent of actual performance. Without a validation study it is impossible to determine which aproach to estimating radiation induced performance degradation is better, but the simple judgement of the percent of overall performance appears to be a strong candidate for an effective predictor.

4.5 RESULTS SUMMARY.

In addition to the normative data collected in this study, there are five major conclusions that can be made from these data:

- Pilots were most accurate at estimating enroute flight time.



Order of Symptom Complexes

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*15. 411111	35. 111151
16. 111411	36. 111511
17. 115111	37. 111115
*18. 314112	
19. 141111	
*20. 414112	

*Symptom complexes used by Glickman, et al., 1983.

Figure 12. Mean percentage of actual performance and overall performance estimates as a function of symptom complex severity.

- Pilots were much less accurate at estimating shorter, more micro level tasks. In general, they were only within about 30% of the actual times obtained in the simulator.

- There was no obvious improvement in the accuracy of time estimates after simulator flights, except where the simulation helped clarify the task definitions.

- No additional information was gained by asking the pilots to estimate times for multiple tasks. There is no evidence that they discriminated the effects of different symptom complexes between tasks.

- Estimates of overall performance were excellent predictors of symptom based task time estimates. Which of these two estimates of performance degradation will be most closely related to actual performance remains to be investigated.

SECTION 5

DISCUSSION

This research project was designed to collect information about the possible effects of intermediate doses of radiation on the performance of U.S. Army helicopter crews. After flying two missions in a CH47 flight simulator, helicopter pilots were asked to estimate how long it would take them to complete nine different tasks if they were suffering from a variety of different symptoms that could be caused by intermediate doses of radiation.

There were three principal hypotheses in this study. The first was that helicopter pilots would be able to accurately estimate how long the tasks took during their simulation. The second was that different symptoms would degrade performance more than others. The third was that different tasks would be predicted to be more susceptable to radiation induced symptoms than others.

The first part of this section discusses these three hypotheses and summarizes the major results of this project. The second part of this section discusses the implications of these results for future efforts to estimate the effects of intermediate doses of radiation, not only on helicopter crews, but for all military personnel working at all types of jobs.

5.1 MAJOR FINDINGS OF THIS STUDY.

Two of the three major hypotheses of this study were confirmed. The participating pilots can make reasonably accurate estimates of some task times, if the task is carefully chosen. The participants also appeared to distinguish between the effects of the different symptoms. There was no evidence, however, that the symptoms affected performance of some tasks more than others.

5.1.1 Task Time Estimation.

The pilots were reasonably accurate in their time estimates for only one task: enroute flight time. There are several reasons this may have occurred. First, differences between the simulator and actual aircraft may have introduced artifactual problems in estimating tasks involving hovering, hooking-up and dropping loads. At a low altitude hover, the video pictures depicting the surrounding lan scape tended to blur. In addition, the display in the chin bubble (windows at the feet of the pilot and copilot) showed only a rectangular grid, with change in the size of the grid squares as the only cue to distance from the ground. These problems may have been sufficient enough to degrade the pilots' ability to correctly estimate the time it took to perform the tasks requiring take-off, hovering, cargo hook-up, and drop off, and landing.

Another possible explanation is that enroute time is by far the most frequently practiced time estimation for pilots. Fuel requirements are determined by flight planned enroute times, and must be determined before every flight. Futhermore, they have constantly received feedback about the accuracy of their estimates of flight time. The other tasks are not normally estimated by helicoper pilots, and most of the tasks were mission segments that may never have been previously considered as discrete tasks. This unfamiliarity and lack of practice at estimating task times may have been at least partly responsible for the generally poor task time estimates for the other eight tasks (Carroll and Taylor, 1969; Hinrichs, 1964, Appendix F).

Finally, the eight tasks which did not seem to be estimated particularly well were also of fairly short duration. The longest of them took only a little more than one minute. Previous literature on time estimation suggests that longer durations are easier to estimate (Bakan and Kleba, 1957 Appendix F), and that estimates of longer (more than a minute) tasks improved more by practice. This certainly suggests that estimating enroute flight time, with a duration of over ten minutes and being an extensively practiced skill, should be the most easily estimated of the tasks.

Overall, the results indicate that personnel may be able to estimate task times accurately, but only if the task is carefully chosen. The chosen tasks should be already considered a natural unit by the personnel, and take well over a minute. If they are not already experienced at estimating the time required for the task, practice should be provided along with the appropriate feedback.

5.1.2 Discrimination Between Syndromes.

Pilot estimates showed that the symptoms produced by intermediate doses of radiation are expected to markedly reduce helicopter crew performance. Even relatively mild symptoms were estimated to degrade performance substantially. For example, the second mildest symptom, feeling slightly lightheaded, was predicted to increase flight times by twenty percent.

The pilots also judged some syndromes to be more debilitating than others. Upper and lower gastrointestinal disorders (which may be acutely uncomfortable) were seen as less detrimental to performance than syndromes which involved feeling shaky or faint. Given the high cognitive workload of flying a helicopter, reduced cognitive ability appears to be more important than acute physical discomfort.

5.1.3 Discriminating Between Tasks.

There is no evidence that the particular task being performed was differentialy influenced by the effects of the syndromes. All nine tasks were affected equally. Extremely high correlations between performance degradations in the nine tasks and virtually identical regression slopes indicate that pilots did not discriminate between tasks. This is quite similar to the findings of Glickman, et al. (1983), where only one task was found to show any real difference in susceptibility to physical symptoms. The one task involved a hard physical chore (loading a heavy howitzer shell), which was particularly susceptible to symptom complexes which mentioned weakness.

There are several possible explanations for this lack of discrimination. First, the pilots have overlooked real sensitivities of certain tasks to particular symptoms. Without further validation studies this cannot be completely ruled out. However, given their ability to discriminate between the effects of the symptoms complexes, it seems unlikely that any such major effect would be ignored so emphatically.

On the other hand, it may be that there are some tasks involved in flying helicopters that are particularly susceptible to the effects of radiation. This study may just not have selected them. However, flying a helicopter is a full time job, with similar tasks being done continuously, unlike the more segmented, sequential nature of many tasks, such as loading and firing a howitzer. The tasks selected in this study cover all the different segments of two demanding flight missions. It is possible, but unlikely, that a major task which could strongly affect completion of a broad range of missions was not performed during at least one of these missions. Such a task would need to require a particular cognitive ability which is not critical to the tasks selected here, but which is vital to others. Given the heavy demands that piloting a helicopter places on the range of cognitive abilities, this does not seem particularly likely.

It seems more reasonable to assume that the effects of intermediate doses of radiation are felt fairly uniformly across the range of cognitive abilities. There is little evidence to indicate that radiation affects different cognitive abilities to any great extent. Task taxonomies distinguishing the gross task characteristics of cognitive versus physical effort may help improve prediction of performance. Taxonomies dealing with subtle distinctions between a variety of specific cognitive abilities, on the other hand, should not be necessary.

5.2 IMPLICATIONS FOR FUTURE RESEARCH.

The results of this research effort have a number of implications for future efforts to determine the effects of intermediate doses of radiation on human performance. This study helps to confirm the premise of using task experts to predict these effects. The helicopter pilots in this study were able to make valuable distinctions between the effects of the different syndromes, which emphasized the importance of cognitive functioning over physical discomfort. Their ratings appear to be fairly reliable, two different measures of performance decrement (the percent of actual performance and more global judgements of overall performance) both produced quite similar results. These findings, while insufficient to fully validate this paradigm without further validation research, clearly support further investigation of this methodology.

Some guidelines for such investigations can be drawn from this effort. If task time estimates are to be used as the critical measure of performance, several precautions should be observed. Tasks should be chosen which last well over a minute, and which form a clear and familiar unit to the personnel. If possible, tasks should be chosen where they already have experience at estimating task times. If this cannot be done, the personnel should be given practice estimating the time it takes them to do the task, and they should receive immediate feedback about their estimates. If they cannot estimate their own times well, it is unlikely that they will be able to estimate illness degraded task times any better.

Task time may not be the only dependent measure worth consideration, however. The purpose of this research is to help military planners to estimate the effectiveness of personnel under different conditions. The time it takes to perform specific sub-tasks is only an intermediate step to predicting effectiveness. Other variables such as the percent of missions completed or overall estimates of performance may be more directly related to military effectiveness, and hence be better predictors of the effects of radiation. What types of estimates will supply the best predictions can only be determined by future research designed to validate this method.

Developing a taxonomy that can be used to classify the full range of military activities, and then predict how different levels of exposure to radiation will impact performance still seems a reasonable goal. However, it is beginning to appear that a very simple taxonomy (such as cognitive vs. physical) should be most appropriate. While some symptoms may affect tasks differently, these differences do not seem particularly subtle or elaborate.

In closing, it must be emphasized that while using expert opinion is a promising technique, it has not presently been validated. The only way to do this will be to actually induce at least some set of the physical symptoms in people and see how their performance is affected. The actual performance degradation measured in such studies can then be compared to experts' judgements of what they should be to validate and calibrate this technique. Without such validation studies, these predictions can be nothing more than educated guesses.

This research project is a first step to performing such validation studies. It has established a set of normative task times, and expanded the set of predictions that can be put to use as soon as they have been validated and calibrated. By continuing this line of research, it may soon be possible to increase significantly the accuracy of predictions of just how effective personnel can be in a nuclear battlefield.

SECTION 6

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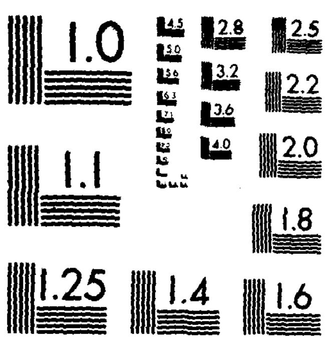

MICROCOPY RESOLUTION TEST CHART
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APPENDIX A

HANDOUTS TO CH-47 PILOTS

STUDY OF HELICOPTER CREW PERFORMANCE

PART 1. INTRODUCTION

The purpose of this study is threefold: (1) to measure how fast you can perform certain helicopter tasks under high workload, high threat conditions; (2) to assess your ability to estimate how long it takes to do these helicopter tasks in the simulator; and, (3) to obtain your estimates on how various types and levels of sickness associated with exposure to nuclear radiation might affect these task times. In order to assess your abilities accurately, we will provide you with a well-defined list of tasks and a flight plan and scenario which identify the conditions under which these tasks will be performed in the simulator.

Please be assured that in this study, we are in no way going to expose you to any kind of nuclear radiation or hazard of any kind. Instead, we are merely going to take measurements of your performance in the simulator in order to establish a baseline of information for healthy aircrews. With your participation, we will be able to obtain a large number of measurements over many crews participating in the study, and from these, determine average task times and average task accuracy for a large group of seasoned, operational crews.

The flight plans provided in Part 2 give a general overview of the missions to be flown plus specifics pertinent to each sortie. The map provided to you as part of the flight plan outlines the routes to be taken for each sortie. The scenario in which you will be flying is one which requires rapid speed but also portrays some enemy force presence. Therefore, you must strictly adhere to the flight routes indicated on the map and adhere to threat driven, altitude restrictions. In addition, since we are interested in obtaining measurements from crews with relatively heavy workloads, the meteorological conditions you will be experiencing, such as visibility, winds, and ceiling, may be less than optimal.

Because we want to obtain good measurements from this study, we want the simulated situation to be as real as possible. Therefore, please keep communication with the simulator operator down to a minimum except for those times when he is serving as your crew chief (such as when you are picking up or dropping off a sling load). Also, do not hesitate to talk with your other crew member as you would in the real situation. Remember, however, that although speed is of the essence, we will be measuring every-time your altitude is excessive.

Any information we obtain will be strictly confidential. That is, no individual participant's name will be revealed in association with his performance scores. Any use of names will be strictly for either obtaining further follow-up information or for inclusion in letters of commendation for their participation in this study.

Before entering the simulator, please study the flight plan information provided in Part 2 and then answer some questions in Part 3. Upon completion of Part 3, you will fly your simulated mission. After your mission is complete, you will be given Part 4 to fill out before you depart.

STUDY OF HELICOPTER CREW PERFORMANCE

PART 2. FLIGHT PLANS

In this portion of the study, we will record times for the successful completion of individual tasks performed during missions by crew members who are healthy. To do this, time data will be collected from missions that have been previously defined for this sutdy. It is essential that you fly the mission, along the planned route so different crews' performances can be compared. All crews will fly the same missions.

Each mission starts at the end of the runway with engines running. You will then proceed to pick up a high density 18,000 lb. sling-load located halfway down the runway. Using contour flying techniques and traveling as quickly as possible, fly the preplanned route as indicated on the map. The air check points (ACP) along the enroute portion of the mission are to be identified. Upon reaching the destination, you will deliver the cargo and go back to the airfield via the return route.

FLIGHT MISSION TO CONFINED AREA 5

CONDITIONS	WINDS
CONDITION Daylight	DEPARTURE WD/WV 020/20
VISIBILITY 1 mile	CARGO DESTINATION WD/WV 330/20
CEILING 500 ft.	LANDING APPROACH WD/WV 220/20
TEMPERATURE +15 ^{o}C	TURBULENCE Moderate for Entire Route
ALTIMETER 2992	

AIRFIELD LOCATION Campbell AAF

CARGO 18,000 lbs. High Density Sling-Load

DESTINATION Confined Area 5

ALTITUDE RESTRICTIONS Below 300 ft. AGL

NOTE:

- Due to ground tactical plan, you must adhere to the preplanned route.
- Every effort must be made to accomplish the mission as quickly as possible.
- Numerous spot reports have been made of enemy activity to the south of confined area 5.
- Aircraft configured to just under 46,000 lbs.

DESCRIPTION:

- Without drifting, takeoff and maintain a hover (ALPHA).
- Perform a hover power check announcing check items.
- Proceed to and pick up 18,000 lb. high density sling-load near center of the runway (BRAVO).
- While maintaining position, perform a hover power check.
- Using contour flying techniques (below 300 ft. AGL), fly the preplanned route drawn on the map. Announce when you think you have reached each of the following ACPs:
    - BRIDGE - (CHARLIE)
    - BRIDGE - (DELTA)

FLIGHT MISSION TO CONFINED AREA 5

- BUILDING - (ECHO)
- BRIDGE - (FOXTROT)
- BRIDGE - (GOLF)

- At ACP GOLF, turn left and proceed along the route to confined area 5 (HOTEL). Announce when you have identified confined area 5.

- Deliver cargo to confined area 5 (HOTEL).

- Continuing to use contour flying techniques (below 300 ft. AGL) quickly return to the airfield along the preplanned route. Identify and announce reaching ACP (INDIA).

- Make a running approach to the airfield.

- Final task is the front wheels touching down on the runway.

FLIGHT MISSION TO CONFINED AREA 7

CONDITIONS

CONDITION Daylight

VISIBILITY 1/2 mile

CEILING 500 ft.

TEMPERATURE +15 °C

ALTIMETER 2992

WINDS

DEPARTURE WD/WV 020/20

CARGO DESTINATION WD/WV 330/20

LANDING APPROACH WD/WV 220/20

AIRFIELD LOCATION Campbell AAF

CARGO 18,000 lbs. High Density Load (Sling)

DESTINATION Confined Area 7

ALTITUDE RESTRICTIONS Below 300 ft.

NOTE:

- Due to the ground tactical plan, you must adhere to the preplanned route.
- Every effort must be made to accomplish this mission as quickly as possible.
- Aircraft is configured to just under 46,000 lbs.

DESCRIPTION:

- Takeoff to a hover and maintain position (ALPHA).
- Perform a hover (power) check announcing checklist items.
- Proceed to and pick up 18,000 lb. high density sling-load near center of the runway (BRAVO).
- Perform another hover (power) check announcing check items.
- Using contour flying techniques (below 300 ft. AGL) fly the preplanned route on the map to confined area 7.
- Announce identification of confined area 7 and deliver the sling-load.
- Following the route indicated, depart confined area 7, resume contour flying and return to airfield making a running approach.

FLIGHT MISSION TO CONFINED AREA 7

- Final task is the front wheels touching down on the runway.

STUDY OF HELICOPTER CREW PERFORMANCE

PART 3. SIMULATOR PRE-FLIGHT QUESTIONNAIRE

PARTICIPANT'S NAME (PLEASE PRINT) ______________________

PARTICIPANT'S NUMBER (FOR OUR USE) ______________________

CREW NUMBER (FOR OUR USE) ______________________

SIMULATOR PRE-FLIGHT QUESTIONNAIRE

SECTION 1. BIOGRAPHICAL DATA

PERSONAL INFORMATION IS BEING COLLECTED AS PART OF THE DEFENSE NUCLEAR AGENCY'S EFFORT TO STUDY THE EFFECTS THAT NUCLEAR RADIATION MAY HAVE ON HELICOPTER CREWS. THIS IS A BASELINE STUDY INVOLVING NO EXPOSURE TO RADIATION OR ANY SIMILAR HAZARDS. THE INFORMATION ABOUT YOUR EXPERIENCE AS AN AVIATOR WILL BE KEPT TOGETHER WITH DATA COLLECTED FROM YOUR PERFORMANCE IN THE SIMULATOR AND A QUESTIONNAIRE TO BE FILLED OUT AFTERWARDS. THE INCLUSION OF YOUR BACKGROUND EXPERIENCES WILL GREATLY ENHANCE THE VALUE OF THIS STUDY.

ALL PERSONAL INFORMATION WILL BE KEPT CONFIDENTIAL. EACH PERSON WILL BE ASSIGNED A SUBJECT NUMBER TO BE USED WHEN REPORTING THE RESULTS OF THIS STUDY TO THE MILITARY. THE LIST OF NAMES AND THE ASSIGNED SUBJECT NUMBERS WILL BE RETAINED AT SCIENCE APPLICATIONS INTERNATIONAL CORPORATION.

PLEASE FILL OUT THE INFORMATION REQUESTED BELOW.

CREW # ____________

SUBJECT # ____________

(PLEASE PRINT)

1. NAME ____________ (LAST), ____________ (FIRST), ____________ (MI)

2. DATE ____________ 3. TIME ____________ 4. GRADE ____________ 5. MOS ____________

6. UNIT ____________ 7. DUTY PHONE ____________ 8. AGE ____________

9. HOW LONG HAVE YOU BEEN IN THE MILITARY? ____________ 10. HOW MANY FLYING HOURS HAVE YOUR LOGGED? ____________

11. INDICATE THOSE AIRCRAFT YOU HAVE FLOWN IN AN OPERATIONAL SETTING (CIRCLE THE APPROPRIATE AIRCRAFT):

UH-1 AH-1 OH-58 CH-47 CH-54 OH-6 OTHER (PLEASE LIST) ____________

12. DO YOU HAVE COMBAT EXPERIENCE? YES____ NO____

13. WAS YOUR COMBAT EXPERIENCE AS AN AVIATOR? YES____ NO____

14. INDICATE THOSE AIRCRAFT YOU HAVE FLOWN IN COMBAT (CIRCLE THE APPROPRIATE AIRCRAFT):

UH-1 AH-1 OV-1 CH-47 CH-54 OH-6 OTHER (PLEASE LIST) ____________

15. HOW MANY CH-47 FLIGHT SIMULATOR HOURS HAVE YOUR LOGGED? ________HOURS

6. WHICH POSITION WILL YOU BE FLYING IN TODAY'S SIMULATION? (CHECK ONE) PILOT________ CO-PILOT________

AFTER READING OVER THE FLIGHT PLAN AND EXAMINING THE CHART AND DESIGNATED ROUTES TO BE FLOWN IN TODAY'S STUDY, PLEASE TURN TO THE NEXT PAGE FOR QUESTIONNAIRE INSTRUCTIONS.

TURN PAGE OVER.......

SECTION 2. ESTIMATES OF TASK TIMES

UNLESS INDICATED OTHERWISE, ALL DEFINITIONS BELOW ARE BASED ON THE USE OF THE CH-47 FLIGHT SIMULATOR, AND THE METEOROLOGICAL CONDITIONS USED DURING FLIGHT PLANNING FOR TODAY'S SIMULATION. ON THE SPACES PROVIDED BELOW, PLEASE ESTIMATE THE NUMBER OF SECONDS YOU WILL TAKE TO PERFORM THE FOLLOWING TASKS:

TAKEOFF

<u>TAKEOFF</u> TO A HOVER (NO CARGO) WITH BEFORE-TAKEOFF CHECK COMPLETED. TAKEOFF TO A HOVER OF 10 FT ± 3, MAINTAINING HEADING, AND ELIMINATING ANY DRIFT. ASSUME THAT THERE IS NO CARGO INVOLVED.

<u>PERFORM HOVER</u> (POWER CHECK) PERFORM A HOVER POWER CHECK USING APPROPRIATE CHECKLIST AND CHECKING PREDICTED HOVER TORQUE WITH REQUIRED TORQUE. CHECK HOVER TORQUE, N1, AND RPM, AND DETERMINE IF NEEDED POWER TO FLY IS AVAILABLE.

SLING-LOAD PICK-UP

<u>LOAD UNDER THE NOSE TO CARGO HOOKED-UP</u>

FROM THE PILOT'S ANNOUNCEMENT THAT THE 18K LB HIGH DENSITY LOAD OF CARGO IS UNDER THE NOSE OF THE HELICOPTER UNTIL THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED-UP.

<u>CARGO HOOKED-UP TO TRANSLATIONAL FLIGHT</u>

FROM THE TIME THAT THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED AND CLEARED UNTIL THE LOAD IS AT 10 FT ABOVE GROUND LEVEL AND THE PILOT INITIATES TRANSLATIONAL FLIGHT.

SLING-LOAD DROP-OFF

<u>LOAD AT 100 FT AGL TO LOAD ON THE GROUND</u>

FROM THE TIME THAT THE 18K LB HIGH DENSITY LOAD IS 100 FT ABOVE GROUND LEVEL DURING YOUR APPROACH TO LAND UNTIL THE CARGO IS ON THE GROUND.

<u>LOAD ON THE GROUND TO TRANSLATIONAL FLIGHT</u>

FROM THE FLIGHT ENGINEER'S ANNOUNCEMENT THAT THE LOAD IS ON THE GROUND, THE HOOK WILL HAVE TO BE RELEASED AND AN ADDITIONAL ANNOUNCEMENT MADE THAT THE AIRCRAFT IS CLEARED FOR FLIGHT. THIS TASK ENDS WHEN THE PILOT INITIATES TRANSLATIONAL FLIGHT.

CONTOUR FLIGHT

ENROUTE TIME (WITH SLING-LOAD) TO CONFINED AREA 5

THIS TASK IS DEFINED AS THE TIME ENROUTE FROM TAKEOFF AT THE AIRFIELD WITH AN 18K LB HIGH DENSITY LOAD UNTIL THE FINAL BARRIOR IS CLEARED AT CONFINED AREA 5. THE PLANNED ROUTE SHOULD BE USED FOR THIS ESTIMATE.

EVADE THREAT

FROM RADAR WARNING UNTIL FLIGHT ROUTE IS RESUMED

WHILE CONTOUR FLYING ALONG A PREDETERMINED ROUTE, THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR. THIS TASK STARTS FROM THE MOMENT THE RADAR WARNING RECEIVER INDICATES A THREAT UNTIL THE PLANNED FLIGHT IS RESUMED AFTER EVADING THE THREAT.

SPOT REPORT

FROM RADAR WARNING UNTIL SPOT REPORT TRANSMITTED

THIS TASK IS THE TIME IT TAKES TO FINISH TRANSMITTING A SPOT REPORT AFTER THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR.

ENGINE FIRE

TIME TO ACCOMPLISH REQUIRED EMERGENCY PROCEDURES

THIS TASK IS FROM THE FIRST INDICATION OF AN ABNORMAL ENGINE CONDITION TO INCLUDE THE TIME IT TAKES THE CREW TO RECOGNIZE THE EMERGENCY, DETERMINE A SUITABLE ACTION, AND ACCOMPLISH THE REQUIRED PROCEDURES FOR AN IN-FLIGHT ENGINE FIRE.

How long will it take you to perform these tasks?

Accurately Estimate The Time To Complete The Following Tasks

Takeoff	Takeoff to a hover (no cargo)	sec.
Takeoff	Perform hover (power) check	sec.
Sling-load Pick-up	Load under the nose to cargo hooked-up	sec.
Sling-load Pick-up	Cargo hooked-up to translational flight	sec.
Sling-load Drop-off	Load at 100 FT. AGL to load on the ground	sec.
Sling-load Drop-off	Load on the ground to translational flight	sec.
Contour Flight	Enroute time (with sling load) to confined area 5	sec.
Evade Threat	From radar warning until flight route is resumed	sec.
Spot Report	From radar warning until spot report transmitted	sec.
Engine Fire	Time to accomplish required emergency procedures	sec.

STOP HERE!

YOU ARE NOW READY TO ENTER THE SIMULATOR.

STUDY OF HELICOPTER CREW PERFORMANCE

PART 4. SIMULATOR POST-FLIGHT QUESTIONNAIRE

PARTICIPANT'S NAME (PLEASE PRINT)______________________________

PARTICIPANT'S NUMBER (FOR OUR USE)______________________________

CREW NUMBER (FOR OUR USE)______________________________

SIMULATOR POST-FLIGHT QUESTIONNAIRE

SECTION 1. ESTIMATES OF TASK TIMES FOR TASKS JUST FLOWN

NOW THAT YOU HAVE JUST FLOWN THE SIMULATOR AND ACTUALLY PERFORMED THOSE TASKS WHICH YOU ESTIMATED, PLEASE WRITE THE NUMBER OF SECONDS YOU THINK IT ACTUALLY TOOK YOU TO COMPLETE EACH TASK AND RATE THE TASKS AS REQUESTED ON THE PAGE BELOW. FOR YOUR CONVENIENCE, THE TASK DEFINITIONS ARE REPEATED HERE.

TAKEOFF

TAKEOFF TO A HOVER (NO CARGO)

WITH BEFORE TAKEOFF CHECK COMPLETED. TAKEOFF TO A HOVER OF 10 FT ± 3, MAINTAINING HEADING, AND ELIMINATING ANY DRIFT. ASSUME THAT THERE IS NO CARGO INVOLVED.

PERFORM HOVER (POWER CHECK)

PERFORM A HOVER POWER CHECK USING APPROPRIATE CHECKLIST AND CHECKING PREDICTED HOVER TORQUE WITH REQUIRED TORQUE. CHECK HOVER TORQUE, N1, AND RPM, AND DETERMINE IF NEEDED POWER TO FLY IS AVAILABLE.

SLING-LOAD PICK-UP

LOAD UNDER THE NOSE TO CARGO HOOKED-UP

FROM THE PILOT'S ANNOUNCEMENT THAT THE 18K LB HIGH DENSITY LOAD OF CARGO IS UNDER THE NOSE OF THE HELICOPTER UNTIL THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED-UP.

CARGO HOOKED-UP TO TRANSLATIONAL FLIGHT

FROM THE TIME THAT THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED AND CLEARED UNTIL THE LOAD IS AT 10 FT ABOVE GROUND LEVEL AND THE PILOT INITIATES TRANSLATIONAL FLIGHT.

SLING-LOAD DROP-OFF

LOAD AT 100 FT AGL TO LOAD ON THE GROUND

FROM THE TIME THAT THE 18K LB HIGH DENSITY LOAD IS 100 FT ABOVE GROUND LEVEL DURING YOUR APPROACH TO LAND UNTIL THE CARGO IS ON THE GROUND.

LOAD ON THE GROUND TO TRANSLATIONAL FLIGHT

FROM THE FLIGHT ENGINEER'S ANNOUNCEMENT THAT THE LOAD IS ON THE GROUND, THE HOOK WILL HAVE TO BE RELEASED AND AN ADDITIONAL ANNOUNCEMENT MADE THAT THE AIRCRAFT IS CLEARED FOR FLIGHT. THIS TASK ENDS WHEN THE PILOT INITIATES TRANSLATIONAL FLIGHT.

CONTOUR FLIGHT

ENROUTE TIME (WITH SLING-LOAD) TO CONFINED AREA 5

THIS TASK IS DEFINED AS THE TIME ENROUTE FROM TAKEOFF AT THE AIR-FIELD WITH AN 18K LB HIGH DENSITY LOAD UNTIL THE FINAL BARRIOR IS CLEARED AT CONFINED AREA 5. THE PLANNED ROUTE SHOULD BE USED FOR THIS ESTIMATE.

EVADE THREAT

FROM RADAR WARNING UNTIL FLIGHT ROUTE IS RESUMED

WHILE CONTOUR FLYING ALONG A PREDETERMINED ROUTE, THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR. THIS TASK STARTS FROM THE MOMENT THE RADAR WARNING RECEIVER INDICATES A THREAT UNTIL THE PLANNED FLIGHT IS RESUMED AFTER EVADING THE THREAT.

SPOT REPORT

FROM RADAR WARNING UNTIL SPOT REPORT TRANSMITTED

THIS TASK IS THE TIME IT TAKES TO FINISH TRANSMITTING A SPOT REPORT AFTER THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR.

ENGINE FIRE

TIME TO ACCOMPLISH REQUIRED EMERGENCY PROCEDURES

THIS TASK IS FROM THE FIRST INDICATION OF AN ABNORMAL ENGINE CONDITION TO INCLUDE THE TIME IT TAKES THE CREW TO RECOGNIZE THE EMERGENCY, DETERMINE A SUITABLE ACTION, AND ACCOMPLISH THE REQUIRED PROCEDURES FOR AN IN FLIGHT ENGINE FIRE.

1. How long did it take you to perform these tasks?

2. In the simulation you just completed, we measured the time it took you to do a number of tasks. Please indicate how similar the simulator task times were when compared to the times they would take in an actual mission. For each task, write in a number from 1 to 5 where "1" means "the same" and "5" means "very different."

3. Overall, how realistic is the simulator? (Circle one)

1	2	3	4	5
very unrealistic				very realistic

Accurately Estimate The Time To Complete The Following Tasks

Takeoff	Takeoff to a hover (no cargo)	sec.
Takeoff	Perform hover (power) check	sec.
Sling-load Pick-up	Load under the nose to cargo hooked-up	sec.
Sling-load Pick-up	Cargo hooked-up to translational flight	sec.
Sling-load Drop-off	Load at 100 FT. AGL to load on the ground	sec.
Sling-load Drop-off	Load on the ground to translational flight	sec.
Contour Flight	Enroute time (with sling load) to confined area 5	sec.
Evade Threat	From radar warning until flight route is resumed	sec.
Spot Report	From radar warning until spot report transmitted	sec.
Engine Fire	Time to accomplish required emergency procedures	sec.

WRITE A NUMBER FROM 1 ("THE SAME") TO 5 ("VERY DIFFERENT") IN COMPARING SIMULATOR VS ACTUAL AIRCRAFT TASK TIMES.

PROCEED TO NEXT PAGE

SECTION 2. EXAMPLE ESTIMATES OF HEALTH EFFECTS ON TASK TIMES

THIS SECTION OF THE QUESTIONNAIRE *REQUIRES* YOU TO ESTIMATE HOW CERTAIN PHYSICAL SYMPTOMS WILL AFFECT YOUR PERFORMANCE IN TERMS OF TIME. A SAMPLE QUESTIONNAIRE INVOLVING THE PARALLEL PARKING OF AN AUTOMOBILE IS PROVIDED ON THE PAGE BELOW AS AN EXAMPLE TO ACQUAINT YOU WITH THE PROCEDURE FOR ANSWERING THIS PART OF THE QUESTIONNAIRE. PLEASE REFER TO THIS EXAMPLE QUESTIONNAIRE AS YOU READ THE FOLLOWING DESCRIPTIONS.

COLUMN 1 - "PHYSICAL CONDITIONS"

THE LEFT COLUMN (COL. 1) IS FOR LISTING VARIOUS WAYS OF DEFINING CREW MEMBERS' PHYSICAL CONDITIONS. THE FIRST ROW OF THIS COLUMN INDICATES A CONDITION OF BEING "HEALTHY AND FEELING FINE." LISTED SECONDLY ARE THE SYMPTOMS OF "SEVERE STOMACH CRAMPS, MODERATE FEVER." FOR EACH ROW OF PHYSICAL SYMPTOMS, YOU SHOULD DRAW ON YOUR OWN BACKGROUND OF VARIOUS EXPERIENCES SUCH AS BEING SICK, LACK OF SLEEP, ETC. AFTER READING THE SYMPTOM, TAKE A SECOND OR TWO, CLOSE YOUR EYES AND TRY TO IMAGINE HOW YOU WOULD FEEL IF YOU HAD THESE SYMPTOMS.

COLUMN 2 - "HOW SICK ARE YOU?" SCALE 1-20

FOR EACH OF THE SYMPTOMS OR SET OF SYMPTOMS LISTED IN THE LEFT-HAND COLUMN, IMAGINE HOW SICK YOU WOULD BE IF YOU HAD THIS PROBLEM. NEXT, RELATE LEVEL OF SICKNESS TO A SCALE OF 1 TO 20 DEFINED BELOW:

1 - COMPLETELY INCAPACITATED - CANNOT MOVE OR TALK   10 - FAIRLY ILL   20 - FEEL GOOD - A GOOD NIGHTS SLEEP THE NIGHT BEFORE

EXAMPLE: THE PERSON WHO FILLED IN THIS QUESTIONNAIRE INDICATED THAT THE COLUMN 1 SYMPTOM, "HEALTHY - FEELING FINE" WAS RATED BY HIM AS A "20." IN *ADDITION, HE RATED "SEVERE STOMACH CRAMPS AND MODERATE FEVER"* AS BEING FAIRLY ILL AND THUS GAVE IT A "10."

COLUMN 3 - "OVERALL PERFORMANCE? WHAT %?"

FOR EACH OF THE SYMPTOMS OR SYMPTOM COMPLEXES LISTED IN THE LEFT-HAND COLUMN, IMAGINE HOW THIS PROBLEM WOULD AFFECT YOUR ABILITY TO PERFORM YOUR DUTY AS A PILOT (IN THIS EXAMPLE, AS AN AUTOMOBILE DRIVER). AT WHAT PERCENT DO YOU THINK YOU WOULD BE FUNCTIONING AT? YOUR ANSWER SHOULD BE ANY NUMBER BETWEEN 0 AND 100.

EXAMPLE: THE PERSON WHO FILLED IN THIS QUESTIONNAIRE ANSWERED THAT IF HE FELT "HEALTHY AND FINE" HE WOULD BE PERFORMING AT 100%; HOWEVER, IF HE HAD "SEVERE STOMACH CRAMPS AND A MODERATE FEVER," HE WOULD BE PERFORMING AT 60%.

COLUMNS 4-8 - ACROSS THE REST OF THE PAGE (COLUMNS 4-8) ARE FIVE OF THE TASKS REQUIRED TO PARALLEL PARK A CAR FROM "POSITION YOUR CAR PARALLEL TO THE CAR IN FRONT OF THE SPACE YOU WANT" TO THE FINAL TASK OF "CUT WHEEL TO THE RIGHT AND PULL FORWARD AND STOP." EACH OF THESE TASKS SHOULD BE CONSIDERED SEPARATELY WHEN ESTIMATING THE TIME NEEDED TO COMPLETE THEM.

EXAMPLE: STARTING WITH THE FIRST ROW "HEALTHY - FEELING FINE," THE PERSON WHO FILLED IN THIS QUESTIONNAIRE ESTIMATED THAT WHEN HE WAS HEALTHY AND FEELING FINE, IT WOULD TAKE HIM 4 SECONDS TO DO THE FIRST TASK ("POSITION YOUR CAR PARALLEL TO THE CAR IN FRONT OF THE SPACE YOU WANT."). THAT SAME PERSON THEN RECORDED HIS ESTIMATES FOR EACH OF THE OTHER DRIVING TASKS. THIS COMPLETED THE FIRST ROW.

NOW LOOK AT THE SECOND ROW, "SEVERE STOMACH CRAMPS, MODERATE FEVER." THE SAME PERSON CONSIDERED HOW HE WOULD FEEL IF THESE WERE HIS SYMPTOMS AND HOW SUCH SYMPTOMS WOULD AFFECT HIS ABILITY TO GET THINGS DONE. *COMPARING HIS SECOND ROW TIMES WITH HIS FIRST ROW TIMES*, WE CAN SEE THAT FOR SOME TASKS, CRAMPING AND FEVER ARE PROJECTED TO HAVE LITTLE EFFECT WHEREAS IN OTHER TASKS, THOSE WHICH REQUIRE STRETCHING OF THE STOMACH MUSCLES, CRAMPING AND FEVER WERE PROJECTED TO HAVE A CONSIDERABLE EFFECT. FOR EXAMPLE, IF WE FOCUS ON COLUMN 3, WE CAN SEE THAT THE RESPONDENT ESTIMATED THAT THIS TASK (I.E., POSITIONING HIS CAR IN PARALLEL TO THE CAR IN FRONT OF THE SPACE HE WANTS) WOULD TAKE 4 SECONDS REGARDLESS OF WHETHER HE FELT FINE OR HAD SEVERE STOMACH CRAMPS AND A MODERATE FEVER. ON THE OTHER HAND, WHEN THE RESPONDENT HAD TO IMAGINE THAT HE WAS BACKING HIS CAR UP AND TURNING THE WHEEL TO THE RIGHT (COLUMN 5), HIS ESTIMATE CHANGED FROM 9 SECONDS WHEN FEELING FINE TO 20 SECONDS WHEN HAVING SEVERE STOMACH CRAMPS AND A MODERATE FEVER.

EXAMPLE QUESTIONNAIRE FORM

PARALLEL PARKING A CAR

Accurately Estimate The Time To Complete The Following Tasks

PHYSICAL CONDITIONS (Column 1)	(Col 2) How sick are you? Scale 1-20	(Col 3) Overall performance? What %?	(Col 4) Position your car parallel to the car in front of the space you wanted.	(Col 5) Back up car and cut wheel to the right.	(Col 6) When rear wheel is approaching curve, cut wheel to the left.	(Col 7) When rear of car reaches parking position, stop car.	(Col 8) Turn wheel to the right and pull forward and stop.
	1-20	%	sec.	sec.	sec.	sec.	sec.
1. Healthy - Feeling Fine	20	100	4	9	2	7	5
2. Severe Stomach Cramps and Moderate Fever	10	[illegible]	4	20	4	8	6

PROCEED TO NEXT PAGE

SECTION 3. YOUR ESTIMATES OF TASK TIMES UNDER VARYING CONDITIONS OF HEALTH

PLEASE FILL OUT THE FORM ON THE PAGE BELOW IN THE SAME MANNER AS DISCUSSED IN THE EXAMPLE (PARALLEL PARKING YOUR CAR) IN SECTION 2. YOUR ESTIMATED TIMES SHOULD BE BASED ON THE SIMULATOR MISSIONS YOU HAVE JUST FLOWN. TASK DEFINITIONS AND SCALE DESCRIPTIONS (FROM 1 - 20) ARE PROVIDED HERE FOR YOUR REFERENCE.

TASK DEFINITIONS

TAKEOFF

TAKEOFF TO A HOVER (NO CARGO)

WITH BEFORE-TAKEOFF CHECK COMPLETED, TAKEOFF TO A HOVER OF 10 FT ± 3, MAINTAINING HEADING, AND ELIMINATING ANY DRIFT, ASSUME THAT THERE IS NO CARGO INVOLVED.

PERFORM HOVER (POWER CHECK)

PERFORM A HOVER POWER CHECK USING APPROPRIATE CHECKLIST AND CHECKING PREDICTED HOVER TORQUE WITH REQUIRED TORQUE. CHECK HOVER TORQUE, N1, AND RPM, AND DETERMINE IF NEEDED POWER TO FLY IS AVAILABLE.

SLING-LOAD PICK-UP

LOAD UNDER THE NOSE TO CARGO HOOKED-UP

FROM THE PILOT'S ANNOUNCEMENT THAT THE 18K LB HIGH DENSITY LOAD OF CARGO IS UNDER THE NOSE OF THE HELICOPTER UNTIL THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED-UP.

CARGO HOOKED-UP TO TRANSLATIONAL FLIGHT

FROM THE TIME THAT THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED AND CLEARED UNTIL THE LOAD IS AT 10 FT ABOVE GROUND LEVEL AND THE PILOT INITIATES TRANSLATIONAL FLIGHT.

SLING-LOAD DROP-OFF

LOAD AT 100 FT AGL TO LOAD ON THE GROUND

FROM THE TIME THAT THE 18K LB HIGH DENSITY LOAD IS 100 FT ABOVE GROUND LEVEL DURING YOUR APPROACH TO LAND UNTIL THE CARGO IS ON THE GROUND.

LOAD ON THE GROUND TO TRANSLATIONAL FLIGHT

FROM THE FLIGHT ENGINEER'S ANNOUNCEMENT THAT THE LOAD IS ON THE GROUND, THE HOOK WILL HAVE TO BE RELEASED AND AN ADDITIONAL ANNOUNCEMENT MADE THAT THE AIRCRAFT IS CLEARED FOR FLIGHT. THIS TASK ENDS WHEN THE PILOT INITIATES TRANSLATIONAL FLIGHT.

CONTOUR FLIGHT

ENROUTE TIME (WITH SLING-LOAD) TO CONFINED AREA 5

THIS TASK IS DEFINED AS THE TIME ENROUTE FROM TAKEOFF AT THE AIR FIELD WITH AN 18K LB HIGH DENSITY LOAD UNTIL THE FINAL BARRIOR IS CLEARED AT CONFINED AREA 5. THE PLANNED ROUTE SHOULD BE USED FOR THIS ESTIMATE.

EVADE THREAT

FROM RADAR WARNING UNTIL FLIGHT ROUTE IS RESUMED

WHILE CONTOUR FLYING ALONG A PREDETERMINED ROUTE, THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR. THIS TASK STARTS FROM THE MOMENT THE RADAR WARNING RECEIVER INDICATES A THREAT UNTIL THE PLANNED FLIGHT IS RESUMED AFTER EVADING THE THREAT.

SPOT REPORT

FROM RADAR WARNING UNTIL SPOT REPORT TRANSMITTED

THIS TASK IS THE TIME IT TAKES TO FINISH TRANSMITTING A SPOT REPORT AFTER THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR.

ENGINE FIRE

TIME TO ACCOMPLISH REQUIRED EMERGENCY PROCEDURES

THIS TASK IS FROM THE FIRST INDICATION OF AN ABNORMAL ENGINE CONDITION TO INCLUDE THE TIME IT TAKES THE CREW TO RECOGNIZE THE EMERGENCY, DETERMINE A SUITABLE ACTION, AND ACCOMPLISH THE REQUIRED PROCEDURES FOR AN IN-FLIGHT ENGINE FIRE.

SCALE

1 - COMPLETELY INCAPACITATED; CANNOT MOVE OR TALK

10 - FAIRLY ILL

20 - FEEL GOOD; A GOOD NIGHT'S SLEEP THE NIGHT BEFORE

HELICOPTER FLIGHT TASKS / PHYSICAL CONDITIONS	How sick are you? Scale 1-20.	Overall performance? What %?	Takeoff: Takeoff to a hover (no cargo)	Takeoff: Perform hover (power) check	Sling-load Pick-up: Load under the nose to cargo hooked-up	Sling-load Pick-up: Cargo hooked-up to translational flight	Sling-load Drop-off: Load at 100 FT. AGL to load on the ground	Sling-load Drop-off: Load on the ground to translational flight	Contour Flight: Enroute time (with sling load) to confined area 5	Evade Threat: From radar warning until flight route is resumed	Spot Report: From radar warning until spot report transmitted	Engine Fire: Time to accomplish required emergency procedures
	1-20	%	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.
Healthy - Feeling Fine												
FATIGABILITY AND WEAKNESS												
Somewhat tired with mild weakness												
Tired, with moderate weakness												
Very tired and weak												
Exhausted with almost no strength												
HYPOTENSION												
Slightly light-headed												
Unsteady upon standing quickly												
Faints upon standing quickly												
In shock: breathes rapidly and shallowly, motionless, skin cold, clammy, and very pale												

Accurately Estimate The Time To Complete The Following Tasks

PROCEED TO NEXT PAGE

PLEASE CONTINUE. DEFINITIONS ARE PROVIDED HERE FOR YOUR REFERENCE.

TASK DEFINITIONS

TAKEOFF

TAKEOFF TO A HOVER (NO CARGO)

WITH BEFORE TAKEOFF CHECK COMPLETED, TAKEOFF TO A HOVER OF 10 FT ± 3, MAINTAINING HEADING, AND ELIMINATING ANY DRIFT. ASSUME THAT THERE IS NO CARGO INVOLVED.

PERFORM HOVER (POWER CHECK)

PERFORM A HOVER POWER CHECK USING APPROPRIATE CHECKLIST AND CHECKING PREDICTED HOVER TORQUE WITH REQUIRED TORQUE. CHECK HOVER TORQUE, N1, AND RPM, AND DETERMINE IF NEEDED POWER TO FLY IS AVAILABLE.

SLING-LOAD PICK-UP

LOAD UNDER THE NOSE TO CARGO HOOKED-UP

FROM THE PILOT'S ANNOUNCEMENT THAT THE 18K LB HIGH DENSITY LOAD OF CARGO IS UNDER THE NOSE OF THE HELICOPTER UNTIL THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED-UP.

CARGO HOOKED-UP TO TRANSLATIONAL FLIGHT

FROM THE TIME THAT THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED AND CLEARED UNTIL THE LOAD IS AT 10 FT ABOVE GROUND LEVEL AND THE PILOT INITIATES TRANSLATIONAL FLIGHT.

SLING-LOAD DROP-OFF

LOAD AT 100 FT AGL TO LOAD ON THE GROUND

FROM THE TIME THAT THE 18K LB HIGH DENSITY LOAD IS 100 FT ABOVE GROUND LEVEL DURING YOUR APPROACH TO LAND UNTIL THE CARGO IS ON THE GROUND.

LOAD ON THE GROUND TO TRANSLATIONAL FLIGHT

FROM THE FLIGHT ENGINEER'S ANNOUNCEMENT THAT THE LOAD IS ON THE GROUND, THE HOOK WILL HAVE TO BE RELEASED AND AN ADDITIONAL ANNOUNCEMENT MADE THAT THE AIRCRAFT IS CLEARED FOR FLIGHT. THIS TASK ENDS WHEN THE PILOT INITIATES TRANSLATIONAL FLIGHT.

CONTOUR FLIGHT

ENROUTE TIME (WITH SLING-LOAD) TO CONFINED AREA 5

THIS TASK IS DEFINED AS THE TIME ENROUTE FROM TAKEOFF AT THE AIRFIELD WITH AN 18K LB HIGH DENSITY LOAD UNTIL THE FINAL BARRIOR IS CLEARED AT CONFINED AREA 5. THE PLANNED ROUTE SHOULD BE USED FOR THIS ESTIMATE.

EVADE THREAT

FROM RADAR WARNING UNTIL FLIGHT ROUTE IS RESUMED

WHILE CONTOUR FLYING ALONG A PREDETERMINED ROUTE, THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR. THIS TASK STARTS FROM THE MOMENT THE RADAR WARNING RECEIVER INDICATES A THREAT UNTIL THE PLANNED FLIGHT IS RESUMED AFTER EVADING THE THREAT.

SPOT REPORT

FROM RADAR WARNING UNTIL SPOT REPORT TRANSMITTED

THIS TASK IS THE TIME IT TAKES TO FINISH TRANSMITTING A SPOT REPORT AFTER THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR.

ENGINE FIRE

TIME TO ACCOMPLISH REQUIRED EMERGENCY PROCEDURES

THIS TASK IS FROM THE FIRST INDICATION OF AN ABNORMAL ENGINE CONDITION TO INCLUDE THE TIME IT TAKES THE CREW TO RECOGNIZE THE EMERGENCY, DETERMINE A SUITABLE ACTION, AND ACCOMPLISH THE REQUIRED PROCEDURES FOR AN IN-FLIGHT ENGINE FIRE.

SCALE

1 - COMPLETELY INCAPACITATED; CANNOT MOVE OR TALK

10 - FAIRLY ILL

20 - FEEL GOOD; A GOOD NIGHT'S SLEEP THE NIGHT BEFORE

HELICOPTER FLIGHT TASKS / PHYSICAL CONDITIONS	How sick are you? Scale 1-20	Overall performance? What %?	Accurately Estimate The Time To Complete The Following Tasks: Takeoff — Takeoff to a hover (no cargo)	Takeoff — Perform hover (power) check	Sling-load Pick-up — Load under the nose to cargo hooked-up	Sling-load Pick-up — Cargo hooked-up to translational flight	Sling-load Drop-off — Load at 100 FT. AGL to load on the ground	Sling-load Drop-off — Load on the ground to translational flight	Contour Flight — Enroute time (with sling load) to confined area 5	Evade Threat — From radar warning until flight route is resumed	Spot Report — From radar warning until spot report transmitted	Engine Fire — Time to accomplish required emergency procedures
	1-20	%	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.
UPPER GI DISTRESS												
Upset stomach; clammy and sweaty; mouth waters and swallows frequently												
Nauseated; considerable sweating; swallows frequently to avoid vomiting												
Vomited once or twice; nauseated and may vomit again												
Vomited several times including the dry heaves; severely nauseated and will soon vomit again												
LOWER GI DISTRESS												
Feels uncomfortable urge to defecate												
Occasional diarrhea, recently defecated and may again												
Frequent diarrhea and cramps, defecated several times and will again soon												
Uncontrollable diarrhea and painful cramps												

PROCEED TO NEXT PAGE

PLEASE CONTINUE. DEFINITIONS ARE PROVIDED HERE FOR YOUR REFERENCE.

TASK DEFINITIONS

TAKEOFF

TAKEOFF TO A HOVER (NO CARGO)

WITH BEFORE-TAKEOFF CHECK COMPLETED, TAKEOFF TO A HOVER OF 10 FT ± 3, MAINTAINING HEADING, AND ELIMINATING ANY DRIFT. ASSUME THAT THERE IS NO CARGO INVOLVED.

PERFORM HOVER (POWER CHECK)

PERFORM A HOVER POWER CHECK USING APPROPRIATE CHECKLIST AND CHECKING PREDICTED HOVER TORQUE WITH REQUIRED TORQUE. CHECK HOVER TORQUE, N1, AND RPM, AND DETERMINE IF NEEDED POWER TO FLY IS AVAILABLE.

SLING-LOAD PICK-UP

LOAD UNDER THE NOSE TO CARGO HOOKED-UP

FROM THE PILOT'S ANNOUNCEMENT THAT THE 18K LB HIGH DENSITY LOAD OF CARGO IS UNDER THE NOSE OF THE HELICOPTER UNTIL THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED-UP.

CARGO HOOKED-UP TO TRANSLATIONAL FLIGHT

FROM THE TIME THAT THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED AND CLEARED UNTIL THE LOAD IS AT 10 FT ABOVE GROUND LEVEL AND THE PILOT INITIATES TRANSLATIONAL FLIGHT.

SLING-LOAD DROP-OFF

LOAD AT 100 FT AGL TO LOAD ON THE GROUND

FROM THE TIME THAT THE 18K LB HIGH DENSITY LOAD IS 100 FT ABOVE GROUND LEVEL DURING YOUR APPROACH TO LAND UNTIL THE CARGO IS ON THE GROUND.

LOAD ON THE GROUND TO TRANSLATIONAL FLIGHT

FROM THE FLIGHT ENGINEER'S ANNOUNCEMENT THAT THE LOAD IS ON THE GROUND, THE HOOK WILL HAVE TO BE RELEASED AND AN ADDITIONAL ANNOUNCEMENT MADE THAT THE AIRCRAFT IS CLEARED FOR FLIGHT. THIS TASK ENDS WHEN THE PILOT INITIATES TRANSLATIONAL FLIGHT.

CONTOUR FLIGHT

ENROUTE TIME (WITH SLING-LOAD) TO CONFINED AREA 5

THIS TASK IS DEFINED AS THE TIME ENROUTE FROM TAKEOFF AT THE AIRFIELD WITH AN 18K LB HIGH DENSITY LOAD UNTIL THE FINAL BARRIOR IS CLEARED AT CONFINED AREA 5. THE PLANNED ROUTE SHOULD BE USED FOR THIS ESTIMATE.

EVADE THREAT

FROM RADAR WARNING UNTIL FLIGHT ROUTE IS RESUMED

WHILE CONTOUR FLYING ALONG A PREDETERMINED ROUTE, THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR. THIS TASK STARTS FROM THE MOMENT THE RADAR WARNING RECEIVER INDICATES A THREAT UNTIL THE PLANNED FLIGHT IS RESUMED AFTER EVADING THE THREAT.

SPOT REPORT

FROM RADAR WARNING UNTIL SPOT REPORT TRANSMITTED

THIS TASK IS THE TIME IT TAKES TO FINISH TRANSMITTING A SPOT REPORT AFTER THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR.

ENGINE FIRE

TIME TO ACCOMPLISH REQUIRED EMERGENCY PROCEDURES

THIS TASK IS FROM THE FIRST INDICATION OF AN ABNORMAL ENGINE CONDITION TO INCLUDE THE TIME IT TAKES THE CREW TO RECOGNIZE THE EMERGENCY, DETERMINE A SUITABLE ACTION, AND ACCOMPLISH THE REQUIRED PROCEDURES FOR AN IN-FLIGHT ENGINE FIRE.

SCALE

1 - COMPLETELY INCAPACITATED; CANNOT MOVE OR TALK

10 - FAIRLY ILL

20 - FEEL GOOD; A GOOD NIGHT'S SLEEP THE NIGHT BEFORE

Accurately Estimate The Time To Complete The Following Tasks

PHYSICAL CONDITIONS / HELICOPTER FLIGHT TASKS	How sick are you? Scale 1-20	Overall performance? What %?	Takeoff: Takeoff to a hover (no cargo)	Takeoff: Perform hover (power) check	Sling-load Pick-up: Load under the nose to cargo hooked-up	Sling-load Pick-up: Cargo hooked-up to translational flight	Sling-load Drop-off: Load at 100 FT. AGL to load on the ground	Sling-load Drop-off: Load on the ground to translational flight	Contour Flight: Enroute time (with sling load) to confined area 5	Evade Threat: From radar warning until flight route is resumed	Spot Report: From radar warning until spot report transmitted	Engine Fire: Time to accomplish required emergency procedures
	1-20	%	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.
INFECTION AND BLEEDING												
. Mild fever and headache--like starting to come down with flu												
. Joints ache, considerable sweating; moderate fever; doesn't want to eat; sores in mouth/throat												
. Shakes and chills and aches all over; difficulty in stopping any bleeding												
. Delirious, overwhelming infections; cannot stop any bleeding												
FLUID LOSS AND ELECTROLYTE IMBALANCE												
. Thirsty and has dry mouth; weak and faint												
. Very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion												
. Extremely dry mouth, throat, skin and very painful headache; has difficulty moving; short of breath, burning skin and eyes												
. Prostrate												

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PLEASE CONTINUE. DEFINITIONS ARE PROVIDED HERE FOR YOUR REFERENCE.

TASK DEFINITIONS

TAKEOFF

TAKEOFF TO A HOVER (NO CARGO)

WITH BEFORE TAKEOFF CHECK COMPLETED, TAKEOFF TO A HOVER OF 10 FT ± 5, MAINTAINING HEADING, AND ELIMINATING ANY DRIFT. ASSUME THAT THERE IS NO CARGO INVOLVED.

PERFORM HOVER (POWER CHECK)

PERFORM A HOVER POWER CHECK USING APPROPRIATE CHECKLIST AND CHECKING PREDICTED HOVER TORQUE WITH REQUIRED TORQUE. CHECK HOVER TORQUE, N1, AND RPM, AND DETERMINE IF NEEDED POWER TO FLY IS AVAILABLE.

SLING-LOAD PICK-UP

LOAD UNDER THE NOSE TO CARGO HOOKED-UP

FROM THE PILOT'S ANNOUNCEMENT THAT THE 18K LB HIGH DENSITY LOAD OF CARGO IS UNDER THE NOSE OF THE HELICOPTER UNTIL THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED-UP.

CARGO HOOKED-UP TO TRANSLATIONAL FLIGHT

FROM THE TIME THAT THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED AND CLEARED UNTIL THE LOAD IS AT 10 FT ABOVE GROUND LEVEL AND THE PILOT INITIATES TRANSLATIONAL FLIGHT.

SLING-LOAD DROP-OFF

LOAD AT 100 FT AGL TO LOAD ON THE GROUND

FROM THE TIME THAT THE 18K LB HIGH DENSITY LOAD IS 100 FT ABOVE GROUND LEVEL DURING YOUR APPROACH TO LAND UNTIL THE CARGO IS ON THE GROUND.

LOAD ON THE GROUND TO TRANSLATIONAL FLIGHT

FROM THE FLIGHT ENGINEER'S ANNOUNCEMENT THAT THE LOAD IS ON THE GROUND, THE HOOK WILL HAVE TO BE RELEASED AND AN ADDITIONAL ANNOUNCEMENT MADE THAT THE AIRCRAFT IS CLEARED FOR FLIGHT. THIS TASK ENDS WHEN THE PILOT INITIATES TRANSLATIONAL FLIGHT.

CONTOUR FLIGHT

ENROUTE TIME (WITH SLING-LOAD) TO CONFINED AREA 5

THIS TASK IS DEFINED AS THE TIME ENROUTE FROM TAKEOFF AT THE AIR-FIELD WITH AN 18K LB HIGH DENSITY LOAD UNTIL THE FINAL BARRIOR IS CLEARED AT CONFINED AREA 5. THE PLANNED ROUTE SHOULD BE USED FOR THIS ESTIMATE.

EVADE THREAT

FROM RADAR WARNING UNTIL FLIGHT ROUTE IS RESUMED

WHILE CONTOUR FLYING ALONG A PREDETERMINED ROUTE, THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR. THIS TASK STARTS FROM THE MOMENT THE RADAR WARNING RECEIVER INDICATES A THREAT UNTIL THE PLANNED FLIGHT IS RESUMED AFTER EVADING THE THREAT.

SPOT REPORT

FROM RADAR WARNING UNTIL SPOT REPORT TRANSMITTED

THIS TASK IS THE TIME IT TAKES TO FINISH TRANSMITTING A SPOT REPORT AFTER THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR.

ENGINE FIRE

TIME TO ACCOMPLISH REQUIRED EMERGENCY PROCEDURES

THIS TASK IS FROM THE FIRST INDICATION OF AN ABNORMAL ENGINE CONDITION TO INCLUDE THE TIME IT TAKES THE CREW TO RECOGNIZE THE EMERGENCY, DETERMINE A SUITABLE ACTION, AND ACCOMPLISH THE REQUIRED PROCEDURES FOR AN IN-FLIGHT ENGINE FIRE.

SCALE

1 - COMPLETELY INCAPACITATED, CANNOT MOVE OR TALK

10 - FAIRLY ILL

20 - FEEL GOOD; A GOOD NIGHT'S SLEEP THE NIGHT BEFORE

Accurately Estimate The Time To Complete The Following Tasks

HELICOPTER FLIGHT TASKS / PHYSICAL CONDITIONS	How sick are you? Scale 1-20	Overall performance? What %?	Takeoff: Takeoff to a hover (no cargo)	Takeoff: Perform hover (power) check	Sling-load Pick-up: Load under the nose to cargo hooked-up	Sling-load Pick-up: Cargo hooked-up to translational flight	Sling-load Drop-off: Load at 100 FT. AGL to load on the ground	Sling-load Drop-off: Load on the ground to translational flight	Contour Flight: Enroute time (with sling load) to confined area 5	Evade Threat: From radar warning until flight route is resumed	Spot Report: From radar warning until spot report transmitted	Engine Fire: Time to accomplish required emergency procedures
	1-20	%	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.
Vomited several times including the dry heaves; severely nauseated and will soon vomit again; very tired and weak.												
Vomited once or twice; nauseated and may vomit again; very tired and weak; thirsty and has dry mouth; weak and faint.												
Nauseated; considerable sweating; swallows frequently to avoid vomiting; very tired and weak; thirsty and has dry mouth; weak and faint.												
Vomited several times including the dry heaves; severely nauseated and will soon vomit again; exhausted with almost no strength; unsteady upon standing quickly.												
Nauseated; considerable sweating; swallows frequently to avoid vomiting; very tired and weak; very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion.												
Vomited several times including the dry heaves; severely nauseated and will soon vomit again; feels uncomfortable urge to defecate; exhausted with almost no strength.												
Nauseated; considerable sweating; swallows frequently to avoid vomiting; exhausted with almost no strength; very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion.												

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PLEASE CONTINUE. DEFINITIONS ARE PROVIDED HERE FOR YOUR REFERENCE.

TASK DEFINITIONS

TAKEOFF

TAKEOFF TO A HOVER (NO CARGO)

WITH BEFORE TAKEOFF CHECK COMPLETED, TAKEOFF TO A HOVER OF 10 FT ± 3, MAINTAINING HEADING, AND ELIMINATING ANY DRIFT. ASSUME THAT THERE IS NO CARGO INVOLVED.

PERFORM HOVER (POWER CHECK)

PERFORM A HOVER POWER CHECK USING APPROPRIATE CHECKLIST AND CHECKING PREDICTED HOVER TORQUE WITH REQUIRED TORQUE. CHECK HOVER TORQUE, N1, AND RPM, AND DETERMINE IF NEEDED POWER TO FLY IS AVAILABLE.

SLING-LOAD PICK-UP

LOAD UNDER THE NOSE TO CARGO HOOKED-UP

FROM THE PILOT'S ANNOUNCEMENT THAT THE 18K LB HIGH DENSITY LOAD OF CARGO IS UNDER THE NOSE OF THE HELICOPTER UNTIL THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED-UP.

CARGO HOOKED-UP TO TRANSLATIONAL FLIGHT

FROM THE TIME THAT THE FLIGHT ENGINEER ANNOUNCES THAT THE LOAD IS HOOKED AND CLEARED UNTIL THE LOAD IS AT 10 FT ABOVE GROUND LEVEL AND THE PILOT INITIATES TRANSLATIONAL FLIGHT.

SLING-LOAD DROP-OFF

LOAD AT 100 FT AGL TO LOAD ON THE GROUND

FROM THE TIME THAT THE 18K LB HIGH DENSITY LOAD IS 100 FT ABOVE GROUND LEVEL DURING YOUR APPROACH TO LAND UNTIL THE CARGO IS ON THE GROUND.

LOAD ON THE GROUND TO TRANSLATIONAL FLIGHT

FROM THE FLIGHT ENGINEER'S ANNOUNCEMENT THAT THE LOAD IS ON THE GROUND, THE HOOK WILL HAVE TO BE RELEASED AND AN ADDITIONAL ANNOUNCEMENT MADE THAT THE AIRCRAFT IS CLEARED FOR FLIGHT. THIS TASK ENDS WHEN THE PILOT INITIATES TRANSLATIONAL FLIGHT.

CONTOUR FLIGHT

ENROUTE TIME (WITH SLING-LOAD) TO CONFINED AREA 5

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EVADE THREAT

FROM RADAR WARNING UNTIL FLIGHT ROUTE IS RESUMED

WHILE CONTOUR FLYING ALONG A PREDETERMINED ROUTE, THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR. THIS TASK STARTS FROM THE MOMENT THE RADAR WARNING RECEIVER INDICATES A THREAT UNTIL THE PLANNED FLIGHT IS RESUMED AFTER EVADING THE THREAT.

SPOT REPORT

FROM RADAR WARNING UNTIL SPOT REPORT TRANSMITTED

THIS TASK IS THE TIME IT TAKES TO FINISH TRANSMITTING A SPOT REPORT AFTER THE RADAR WARNING RECEIVER INDICATES A THREAT RADAR.

ENGINE FIRE

TIME TO ACCOMPLISH REQUIRED EMERGENCY PROCEDURES

THIS TASK IS FROM THE FIRST INDICATION OF AN ABNORMAL ENGINE CONDITION TO INCLUDE THE TIME IT TAKES THE CREW TO RECOGNIZE THE EMERGENCY, DETERMINE A SUITABLE ACTION, AND ACCOMPLISH THE REQUIRED PROCEDURES FOR AN IN-FLIGHT ENGINE FIRE.

SCALE

1 - COMPLETELY INCAPACITATED, CANNOT MOVE OR TALK
10 - FAIRLY ILL
20 - FEEL GOOD; A GOOD NIGHT'S SLEEP THE NIGHT BEFORE

Accurately Estimate The Time To Complete The Following Tasks

PHYSICAL CONDITIONS \ HELICOPTER FLIGHT TASKS			Takeoff		Sling-load Pick-up		Sling-load Drop-off		Contour Flight	Evade Threat	Spot Report	Engine Fire
	How sick are you? Scale 1-20	Overall performance? What %?	Takeoff to a hover (no cargo)	Perform hover (power) check	Load under the nose to cargo hooked-up	Cargo hooked-up to translational flight	Load at 100 FT. AGL to load on the ground	Load on the ground to translational flight	Enroute time (with sling load) to confined area 5	From radar warning until flight route is resumed	From radar warning until spot report transmitted	Time to accomplish required emergency procedures
	1-20	%	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.
Nauseated; considerable sweating swallows frequently to avoid vomiting; occasional diarrhea and cramps, defecated several times and will again soon; very tired and weak; slightly light-headed; joints ache, considerable sweating; moderate fever; doesn't want to eat; sores in mouth/throat.												
Vomited several times including the dry heaves: severely nauseated and will soon vomit again: occasional diarrhea, recently defecated and may again; exhausted with almost no strength.												
Vomited several times including the dry heaves; severely nauseated and will soon vomit again; exhausted with almost no strength; slightly light-headed; mild fever and headache-like starting to come down with flu; very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion.												
Vomited several times including the dry heaves; severely nauseated and will soon vomit again; exhausted with almost no strength; faints upon standing quickly; joints ache, considerable sweating; moderate fever; doesn't want to eat; sores in mouth/throat.												
Vomited once or twice; nauseated and may vomit again; exhausted with almost no strength; unsteady upon standing quickly extremely dry mouth, throat, skin and very painful headache has difficulty moving; short of breath; burning skin and eyes.												

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THANK YOU FOR YOUR PARTICIPATION!!

WE ARE INTERESTED IN ANY COMMENTS YOU MAY HAVE: ______________________________

APPENDIX B

ATTACK AND TRANSPORT MISSION SCENARIOS

B.1 ATTACK MISSION SCENARIO.

As evening approaches, an armored enemy force has penetrated friendly defenses and is gradually gaining momentum. Friendly Air Cavalry units have been able to determine the extent of the force, make initial contact and have been in touch with friendly ground elements. An attack helicopter battalion has been assigned the task of attacking the flank of the enemy force.

During flight planning and preflight tasks, the required MOPP gear in conjunction with the heat of the day makes the pilots uncomfortable. Aircraft of the attack company perform their hovering tasks and then proceed with a normal takeoff. The unit, using the traveling technique of movement, moves forward to the holding area leaving the forward assembly area behind. At the holding area, the attack helicopters coordinate with the aeroscouts and by platoons, using traveling and bounding overwatch techniques, move out to the battle positions and receive target hand offs.

From firing positions, the cobras partially unmask themselves and acquire their targets. Then, the AH-1s unmask as required to fire, engaging the enemy T-62s and BMPs, then quickly remasking and shifting to alternate firing positions to deter the efforts of the ZSU-23-4s. This process of engagement is repeated several times adding to the number of burning vehicles resulting in a smoke screen that threatens to obscure the battle area.

The road, now clogged with wrecked vehicles is blocking the lead elements of the advance as the force attempts to reform and continue the operation. The enemy commander, not easily put off by these set backs, initiates a flanking movement which is quickly discovered by cavalry. In need of fire power, aeroscouts direct one platoon of the cobras from their battle positions to counter the flanking maneuver. The AH-1s again set into firing positions then using their guns, assist friendly artillery in providing suppressive fire at BMPs and dismounted infantry threatening to overrun a friendly ground element.

Having expended their munitions, the cobra platoon retires from the battle area flying nap-of-the-earth. It is after sunset, requiring the crews to use night vision goggles. Enroute to the holding area, a small enemy ground element is discovered and a cobra pilot transmits a spot report. Using the appropriate techniques of movement along the avenues of approach, the platoon returns to the forward area rearm/refuel point to begin preparations for the next mission.

B.2 TRANSPORT MISSION SCENARIOS.

See Appendix A, Part 2.

APPENDIX C

MISSION SEGMENT SCENARIOS

<u>Mission</u>: Attack, Observation or Utility

<u>Mission Segment</u>: Takeoff and Maintain Hover

<u>Helicopters</u>: AH-1s, OH-58, UH-1

<u>Scenario</u>: It is early morning. Your aircraft is ready to go. It has undergone a pre-dawn health indicator test and the throttle has been pre-set. You are about to go through engine start-up procedures using asterisked items on the check list.

Mission: Attack

Mission Segment: Fire Suppression

Helicopter: AH-1s

Scenario: You are the second of a two-ship attack formation. Lead ship is directly in front of you as you use traveling overwatch as the planned technique of movement. It is a hot day and you, as pilot, are traveling under visual meteorological conditions (VMC). You detect tracers from ground fire directed to lead ship's 7 o'clock. Your only available armament is guns and the situation calls for helmet sight hand-off to the gunner.

<u>Mission</u>: Attack

<u>Mission Segment</u>: Pop-up and TOW Launch

<u>Helicopter</u>: AH-1s

<u>Scenario</u>: It is a hot day and you are masked in a good firing position. You are under VMC/VFR conditions and are awaiting target handoff from the Scout. You have good local security.

<u>Mission</u>: Observation

<u>Mission Segment</u>: Target Handoff

<u>Helicopter</u>: OH-58

<u>Scenario</u>: It is a hot day and you are a Scout pilot traveling under VMC/VFR conditions. Your Cobra is concealed in firing position and you are moving forward in an NOE environment. You are using lateral masking until you contact the enemy.

<u>Mission</u>: Utility

<u>Mission Segment</u>: Landing Approach

<u>Helicopter</u>: UH-1

<u>Scenario</u>: You are returning from a night, NOE transport mission. You have a full load of troops and are entering the landing approach phase.

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APPENDIX D

COBRA TASK ANALYSES

Mission: Attack

Mission Segment: Takeoff and Maintain Hover

Helicopter: AH-1s (ECAS)

TASK	GUNNER SAYS:	PILOT	TIME
1.	"BATTERY SWITCH START"	TURNS ON BAT SWITCH AND SAYS "ON"	
2.	"VOLTMETER CHECK"	PILOT LOOKS AT VOLTMETER AND AND REPORTS VOLTAGE "24 VOLTS"	
3.	"THROTTLE CHECK"	PILOT CHECKS FULL TRAVEL, CLOSES THROTTLE, OPENS TO FLIGHT IDLE POSITION (LEFT HAND) AND CONFIRMS "THROTTLE CHECK"	
4.	"FUEL SWITCH TO FUEL"	TURNS SWITCH ON AND CHECKS TO CONFIRM FUEL BOOST LIGHTS GO OFF AND RESPONDS "FUEL"	
5.	"MASTER CAUTION AND RPM WARNING LIGHTS CHECK"	PILOT CHECKS FOR LIGHTS ON AND RESPONDS "CHECK"	
6.	"CAUTION PANEL LIGHTS TEST AND RESET"	PILOT TESTS AND RESETS LIGHTS AND RESPONDS "CHECK"	

TASK	GUNNER SAYS:	PILOT	TIME
7.	"FIRE DETECTOR TEST SWITCH-TEST"	PILOT FLIPS SWITCH UP AND CONFIRMS FIRE LITE GOES ON, RELEASES SWITCH AND CONFIRMS LIGHTS GOES OUT AND SAYS "CHECK"	
8.	"ALTIMETER SET" AND ROTATES HIS KNOB TO FIELD ELEVATION	PILOT ROTATES KNOB TO FIELD ELEVATION AND SAYS "CHECK"	
9.	"FIRE GUARD POSTED"	PILOT CHECKS TO SEE IF FIRE GUARD IS IN POSITION AND SAYS "CHECK"	
10.	"ROTOR BLADES"	PILOT INSPECTS TO ENSURE BLADES ARE AT 90^{0}, UNTIED AND CLEAR AND SAYS "CLEAR"	
11.	"ENGINE START"	SIMULTANEOUSLY PRESSES STARTER SWITCH AND HOLDS (LEFT HAND) AND STARTS TIMER (RIGHT HAND); HOLDS COLLECTIVE DOWN AND CENTERS CYCLIC; MONITORS VOLTAGE INCREASE, CLOCK, N1 AND TGT ALTERNATELY; LISTENS FOR UNUSUAL ENGINE SOUNDS; RELEASES STARTER SWITCH AT EITHER 40% N1 OR 35 SECS; TURNS OFF IGNITION KEY AT 750^{0}C TGT; TURNS ON IGNITION SWITCH AT STABLE TGT	
12.	"GENERATOR SWITCH-ON"	PILOT TURNS GENERATOR SWITCH ON, NOTES AMMETER INDICATION, AND CONFIRMS DC GEN LIGHT GOES OUT AND SAYS "ON"	

TASK	GUNNER SAYS:	PILOT	TIME
13.	"BATTERY SWITCH-RUN"	PILOT TURNS BATTERY SWITCH TO RUN POSITION AND SAYS "CHECK"	
14.	"ENGINE AND TRANSMISSION OIL PRESSURE-CHECK"	PILOT ENSURES GAUGES WITHIN LIMITS AND SAYS "CHECK"	
15.	"THROTTLE IDLE"	PILOT TURNS THROTTLE UP TO IDLE AND SAYS "IDLE"	
16.	"N1-CHECK"	PILOT ENSURES N1 IS BETWEEN 68-72% WHILE HOLDING THROTTLE AT IDLE STOP AND SAYS "CHECK"	
	ENGINE RUNUP		
17.	"CAUTION LIGHTS-CHECK"	PILOT CONFIRMS ALL LIGHTS OUT EXCEPT ALTER AND RECTIFIER AND SAYS "CHECK"	
18.	"AMMETER-CHECK"	PILOT CONFIRMS LESS THAN 200 AMP READING AND SAYS "CHECK"	
19.	"AVIONICS-AS DESIRED" AND TURNS ON VHF RADIO	PILOT TURNS ON FM RADIO, RADAR ALTIMETER TO "ON", ADF TO "ON", VHF TO "ON", VOR TO "ON" AND TRANSPONDER TO "STANDBY" AND SAYS "AVIONICS ON"	
20.	"SCASS POWER SWITCH-POWER"	PILOT TURNS SWITCH TO "POWER" AND MONITORS IF SCASS NO-GO LIGHTS GO ON AND EXTINGUISH BY 50 SECS	

TASK	GUNNER SAYS:	PILOT	TIME
21.	"CANOPY DOORS-SECURE" AND SECURES HIS DOOR	PILOT SECURES HIS DOOR AND SAYS "SECURE"	
22.	"ENGINE AND TRANSMISSION INSTRUMENTS-CHECK"	PILOT CHECKS INSTRUMENTS AND SAYS "CHECK"	
23.	"THROTTLE-FULL OPEN"	PILOT SLOWLY INCREASES THROTTLE TO 100% RPM AND MONITORS TGT AND TORQUE	
24.	"ALTERNATOR SWITCH-ON"	PILOT TURNS ALTNR SWITCH ON AND CONFIRMS ALTNR AND RECT LIGHTS OUT AND SAYS "CHECK"	
25.	"ENGINE DE-ICE"	PILOT TURNS DE-ICE SWITCH ON, MONITORS SLIGHT TGT INCREASE, MOVES DE-ICE SWITCH TO OFF AND MONITORS TGT DECRESE AND SAYS "CHECK"	
26.	"SCAS" AND LOCATES HIS FINGER ON SCAS RELEASE SWITCH AND INSPECTS BLADES FOR ABNORMALITY DURING PILOT INDUCED CHECKS	PILOT CHECKS THAT HE'S CLEAR AROUND A/C AND THAT SCAS LIGHTS ARE OUT; LOCATES FINGER ON SCASS RELEASE SWITCH; ENGAGES PITCH, ROLL AND YAW CHANNELS ONE-AT-A-TIME AND INSPECTS BLADES FOR ABNORMALITIES: TELLS GUNNER TO BREAK SCASS	
	GUNNER PRESSES SCAS RELEASE		
		RE-ENGAGE SCAS DISENGAGES SCAS RE-ENGAGES SCAS	

TASK	GUNNER SAYS:	PILOT	TIME
27.	"ALTIMETERS"	RESETS ALTIMETER AND SAYS "CHECK"	
28.	"HSI" AND ANNOUNCES STANDBY COMPASS HEADING	PILOT SETS HSI TO MATCH STANDBY COMPASS HEADING	
		BEFORE TAKE-OFF CHECK	
29.	"RPM"	CHECKS TO ENSURE 100% AND SAYS "100%"	
30.	"SYSTEMS"	CHECKS ENGINE, TRANSMISSION, ELECTRICAL AND FUEL SYSTEMS INDICATORS AND SAYS "CHECK"	
31.	"ARMAMENT SYSTEMS"	CHECKS ARMAMENT SYSTEMS ARE ON-LINE AND FUNCTION PROPERLY AND SAYS "AS REQUIRED"	
32.	"TRANSPONDER"	SETS TRANSPONDER AND SAYS "AS REQUIRED"	
		PICK UP TO HOVER	
33.		PILOT INCREASES COLLECTIVE, PEDALS AS NECESSARY TO MAINTAIN HEADING, CYCLIC AS NECESSARY TO MAINTAIN ALTITUDE	
		HOVER CHECK	
34.	"FLIGHT CONTROLS"	CHECKS FLIGHT CONTROLS FOR PROPER POSITION AND RESPONSES AND ANNOUNCES "CHECK"	

TASK	GUNNER SAYS:	PILOT	TIME
35.	"ENGINE AND TRANS-MISSION INSTRUMENTS"	CHECKS INDICATORS AND SAYS "CHECK"	
36.	"FLIGHT INSTRUMENTS"	PILOT CHECKS: AIR SPEED, ADI, VSI (UVI), SLIP INDICATOR, HSI, AND SAYS "CHECK"	
37.	"POWER"	PILOT CHECKS IF POWER AVAILABLE COMPARES WITH PREDICTED VALUE FROM CHARTS (PPC) AND SAYS "CHECK"	

Mission: Attack

Mission Segment: Fire Suppression

Helicopter: AH-1s (ECAS) (N=4)

TASK	GUNNER	TIME	PILOT	TIME
1.			DETECTS TRACERS DIRECTED AT LEAD SHIP	
2.			RADIOS LEAD SHIP "LEAD TAKING FIRE FROM 7 O'CLOCK"	
3.			TELLS GUNNER TO AQUIRE TARGET - "GUNNER-TARGET!" AND MAINTAINS HSS (HELMET SIGHT SYSTEM) ON TARGET	
4.	VERIFIES TOW CONTROL PANEL SWITCHED TO "TSU/GUNS" AND PUSHES ATS (AQUIRE-TRACK-STOW) SWITCH TO "AQUIRE", CAUSING TSU (TELESCOPIC SIGHT UNIT) TO SLEW TO PILOT-DESIGNATED LOCATION		CHECKS OR PLACES SWITCHES INTO PROPER POSITIONS: - MASTER ARM SWITCH TURNED TO "ARM" - WEAPONS CONTROL SWITCH TURNED TO "GUNNER"	
5.	PRESSES ACTION BAR WHILE LOOKING INTO TSU		MAINTAINS ORIENTATION	

TASK	GUNNER	TIME	PILOT	TIME
6.	IDENTIFIES TARGET, MANEUVERS JOYSTICK TO PUT CROSSHAIRS ON TARGET AND SQUEEZES TRIGGER		MAINTAINS ORIENTATION AND APPROACH	
7.			PULLS AWAY FROM TARGET	
8.	RAISES HEAD FROM TSU AND PLACES ATS SWITCH TO "STOW"			

TIME = 15-20 SECONDS (N=1)

Mission: Attack

Mission Segment: Pop Up and TOW Launch

Helicopter: AH-1s (ECAS) (N=4)

TASK	GUNNER	TIME	PILOT	TIME
1.	SEARCHES MAP FOR REPORTED TARGET LOCATION AND FORMULATES EXPECTANCY OF GEOGRAPHIC LAYOUT		ORIENTS AIRCRAFT TO HEADING GIVEN BY SCOUT	
2.	CHECKS OR PLACES SWITCHES INTO PROPER POSITIONS: - TCP (TOW CONTROL PANEL) MODE SWITCH IS SET TO EITHER "MAN" OR "AUTO" AND THUS ARMED - TCP "MISSILE SELECT" IS SHOWING AN AVAILABLE MISSILE - ATS SWITCH (ACQUIRE, TRACK, STOW) ON SIGHT HAND CONTROL PANEL IS SET TO "TRK" - MAGNIFICATION SWITCH ON LEFT HAND GRIP IS SET TO "LO"		CHECKS OR PLACES SWITCHES INTO PROPER POSITIONS: - MASTER ARM SWITCH TURNED TO "ARM" - WPN CONT SWITCH TURNED TO "GUNNER"	
3.	CONFIRMS "TOW'S READY"	10	ASKS GUNNER "IS TOW "READY"	10

TASK	GUNNER	TIME	PILOT	TIME
4.	VERIFIES POWER AND TGT ARE WITHIN LIMITS BEFORE CLEARING TREE TOPS		INCREASES COLLECTIVE PITCH TO UNMASK THE AIRCRAFT IN PRESCRIBED DIRECTION	
5.	REMOVES M 24 MASK			
6.	PLACES RIGHT HAND ON TRACKING JOYSTICK AND PLACES HEAD IN TSU		ACQUIRES TARGET AND INCREASES COLLECTIVE UNTIL LINE OF SIGHT OF TSU ACHIEVED	
7.	SEARCHES FOR TARGET WHILE SLEWING TSU WITH JOYSTICK		MONITORS PSI ("PILOT STEERING INDICATOR") TO KEEP IN CONSTRAINTS	
8.	DETECTS, AND RECOGNIZES TARGET AND PLACES AND MAINTAINS CROSSHAIRS ON TARGET			
9.	SWITCHES MAGNIFICATION ON LEFT HAND GRIP TO "HIGH"			
10.	PRESSES "ACTION" BAR ADJUSTS CROSSHAIRS AND TELLS PILOT "READY"	10		10
11.			PILOT ENSURES A/C IS IN CONSTRAINTS AND TELLS GUNNER "READY"	

TASK	GUNNER	TIME	PILOT	TIME
12.	LAUNCHES MISSILE ON LEFT HAND GRIP AND MAINTAINS CROSSHAIRS	10	MAINTAINS A/C IN CON-STRAINTS; INSPECTS POWER, TORQUE, TGT	10
13.	AFTER IMPACT, LEAVES TSU, AND PRESSES WIRE CUT BOTTON	23	INITIATES DESCENT	23

=43
=30
=43

=39
N=3

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APPENDIX E

RATING SCALES FOR HELICOPTER TASK TAXONOMY

Example Scale
(from Fleishman and Quaintance, 1984, p. 482)

This dimension considers the amount of muscular effort required to perform the task. Examine the task and identify the most physically strenuous part of it. Rate this part on the scale below.

Definitions	Scale	Examples
	7	
High amount of muscular effort-response(s) require a high degree of muscular involvement.		• Do 40 push-ups • Lift the heaviest weight possible.
	6	
Moderate amount of muscular effort required for the response(s).		• Tighten nuts on bolts securely with a wrench.
	5	
	4	
	3	
	2	
Low amount of muscular effort required.		• Solder two wires together • Add numbers and report the sum aloud.
	1	

Rater #1. Helicopter Task Characteristics Ratings

TASKS \ RATING SCALES	NUMBER OF OUTPUT UNITS	DURATION OUTPUT UNIT MAINTAINED	NUMBER OF ELEMENTS PER OUTPUT UNIT	WORKLOAD	DIFFICULTY OF GOAL ATTAINMENT	PRECISION OF RESPONSES	RESPONSE RATE	SIMULTANEITY OF RESPONSES	DEGREE OF MUSCULAR EFFORT INVOLVED	NUMBER OF PROCEDURAL STEPS	DEPENDENCY OF PROCEDURAL STEPS	ADHERENCE TO PROCEDURES	PROCEDURAL COMPLEXITY	VARIABILITY OF STIMULUS LOCATION	STIMULUS OR STIMULUS COMPLEX DURATION	REGULARITY OF STIMULUS OCCURRENCE	OPERATOR CONTROL OF THE STIMULUS	OPERATOR CONTROL OF THE RESPONSE	REACTION TIME/FEEDBACK LAG RELATIONSHIP	FEEDBACK	DECISION MAKING
TAKE-OFF TO HOVER	1	5	4	2	2	4	3	6	3	7	6	6	6	5	7	3	6	7	2	5	6
HOVER POWER CHECK	1	1	3	2	2	4	3	5	3	5	5	5	3	7	7	3	5	7	4	6	5
CARGO HOOK-UP	4	1	4	3	4	7	2	7	4	6	7	6	5	6	7	4	5	6	3	6	4
DEPART WITH CARGO	1	1	3	1	2	5	4	5	3	5	6	5	4	5	7	4	6	6	3	5	5
CARGO DROP-OFF	4	1	3	2	3	6	3	6	4	5	6	6	5	5	7	4	6	6	3	6	4
DEPART	1	1	3	1	2	5	4	5	3	5	6	5	4	5	7	4	6	6	3	5	5
LOW-LEVEL NAVIGATION	4	6	5	6	3	5	5	6	4	6	5	5	5	5	7	5	6	5	2	5	6
EVADE THREAT	1	1	3	4	7	4	6	7	5	4	6	7	3	1	6	1	1	7	5	6	2
ENGINE FIRE	1	1	3	4	3	6	6	7	5	4	7	7	3	7	7	1	1	7	5	6	2
FIRE SUPPRESSION	3	3	3	2	4	5	6	6	5	4	5	5	3	1	4	3	1	7	5	6	3
TARGET HAND-OFF	4	4	4	3	4	5	4	7	4	6	4	5	4	3	6	4	4	7	3	5	6
POP-UP & TOW LAUNCH	4	4	4	3	5	7	5	7	5	7	7	7	6	4	7	4	3	7	3	6	5
RUNNING LANDING	1	1	3	3	2	6	3	6	3	6	6	6	5	6	7	3	6	7	2	5	6

Rater #2. Helicopter Task Characteristics Ratings

TASKS \ RATING SCALES	NUMBER OF OUTPUT UNITS	DURATION OUTPUT UNIT MAINTAINED	NUMBER OF ELEMENTS PER OUTPUT UNIT	WORKLOAD	DIFFICULTY OF GOAL ATTAINMENT	PRECISION OF RESPONSES	RESPONSE RATE	SIMULTANEITY OF RESPONSES	DEGREE OF MUSCULAR EFFORT INVOLVED	NUMBER OF PROCEDURAL STEPS	DEPENDENCY OF PROCEDURAL STEPS	ADHERENCE TO PROCEDURES	PROCEDURAL COMPLEXITY	VARIABILITY OF STIMULUS LOCATION	STIMULUS OR STIMULUS COMPLEX DURATION	REGULARITY OF STIMULUS OCCURRENCE	OPERATOR CONTROL OF THE STIMULUS	OPERATOR CONTROL OF THE RESPONSE	REACTION TIME/FEEDBACK LAG RELATIONSHIP	FEEDBACK	DECISION MAKING
TAKE-OFF TO HOVER	3	1	7	2	2	4	7	7	3	7	7	7	5	5	7	6	6	3	4	6	1
HOVER POWER CHECK	4	1	7	4	2	4	7	7	1	7	7	7	5	6	7	6	4	4	3	5	7
CARGO HOOK-UP	1	5	7	6	5	7	7	7	4	3	5	5	6	6	7	7	1	7	4	4	3
DEPART WITH CARGO	1	1	1	1	2	2	7	7	2	2	3	5	2	6	7	7	6	7	5	6	3
CARGO DROP-OFF	1	4	5	5	3	5	7	7	2	3	5	5	4	3	7	7	6	7	5	7	3
DEPART	1	1	1	1	2	2	7	7	1	2	7	3	2	6	7	7	6	7	4	7	2
LOW-LEVEL NAVIGATION	4	1	2	4	5	6	7	7	1	1	2	3	7	2	7	6	1	7	2	5	6
EVADE THREAT	1	4	2	7	6	5	7	7	2	3	5	4	5	1	4	2	1	1	3	6	6
ENGINE FIRE	4	5	7	7	6	7	7	7	6	7	7	7	7	2	4	1	1	1	6	4	4
FIRE SUPPRESSION	4	3	2	7	5	7	5	7	2	2	2	2	2	2	4	2	1	5	5	5	5
TARGET HAND-OFF	2	2	4	3	3	6	2	7	2	4	4	4	3	2	6	4	1	6	6	3	3
POP-UP & TOW LAUNCH	1	6	5	7	7	7	7	7	3	7	7	7	7	1	7	3	1	2	4	6	3
RUNNING LANDING	1	2	2	2	2	3	7	7	2	4	4	4	4	5	7	7	4	7	4	7	3

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APPENDIX F

LITERATURE REVIEW ON TIME ESTIMATION

F.1 PURPOSE.

A review of the literature on people's ability to estimate time was undertaken to assist in the design of a subjective workload assessment methodology. This methodology will be used to measure decrements in helicopter crew performance that result from physiological effects of nuclear radiation.

The basic design of the study involves the subjective assessment of time spent performing helicopter crew tasks under normal condition and under conditions where symptoms of radiation illness prevail. Estimates will be made by actual U.S. Army helicopter crew members.

F.2 METHOD.

The literature review was initiated by conducting a computer-assisted search of the psychological literature included in the Psychological Abstracts. A search for studies in the database associated with the descriptors (TIME ESTIMATION and TRAINING) and (TIME ESTIMATION and TASK ANALYSIS) yielded the initial set of articles reviewed. Bibliographies of these articles led to further relevant studies, these led to still further literature pertinent to the problem, and so on.

F.3 RESULTS.

Abstracts of nineteen articles representative of the relevant literature concerning time estimation are contained in the next section (F-4). While no single study directly addresses all of the particular constraints and requirements of the present investigation, previous findings have implications for, and can lend direction to the present effort. A summary of these findings follows.

It appears from the literature that people's accuracy in estimating time depends on a variety of factors. One factor which introduces bias in people's estimates is the length of the interval being judged. It appears, for example, that different cognitive processes are engaged for the judgment of short and long intervals. Kowalski (1943), Clausen (1950), and Guay (1982) all found that short intervals tend to be overestimated, while long intervals are underestimated. The point at which "long interval" processing takes over appears to be somewhere between 3 and 5 seconds. Smith's (1969) finding that underestimation decreases as the interval approaches two minutes and Bakan and Kleba's (1957) finding of greater reliability over time for longer intervals (greater than one minute) suggest that as the interval increases, accuracy in time estimation increases as well. Finally, the ability to judge longer intervals (one minute) appears to be more easily enhanced through training than ability at shorter intervals (Hicks and Miller, 1976).

In sum, these findings suggest that the most accurate and reliable estimates of time will be obtained for tasks greater than about one minute in duration. If it is feasible, perhaps helicopter missions could be task analyzed to yield tasks that would appear to take longer than roughly one minute to accomplish. For example, there may be cases where very short duration tasks done in succession could be combined to produce a single operation that could be labelled meaningfully. It would seem especially appropriate to combine tasks done in succession which receive the same classification in a task taxonomy.

A second factor which appears to influence accuracy of time estimation has to do with the sort of activity in which the individual was engaged during the interval she/he was to judge. Time appears to pass more slowly (i.e., the interval is overestimated) to Ss engaged in fatiguing, painful (Gulliksen, 1927), boring (Gulliksen, 1927; Loehlin, 1959), passive (Loehlin, 1959; Swift & McGeoch, 1925), and unfilled (Cohen, 1971) tasks. Smith (1969) and Harton (1938) both found that Ss tend to underestimate time spent on more difficult, or cognitively complex, tasks. Active involvement in a task has also been shown to lead to underestimation (Swift and McGeoch, 1925). There are contradictory findings with respect to task variety: one study (Loehlin, 1959) suggests that <u>less</u> variety in tasks leads to overestimation of time intervals, while two other studies (Block, 1978; Block and Reed, 1978) suggest instead that <u>greater</u> task variety leads to overestimation. The exact nature of the tasks included in the "variety" may have varied between these studies such that differences on some other unmeasured dimension may be responsible for these results.

One may conclude from these findings that people's estimates of time are biased by the activities in which they are engaged. These findings cast some doubt on the validity of crew members' absolute time estimations and should be considered in these cases where the nature of the helicopter mission task changes as a function of the effects of nuclear radiation. For example, tasks may be perceived as more cognitively complex under certain physiological conditions that result from radiation.

As mentioned above, most of the studies reviewed were not conducted under the same conditions as apply to the present effort. Several, however, do deviate from the usual methodology used in time estimation studies and include some variables of particular interest. For example, there are 2 studies (Carroll and Taylor, 1969; Hinrichs, 1964) that dealt with situations where Ss were familiar with the tasks they were judging. These 2 studies compared estimated time allocations of work activities by workers with actual time allocations as measured by job sampling techniques. While still not perfectly parallel to the present effort, since the task categories used were much broader than those resulting from the task analysis of the helicopter mission, these studies do indicate that people are fairly accurate in their assessments of time spent in various work-related activities.

Guay's (1982) study is another particularly relevant one since he provides some evidence for the effects of delay between experience of the task interval and estimates of the duration of the interval. Most studies gather estimates immediately following each task experience. Introducing delay as a variable will not be possible in the present study (and probably not desirable). Guay showed that when Ss hold time lengths of 1, 4, and 8 seconds in memory for a period of 14 or 28 days, they become less accurate and more variable than if they recall the item immediately or after 2 days. These findings suggest that crew members should be surveyed as soon after carrying out a mission (real or simulated) as possible, and that recency of experience with the tasks should be measured as a control variable.

Meyers (1916) also deviates from the basic methodology used in time estimation studies by examining the influence of incidental vs. purposive perception on accuracy. (In most studies, Ss perception is purposive: they understand that they will experience an interval of time and that they then will be asked to estimate the interval.) Helicopter crew members who will serve as Ss for the present study may or may not know before engaging in their tasks that they will be asked to estimate task durations. Meyers' study concluded that there was slightly greater accuracy for purposive perception of task-filled time than for incidental perception, though the gain was small. There were no studies that examined Ss' ability to estimate duration of tasks where, as with the helicopter crew, time spent on the task is under the Ss control. It is conceivable that purposive perception under these conditions will influence actual time spent on the task, thus compromising the generalizability of the results to the usual helicopter mission situation. Consequently, the internal validity (i.e. accuracy in estimation) that may be gained by informing crews of the nature of the study may not outweigh the possible sacrifices in external validity.

The literature on individual differences reported by Loehlin (1959) indicates that certain skill and personality traits residing within individuals may have a systematic effect on the accuracy of their time estimations. For example, he reported that Ss with greater perceptual abilities overestimated the duration of repetitive tasks while less able Ss tended to underestimate these tasks. This sort of variability between Ss in the kinds of biases they bring to the time estimation task suggests that each S in the present study report time estimations under <u>both</u> radiation <u>and</u> normal conditions rather than using expert judgment for the latter and comparing that to different Ss' estimations of the former. By using the same Ss to judge tasks under both conditions, relative differences between the two conditions will be comparable across Ss.

Although there were no studies that addressed the effects of experience with or ability in performing the task being judged, these factors seem intuitively to have an influence on an individual's accuracy in judging task times. (Individual differences in ability is another reason for having all of the Ss rate tasks under normal, as well as radiation, conditions.) Until empirical evidence can be brought to bear on this question, information on these variables should be collected from crew members and the variables statistically controlled in the data analysis.

F.4 ANNOTATED BIBLIOGRAPHY.

Bakan, P. and Kleba, F. Reliability of time estimates. _Perceptual and Motor Skills_, 1957, _7_, 23-24.

This study was designed to investigate the reliability of time estimates. Ss made estimates of S intervals ranging from 15 seconds to 240 seconds. The estimates were made as verbal reputs of elapsed time. There were two sessions, one week apart, and in each session there were two identical series of time intervals, so that in each Session Ss made estimates of each time interval twice. Reliability coefficients for estimates made in the same session were greater than those made a week apart. The between session coefficients for the second series were greater then for the first, especially for the 3 longer time intervals. No data are reported on the absolute magnitude of the errors in estimation.

Bindra, D. and Waksberg, H. Methods and terminology in studies of time estimation. _Psychological Bulletin_, 1956, _53_, 2, 155-159.

The purpose of this study was to examine systematically the equivalence, or lack thereof, among the various methods and terms used in studies of time estimation. Three main methods were identified: 1) verbal estimation, where E delimits a given interval operatively and S is asked to estimate verbally its duration in terms of seconds or minutes; 2) production, where S is instructed to delimit operatively an interval of a given duration stated verbally by E; and 3) reproduction, where E operatively delimits an interval and then asks S to reproduce operatively an interval of the same duration. The main conclusion of the study was that with the first two methods over- and under-estimation necessarily imply that the S's subjective temporal units (the rate of one's internal clock) are different from objective temporal units (as measured by external clocks, for example). But in the case of the method of reproduction, whether the S's internal clock runs faster or slower than the objective clock, he may still reproduce the duration of the standard quite accurately. for his/her subjective temporal units are not likely to change from the time she/he is exposed to the standard to the time that she/he reproduces it.

Block, R.A. Remembered duration: Effects of event and sequence complexity. Memory Cognition, 1978, 6, 3, 320-326.

Two experiments investigated the remembered duration of relatively long intervals (several minutes). In both, Ss viewed two sequences of visual patterns. They then unexpectedly were asked to make a comparative judgment of duration of the 2 intervals. In experiment, there was no effect of complexity of individual patterns on remembered duration. In experiment 2, however, there was an effect of complexity of the entire sequence, with a complex sequence remembered as longer in durationthan a simple sequenc. In both experiments there was a positive time-order error (i.e., the first of 2 intervals is remembered as longer).

Block, R.A. and Reed, M.A. Remembered duration: Evidence for a contextual change hypothesis. Journal of Experimental Psychology: Human Learning and Memory, 1978, 4, 6, 656-665.

Two experiments used levels-of-processing tasks to investigate hypotheses on remembered duration of intervals several minutes long. In experiment 2, and interval containing different kinds of tasks (both shallow and deep processing) was remembered as being longer than an interval of equal duration containing a single kind of task (either shallow or deep processing).

Carroll, S.J. and Taylor, W.H. Validity of estimates by clerical personnel of job time proportions. Journal of Applied Psychology, 1969, 53, 2, 164-166.

This study compared the estimated time allocations of clerical workers with their actual time allocations as determined by work sampling procedures carried out surreptitiously over a two-week period. The average correlation between estimated and actual time allocations for individual workers was .88. Only 2 of the 16 correlations were under .80. The biggest difference between an estimated and actual time allocation for a particular walk activity was 6% for the group of workers as a whole.

Clausen, J. An evaluation of experimental methods of time judgment. Journal of Experimental Psychology, 1950, 40, 756-761.

This study examined the different methods for studying time estimation and the relative merits of each. Four methods were identified: 1) verbal estimation by the S of an interval set by the examiner, 2) operative estimation, where the S demonstrates an interval set by the examiner (also called the method of production), 3) reproduction, where the examiner presents an interval which the S is asked to reproduce, and 4) comparison, where 2 intervals are presented and S is asked to indicate which is larger (this method is used rarely). Previous studies had criticized the method of verbal estimation because of the predominance of estimates ending with the preferred digits of zero and five and had suggested that the method of reproduction is both easier and produces more accurate results than the method of verbal estimation. An experiment was conducted using the methods of verbal estimation, operative estimation and reproduction of 5, 10, and 15 second intervals which were either filled or unfilled with the sound of a buzzer. The study concluded that the task of reproduction involves a different underlying function than do verbal and operative estimation since reproduction was a markedly less reliable method. The method of reproduction also produced average judgments that were closer to the stimulers interval than either of the other methods. Operative estimation was preferred over verbal estimation since it yielded somewhat more accurate judgments with less scattering of scores, and eliminates the tendency toward verbal rounding of interval judged. Consistent with previous findings, these results also showed that shorter intervals have a tendency to be overestimated and longer ones to be underestimated. The sound of a buzzer did not alter the results significantly for any of the three methods.

Cohen, S. Effects of task, interval and order of presentation on time estimations. Perceptual and Motor Skills, 1971, 33, 101-102.

The purpose of this study was to examine the influence of achievement-oriented versus unfilled tasks on estimated time passage. Temporal units employed were 30, 75, and 120 seconds. Results showed that Ss consistently overestimated actual elapsed time for all periods. The greatest discrepancies occurred for estimations of unfilled time, particularly as duration of interval increased.

Gilliland, A.R., Hofeld, J., and Eckstrand, G. Studies in time perception. Psychological Bulletin, 1946, 43, 162-176.

This article presents a literatue review of studies in time perception conducted between 1933 and the writing of the article. It presents a summary of some of the findings that were reported in other articles contained in the abstracts contained herein and is an often-cited review in the subsequent literature on time estimation.

Gregg, L.W. Fractionation of temporal intervals. Journal of Experimental Psychology, 1951, 42, 4, 307-312.

This study applied the psychophysical method of fractionation to the measure of the perception of time. In the fractionation technique, the s hears a pair of tones. The S's task is to adjust the duration of one of the pair (designated as the "variable") to be half the duration of the other (designated as the "standard"). Five standard durations were used: 400, 800, 1600, 2400, and 4800 msec. Results showed that the second tone (regardless of whether it is the "standard" or the "variable") was underestimated relative to the first. This was consistent with previous findings. The means of the median half-values for all Ss were overestimations of 2.00, 2.08, 1.16, 6.52, and 9.31 per cent suggesting greater error in estimation for longer intervals of time.

Guay, M. Long-term retention of temporal information. Perceptual and Motor Skills, 1982, 54, 843-849.

The main purpose of this study was to determine the characteristics of long term retention of temporal information. Visual durations of 1, 4, and 8 seconds were estimated by 120 Ss under the method of reproduction (see abstract for Bindra and Waksberg (1956) for description of method of reproduction). Four retention intervals were used: immediate reproduction, 2 days, 14 days, and 28 days. The percentage absolute and percentage variable (as measured by standard deviations) errors were used to evaluate effects of forgetting. When Ss hold time lengths of 1, 4, and 8 seconds in memory for a period of 14 or 28 days, they become less accurate and maore variable than if they recall the item immediately or after 2 days. The percentage constant error was used as an index of bias. Ss had a tendency to overestimate the 1-second and to underestimate the 4- and 8-second time durations.

Gulliksen, H. The influence of occupation upon the perception of time. Journal of Experimental Psychology, 1927, 10, 1, 52-59.

Studied the influence of different task situations on people's ability to estimate duration of the task interval. Ss were presented with 8 task situations each lasting 200 seconds. After each task, Ss were asked to estimate the time spent on the task. The study concluded that within a limited range, differences in the estimation of time depend primarily on the way in which the individual is occupied. Of the eight tasks, Ss tended to overestimate time for five of them: complete rest, holding arms extended from the side, listening to a slow metronome, listening to a rapid metronome, and holding a palm on a thumb tack. Time spent was underestimated for the remaining three tasks: reading directions in a mirror, copying from dictation, and doing long division. It may be concluded from these results that time appears to pass more slowly when engaged in boring, fatiguing or painful tasks, and move quickly when engaged more actively in a task situation.

Harton, J.J. The influence of the difficulty of activity on the estimation of time. Journal of Experimental Psychology, 1938, 23, 2, 270-287.

Three experiments were conducted during which Ss listened to a metronome set at various rates while engaging in an easy task (counting the beats) or more difficult tasks (repeating nonsense rhymes). The study concluded that time seems to pass more rapidly during moare difficult activities. (The actual time spent in each experimental condition was 47 seconds.)

Hicks, R.E. and Miller, G.W. Transfers of time judgments as a function of feedback. American Journal of Psychology, 1976, 89, 2, 303-310.

The purpose of this study was to assess the transfer of skill of making judgments between two ranges of intervals (7 seconds and one minute), using control groups whose ranges did not change and control groups without informative feedback. The results indicated that training Ss to judge intervals of 7 seconds transfers to judgments of one minute intervals (and vice versa) as compared to untrained control groups. The transfer between intervals is incomplete, however, in that a group trained to judge the shorter intervals judges the longer intervals less well than a group trained to judge the longer intervals (and vice versa). In addition, the effect of training (i.e., informative feedback) was found to be larger, in an absolute sense, for the longer intervals than for the shorter intervals.

Hinrichs, J.R. Communications activity of industrial research personnel. Personnel Psychology, 1964, 17, 2, 193-204.

This article describes a work sampling study of on-the-job time allocation of technical men. One of the objectives of the study was to compare questionnaire estimates of time allocation with data detained through work sampling. Data for the study were collected primarily in a framework designed to isolate time spent in communications vs. non-communications activities. A comparison between estimated and measured time allocation showed a high degree of accuracy (within at least 5 percent) in estimating the amount of time spent in communication. Results showed some bias in estimation by type of activity (some types of activities are consistantly overestimated and some consistently underestimated) and the study concludes that the questionnaire approach may be a useful technique for comparative studies, though probably not for studies of absolute time distributions.

Kowalski, W.J. The effect of delay upon the duplication of short temporal intervals. Journal of Experimental Psychology, 1943, 33, 3, 239-246.

The prime objective of this investigation was to determine the influence of delay intervals upon the duplication of short temporal intervals. The delay interval is defined as the period of time that elapses between the end of the stimulus and the beginning of the response. The study was designed to determine whether any trend could be discerned and attributed to the varying lengths of the delay interval, i.e., what kind of relationship exists between the delay interval and the stimulus durations. Stimulus durations were 2.5, 5.0, 10.0, 15.0, 20.0, 25.0, and 30.0 seconds. Consistent with previous results, this study found that delay intervals did not significantly influence the dupliction of temporal intervals, and that short stimulus durations are consistently overestimated (for all delay intervals) while the longer stimulus durations were consistently underestimated.

Loehlin, J.C. The influence of different activities on the apparent length of time. Psychological Monographs: General and Applied, 1959, 73, 4, Whole No. 474.

The purpose of this study was to investigate how estimates of time during periods occupied with different activities will be influenced by the content of the intervals. A factor analysis of Ss' time estimates of the apparent duration of sixteen 2-minute activities was conducted. The analysis yielded four main factors: 1) interest vs. boredom, such that time spent in less interesting activities was overestimated, 2) variety, such that time spent in tasks with less variety was overestimated, 3) repetition of an activity, such that more able Ss overestimated duration of repetitive tasks while less able Ss underestimated these tasks, and 4) activity vs. passivity such that Ss overestimated.

Meyers, G.C. Incidental perception. Journal of Experimental Psychology, 1916, 1, 3, 339-350.

The purpose of this study was to investigate incidental perception of time, size, and weight and to make some comparisons between incidental and purposive perception of time and size. Results regarding time perception were as follows. On the average one minute of time was overestimated by about one half. Six and a quarter minutes was doubled in the estimation of the women and overestimated by about one half by the men. The estimation of a minute of filled time incidentally perceived (Ss were asked to read a passage, were interupted, and asked to estimate the time spent reading) was about the same as the estimation of empty time purposely pe ceived. There was, however a slight gain (i.e., more accurate estimation) for purposive perception of filled time over incidental perception of filled time, through the gain was small.

Smith, N.C. The effect on time estimation of increasing the complexity of a cognitive task. The Journal of General Psychology, 1969, 81, 231-235.

This experiment examined the influence of task complexity on verbal estimates of 15-, 30-, 60-, and 120-second intervals. Task complexity was operationalized by presenting Ss with analogies of varying difficulty.

Results showed that, for all temporal intervals, as one increases the complexity of the task, there is an increase in the amount of underestimation. Further, as one increases the length of the temporal interval, one finds a progressive decrease in the percent of actual time underestimated.

Swift, E.J. and McGeoch, J.A. An experimental study of the perception of filled and empty time. Journal of Experimental Psychology, 1925, 8, 3, 240-249.

The purpose of this investigation was to determine differences in the estimation of intervals of time ranging from 30 seconds to 10 minutes under conditions of "empty time" (Ss sat quietly doing nothing) and "filled time" (Ss were occupied in various activities ranging from uninteresting to interesting). Results showed that the intervals ranging from 30 seconds to 5 minutes both filled and empty were consistently overestimated. The 10 minute period was overestimated only when Ss were engaged in an interesting but passive task. This same period was underestimated when Ss were engaged in any active task whether it was interesting or uninteresting.

APPENDIX G

LIST OF SYMPTOM COMPLEXES USED IN THE QUESTIONNAIRE

HEALTHY - FEELING FINE

FATIGABILITY AND WEAKNESS

- Somewhat tired with mild weakness
- Tired with moderate weakness
- Very tired and weak
- Exhausted with almost no strength

HYPOTENSION

- Slightly light-headed
- Unsteady upon standing quickly
- Faints upon standing quickly
- In shock: breathes rapidly and shallowly, motionless, skin cold, clammy, and very pale

UPPER GI DISTRESS

- Upset stomach; clammy and sweaty; mouth waters and swallows frequently
- Nauseated; considerable sweating; swallows frequently to avoid vomiting
- Vomited once or twice; nauseated and may vomit again
- Vomited several times including the dry heaves; severely nauseated and will soon vomit again

LOWER GI DISTRESS

- Feels uncomfortable urge to defecate
- Occasional diarrhea, recently defecated and may again
- Frequent diarrhea and cramps, defecated several times and will again soon

- Uncontrollable diarrhea and painful cramps

INFECTION AND BLEEDING

- Mild fever and headache - like starting to come down with flu
- Joints ache, considerable sweating; moderate fever; doesn't want to eat; sores in mouth/throat
- Shakes and chills and aches all over; difficulty in stopping any bleeding
- Delirious, overwhelming infections; cannot stop any bleeding

FLUID LOSS AND ELECTROLYTE IMBALANCE

- Thirsty and has dry mouth; weak and faint
- Very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion
- Extremely dry mouth, throat, skin and very painful headache; has difficulty moving; short of breath, burning skin and eyes
- Prostrate

ADDITIONAL SYMPTOM COMPLEXES

- Vomited several times including the dry heaves; severely nauseated and will soon vomit again; very tired and weak.
- Vomited once or twice; nauseated and may vomit again; very tired and weak; thirsty and has dry mouth; weak and faint.
- Nauseated; considerable sweating; swallows frequently to avoid vomiting; very tired and weak; thirsty and has dry mouth; weak and faint.
- Vomited several times including the dry heaves; severely nauseated and will soon vomit again; exhausted with almost no strength; unsteady upon standing quickly.
- Nauseated; considerable sweating; swallows frequently to avoid vomiting; very tired and weak; very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion.
- Vomited several times including the dry heaves; severely nauseated and will soon vomit again; feels uncomfortable urge to defecate; exhausted with almost no strength.

- Nauseated; considerable sweating swallows frequently to avoid vomiting; exhausted with almost no strength; very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion.
- Nauseated; considerable sweating; swallows frequently to avoid vomiting; occasional diarrhea and cramps, defecated several times and will again soon; very tired and weak; slightly light-headed; joints ache, considerable sweating; moderate fever; doesn't want to eat; sores in mouth/throat.
- Vomited several times including the dry heaves; severely nauseated and will soon vomit again; occasional diarrhea, recently defecated and may again; exhausted with almost no strength.
- Vomited several times including the dry heaves; severely nauseated and will soon vomit again; exhausted with almost no strength; slightly light-headed; mild fever and headache-like starting to come down with flu; very dry mouth and throat, headache; rapid heartbeat and may faint with moderate exertion.
- Vomited several times including the dry heaves; severely nauseated and will soon vomit again; exhausted with almost no strength; faints upon standing quickly; joints ache, considerable sweating; moderate fever; doesn't want to eat; sores in mouth/throat.
- Vomited once or twice; nauseated and may vomit again; exhausted with almost no strength; unsteady upon standing quickly; extremely dry mouth, throat, skin and very painful headache has difficulty moving short of breath; buring skin and eyes.

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APPENDIX H

MEAN TASK TIME ESTIMATES BY PHYSICAL CONDITION

PHYSICAL* CONDITIONS	TAKE-OFF TO HOVER	HOVER CHECK	HOOK-UP	HOOK-UP TO TRANSLATIONAL FLIGHT	DROP LOAD	RESUME FLIGHT	TIME TO CA 5	BREAK RADAR LOCK	EMERGENCY PROCEDURES
Healthy - Feeling Fine 111111 (N=58)	10.67 (6.04)	12.40 (11.91)	52.90 (62.41)	27.97 (23.81)	44.05 (50.22)	21.22 (18.88)	615.41 (270.54)	260.55 (1304.69)	363.74 (1836.89)
Fatigability and Weakness									
112111 (N=58)	13.24 (8.89)	13.36 (10.28)	62.58 (69.34)	33.17 (28.81)	49.93 (56.92)	24.67 (20.36)	739.48 (340.89)	273.43 (1,304.15)	366.88 (1,836.30)
113111 (N=58)	188.86 (1,310.78)	189.64 (1,310.72)	419.95 (1,827.84)	383.34 (1,833.34)	405.83 (1,830.33)	373.91 (1,835.01)	1,020.36 (1,264.46)	463.59 (1,823.01)	542.17 (2,228.02)
114111 (N=58)	537.24 (2,229.13)	537.55 (2,229.09)	788.05 (2,531.70)	734.10 (2,543.96)	757.76 (2,538.45)	723.12 (2,546.79)	1,646.74 (2,353.66)	1,003.07 (2,791.48)	1,064.83 (3,061.40)
115111 (N=58)	1,917.48 (3,943.85)	1,916.27 (3,944.44)	2,159.76 (4,039.84)	2,108.02 (4,065.69)	2,125.03 (4,057.16)	1,928.66 (3,938.47)	3,301.22 (3,862.09)	2,600.78 (4,223.13)	2,110.91 (4,064.59)
Hypotension									
111211 (N=58)	185.43 (1,311.21)	186.12 (1,311.14)	237.26 (1,305.97)	381.79 (1,833.87)	223.90 (1,307.28)	197.97 (1,309.69)	918.86 (1,258.64)	440.88 (1,825.18)	540.26 (2,228.47)
111311 (N=58)	706.69 (2,551.16	706.93 (2,551.12)	945.26 (2,806.96)	1,086.66 (3,055.02)	1,098.02 (3,050.96)	893.03 (2,821.46)	1,684.83 (2,608.39)	1,139.33 (3,038.38)	1,058.88 (3,063.39)
111411 (N=58)	2,262.07 (4,194.83)	2,261.76 (4,195.06)	2,674.93 (4,364.85)	2,477.88 (4,281.38)	2,489.40 (4,274.75)	2,278.74 (4,186.01)	3,154.00 (3,769.81)	2,892.02 (4,429.01)	2,619.12 (4,396.97)
111511 (N=58)	8,452.57 (3,639.86)	8,624.05 (3,467.40)	8,810.76 (3,235.47)	8,818.57 (3,217.13)	8,813.22 (3,230.29)	8,625.31 (3,464.23)	9,306.41 (2,311.79)	8,798.66 (3,268.29)	8,687.24 (3,335.98)

* Coding scheme is the same as used by Glickman, et al. (1983).

PHYSICAL CONDITIONS	TAKE-OFF TO HOVER	HOVER CHECK	HOOK-UP	HOOK-UP TO TRANSLATIONAL FLIGHT	DROP LOAD	RESUME FLIGHT	TIME TO CA 5	BREAK RADAR LOCK	EMERGENCY PROCEDURES
Upper GI Distress									
211111 (N=58)	787.60 (1,310.94)	188.76 (1,310.82)	245.07 (1,305.61)	207.88 (1,308.63)	232.24 (1,307.35)	213.69 (1,311.54)	946.28 (1,273.27)	461.60 (1,823.15)	543.12 (2,227.83)
311111 (N=58)	880.96 (2,825.11)	881.24 (2,825.02)	1,456.38 (3,448.32)	1,073.78 (3,058.45)	1,268.05 (3,264.15)	1,067.62 (3,060.47)	1,773.07 (2,608.80)	1,197.76 (3,025.86)	1,235.68 (3,275.08)
411111 (N=58)	1,746.18 (3,799.82	1,748.02 (3,799.14	2,336.29 (4,157.27)	1,939.33 (3,933.40)	2,139.88 (4,051.32)	1,760.55 (3,793.34)	3,003.60 (3,685.82)	2,204.90 (4,019.66)	2,270.62 (4,190.25)
511111 (N=58)	4,330.33 (4,977.08)	4,674.16 (5,012.90)	4,535.86 (4,967.82)	4,513.71 (4,987.75)	4,360.78 (4,951.62)	4,338.12 (4,970.30)	5,304.53 (4,436.97)	4,605.57 (4,908.44)	4,507.48 (4,993.29)
Lower GI Distress									
121111 (N=58)	16.53 (11.84)	16.41 (13.62)	75.45 (84.00)	36.48 (33.86)	67.72 (135.02)	31.81 (29.45)	925.50 (1,291.86)	456.45 (1,823.79)	716.86 (2,548.53)
131111 (N=58)	882.72 (2,824.55)	882.00 (2,824.79)	940.34 (2,808.27)	904.17 (2,818.23)	937.84 (2,814.23)	1,071.67 (3,059.20)	1,852.90 (2,829.24)	1,328.84 (3,243.39)	1,411.24 (3,465.34)
141111 (N=58)	3,294.60 (4,720.46)	3,293.34 (4,721.37)	3,343.29 (4,686.96)	2,973.60 (4,563.81)	2,983.86 (4,557.13)	3,142.05 (4,640.36)	3,877.33 (4,199.79)	3,412.90 (4,641.47)	3,473.67 (4,775.40)
151111 (N=58)	5,876.12 (4,950.13)	6,047.16 (4,917.59)	6,248.93 (4,839.58)	6,069.88 (4,890.74)	6,065.41 (4,895.22)	5,911.69 (4,909.83)	6,693.09 (4,287.47)	6,301.71 (4,776.05)	6,048.17 (4,916.28)
Infection and Bleeding									
111121 (N=58)	531.02 (2,230.58)	531.62 (2,230.45)	582.10 (2,219.66)	549.66 (2,226.38)	562.57 (2,223.57)	541.41 (2,228.22)	1,213.29 (2,097.42)	803.59 (2,527.84)	884.93 (2,823.91)
111131 (N=58)	1,397.33 (3,470.75)	1,396.97 (3,470.92)	1,799.86 (3,776.15)	1,589.22 (3,635.84)	1,601.43 (3,630.83)	1,581.60 (3,639.10)	2,209.98 (3,183.24)	1,686.86 (3,596.95)	1,750.26 (3,798.01)
111141 (N=58)	3,295.28 (4,720.00)	3,465.93 (4,781.04)	3,858.10 (4,843.09)	3,488.86 (4,764.91)	3,838.67 (4,858.69)	3,481.47 (4,770.06)	4,352.57 (4,321.55)	4,103.05 (4,825.38)	3,990.33 (4,913.54)

PHYSICAL CONDITIONS	TAKE-OFF TO HOVER	HOVER CHECK	HOOK-UP	HOOK-UP TO TRANSLATIONAL FLIGHT	DROP LOAD	RESUME FLIGHT	TIME TO CA 5	BREAK RADAR LOCK	EMERGENCY PROCEDURES
111151 (N=58)	8,130.50 (3,899.22)	8,299.79 (3,758.19)	8,520.16 (3,502.74)	8,371.14 (3,651.74)	8,385.09 (3,635.65)	8,520.98 (3,510.88)	8,643.47 (3,195.47)	8,502.29 (3,534.93)	8,301.05 (3,754.60)
Fluid Loss and Electrolyte Imbalance									
111112 (N=58)	879.21 (2,825.62)	879.47 (2,825.55)	1,105.24 (3,048.27)	1,071.22 (3,059.31)	1,083.98 (3,055.17)	1,233.40 (3,275.95)	2,118.95 (3,225.12)	1,332.07 (3,242.39)	1,232.91 (3,276.11)
111113 (N=58)	1,573.41 (3,642.55)	1,744.97 (3,800.41	2,156.48 (4,041.95)	2,112.78 (4,063.61)	2,291.78 (4,179.29)	1,930.81 (3,937.61	2,746.74 (3,634.58)	2,394.34 (4,127.53)	2,271.10 (4,190.01)
111114 (N=58)	4,335.53 (4,972.71)	4,852.52 (5,015.76)	4,902.24 (4,969.79)	4,888.03 (4,987.34)	4,882.67 (4,988.41)	4,879.31 (4,994.03)	5,454.00 (4,467.29)	5,162.00 (4,890.15)	5,022.22 (5,020.33)
111115 (N=58)	9,335.44 (2,464.31)	9,388.29 (2,320.95)	9,489.52 (2,200.73)	9,486.90 (2,211.95)	9,487.72 (2,208.35)	9,485.91 (2,216.15)	9,393.90 (2,245.79)	9,658.12 (1,819.59)	9,483.95 (2,224.58)
Symptom Complexes									
514111 (N=58)	3,463.10 (4,783.07)	3,462.91 (4,783.21)	4,020.40 (4,889.23)	3,479.81 (4,770.97)	3,827.95 (4,866.44)	3,472.67 (4,776.11)	4,451.00 (4,414.79)	4,263.43 (4,868.31)	4,156.21 (4,951.83)
414112 (N=58)	2,776.64 (4,496.70)	3,120.10 (4,654.83)	3,683.29 (4,800.03)	3,311.29 (4,708.84)	3,490.74 (4,763.11)	3,303.74 (4,714.08)	4,015.12 (4,243.04)	3,739.78 (4,759.72)	3,642.90 (4,830.37)
314112 (N=58)	2,262.60 (4,194.55)	2,261.16 (4,195.34)	3,352.48 (4,680.43)	3,140.83 (4,640.96)	3,317.59 (4,704.45)	3,132.07 (4,646.81)	3,857.10 (4,185.60)	3,391.81 (4,654.61)	3,128.33 (4,649.30)
515311 (N=58)	4,157.50 (4,950.76)	4,501.26 (4,998.93)	4,724.47 (4,966.33)	4,693.91 (4,994.72)	4,527.91 (4,975.34)	4,512.72 (4,988.60)	5,378.41 (4,399.68)	5,134.45 (4,915.10)	5,020.34 (6,022.19)
314113 (N=58)	3,993.43 (4,911.41)	4,165.16 (4,944.75)	4,589.17 (4,929.96)	4,380.17 (4,941.29)	4,561.71 (4,954.19)	4,351.86 (4,959.33)	5,742.34 (4,352.62)	5,154.71 (4,900.19)	5,023.69 (5,018.87)
525111 (N=58)	5,580.64 (4,957.58	6,101.74 (4,865.82)	6,083.93 (4,872.04)	5,889.26 (4,934.42)	5,895.10 (4,927.42)	5,785.50 (4,913.56)	6,778.69 (4,180.21)	6,282.17 (4,799.89)	6,054,43 (4,908.56)

PHYSICAL CONDITIONS	TAKE-OFF TO HOVER	HOVER CHECK	HOOK-UP	HOOK-UP TO TRANSLATIONAL FLIGHT	DROP LOAD	RESUME FLIGHT	TIME TO CA 5	BREAK RADAR LOCK	EMERGENCY PROCEDURES
315113	6,219.69	6,391.34	6,606.36	6,231.34	6,411.05	6,226.60	6,916.78	6,422.91	6,396.53
(N=58)	(4,876.76)	(4,830.53)	(4,718.15)	(4,861.82)	(4,804.29)	(4,867.91)	(4,153.21)	(4,788.66)	(4,823.63)
344231	3,981.59	3,980.83	4,198.28	4,168.29	4,178.43	4,161.52	4,787.62	4,611.93	4,503.74
(N=58)	(4,920.60)	(4,921.22)	(4,916.48)	(4,941.71)	(4,933.23)	(4,947.36)	(4,332.04)	(4,906.22)	(4,996.69)
535111	4,593.73	4,591.93	4,647.24	4,608.00	4,618.78	4,600.53	5,313.46	4,840.27	4,937.98
(N=59)	(5,007.71)	(5,009.37)	(4,958.80)	(4,994.63)	(4,984.76)	(5,001.46)	(4,384.66)	(4,947.11)	(5,018.74)
515223	4,931.32	5,104.98	4,987.28	4,948.32	4,955.11	4,937.33	5,967.19	5,387.84	5 285.39
(N=57)	(5,023.85)	(5,024.96)	(4,969.09)	(5,007.18)	(5,000.60)	(5,017.93)	(4,356.88)	(4,911.86)	(5,012.84)
515431	6,564.50	6,563.38	6,428.38	6,408.07	6,416.69	6,400.00	6,857.03	6,631.07	6,742.41
(N=58)	(4,775.52)	(4,777.07)	(4,781.29)	(4,808.47)	(4,796.95)	(4,819.06)	(4,227.08)	(4,686.95)	(4,706.54)
415314	7,253.07	7,251.66	7,277.98	7,092.69	7,098.72	7,085.98	7,465.84	7,285.59	7,426.40
(N=58)	(4,487.89)	(4,490.19)	(4,447.42)	(4,553.34)	(4,543.87)	(4,563.56)	(3,985.16)	(4,435.98)	(4,393.84)

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NAVAL INTELLIGENCE SUPPORT CTR
ATTN: NISC-30

NAVAL OCEAN SYSTEMS CENTER
ATTN: CODE 4471, TECH LIB

NAVAL PERSONNEL RES & DEV CENTER
ATTN: CODE P302

NAVAL POSTGRADUATE SCHOOL
ATTN: CODE 1424 LIBRARY

NAVAL RESEARCH LABORATORY
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NAVAL SEA SYSTEMS COMMAND
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ATTN: SEA-09G53 (LIB)
ATTN: SEA-643

NAVAL SURFACE WEAPONS CENTER
ATTN: CODE F-31
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NAVAL WAR COLLEGE
ATTN: CODE E-11 TECH SVC
ATTN: CTR FOR NAV WARFARE STUDIES
ATTN: DOCUMENT CONTROL
ATTN: LIBRARY
ATTN: STRATEGY DEPT

NAVAL WEAPONS EVALUATION FACILITY
ATTN: CLASSIFIED LIBRARY

NUCLEAR WEAPONS TNG GROUP, ATLANTIC
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ATTN: DOCUMENT CONTROL

NUCLEAR WEAPONS TNG GROUP, PACIFIC
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ATTN: NIS-22
ATTN: NOP 009D
ATTN: NOP 009D3
ATTN: NOP 06D
2 CYS ATTN: NOP 403

ATTN: NOP 50, AVN PLNS & RQMNTS DEV
ATTN: NOP 60
ATTN: NOP 60D
ATTN: NOP 603
ATTN: NOP 91
ATTN: OP 654(STRAT EVAL & ANAL BR)
ATTN: OP 955(AAW DIV)
ATTN: OP 981

OFFICE OF NAVAL RESEARCH
ATTN: CODE 713

OFFICE OF THE CHIEF OF NAVAL OPERATIONS
ATTN: CNO EXECUTIVE PANEL

OPERATIONAL TEST & EVALUATION FORCE
ATTN: COMMANDER

PLANS, POLICY & OPERATIONS
ATTN: CODE-P
ATTN: CODE-POC-30

SPACE & NAVAL WARFARE SYSTEMS CMD
ATTN: PME 121-3

STRATEGIC SYSTEMS PROGRAM OFFICE (PM-1)
ATTN: SP-113

TACTICAL TRAINING GROUP, PACIFIC
ATTN: COMMANDER

DEPARTMENT OF THE AIR FORCE

AERONAUTICAL SYSTEMS DIVISION
ATTN: XRO/MAF

AF/INE
ATTN: INA

AFIS/INT
ATTN: INT

AIR FORCE SYSTEMS COMMAND
ATTN: DL
ATTN: SD
ATTN: XR

AIR FORCE WEAPONS LABORATORY
ATTN: SUL

AIR UNIVERSITY
ATTN: AU/SP
ATTN: STRATEGIC STUDIES

AIR UNIVERSITY LIBRARY
ATTN: AUL-LSE
ATTN: LIBRARY

ASSISTANT CHIEF OF STAFF
2 CYS ATTN: AF/SAMI

ASSISTANT CHIEF OF THE AIR FORCE
ATTN: SAF/ALR

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ATTN: AF/RDQI

DEPUTY CHIEF OF STAFF/XOO
ATTN: AF/XOOIR

DEPUTY CHIEF OF STAFF/XOX
ATTN: AFXOXFM/PLN FRC DEV MUN PLNS DIV
ATTN: AFXOXFM/PLN FRC DEV MUN PLN
ATTN: AFXOXFS/FRC DEV STRAT OFF FRC

FOREIGN TECHNOLOGY DIVISION, AFSC
ATTN: CCN
ATTN: SDN
ATTN: TQTM

SPACE DIVISION/YH
ATTN: YH

STRATEGIC AIR COMMAND/ADWN
ATTN: ADWN

STRATEGIC AIR COMMAND/NRI-STINFO
ATTN: NRI/STINFO

STRATEGIC AIR COMMAND/SPD
ATTN: SPD

STRATEGIC AIR COMMAND/STIC
ATTN: STIC

STRATEGIC AIR COMMAND/XOXO
ATTN: XOXO

STRATEGIC AIR COMMAND/XPQ
ATTN: XPQ

STRATEGIC AIR COMMAND/XPX
ATTN: XPZ

TACTICAL AIR COMMAND/XPJ
ATTN: TAC/XPJ

TACTICAL AIR COMMAND/XPSC
ATTN: XPS

U S AIR FORCE ACADEMY
ATTN: LIBRARY
ATTN: STRATEGIC STUDIES
ATTN: USAFA/SP

USAF SCHOOL OF AEROSPACE MEDICINE
ATTN: RADIATION SCIENCES DIV

DEPARTMENT OF ENERGY

DEPARTMENT OF ENERGY
ATTN: OMA, DP 22

LAWRENCE LIVERMORE NATIONAL LAB
ATTN: D DIVISION
ATTN: L-53 TECH INFO DEPT. LIB
ATTN: Z DIVISION LIBRARY

LOS ALAMOS NATIONAL LABORATORY
ATTN: MS P364 REPORT LIBRARY
ATTN: MS 340, T DOWLER
ATTN: R SANDOVAL

SANDIA NATIONAL LABORATORIES
ATTN: TECH LIB 3141 (RPTS REC CLRK)
ATTN: R B STRATTON
ATTN: J STRUVE

OTHER GOVERNMENT

CENTRAL INTELLIGENCE AGENCY
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ATTN: DIRECTOR OF SECURITY
ATTN: MEDICAL SERVICES
ATTN: NIO-T
ATTN: N10 - STRATEGIC SYS
ATTN: OFFICE OF GLOBAL ISSUES
ATTN: R & D SUBCOMMITTEE
ATTN: SECURITY COMMITTEE
ATTN: TECH LIBRARY

FEDERAL BUREAU OF INVEST ACADEMY
ATTN: BEHAVIORAL RSCH UNIT
ATTN: LIBRARY

FEDERAL EMERGENCY MANAGEMENT AGENCY
ATTN: ASST. ASSOC. DIR FOR RSCH
ATTN: CIVIL SECURITY DIVISION
ATTN: G ORRELL NP-CP
ATTN: OFC OF RSCH/NP H TOVEY

U S COAST GUARD ACADEMY
ATTN: LIBRN

U S DEPARTMENT OF STATE
ATTN: PM/STM

U S NUCLEAR REGULATORY COMMISSION
ATTN: DIR DIV OF SAFEGUARDS
ATTN: S YANIV

DEPARTMENT OF DEFENSE CONTRACTORS

ADVANCED RESEARCH & APPLICATIONS CORP
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AEROSPACE CORP
ATTN: LIBRARY ACQUISITION

ANALYTICAL ASSESSMENTS CORP
ATTN: A WAGNER

BDM CORP
ATTN: C SOMERS
ATTN: C WASAFF
ATTN: J BODE
ATTN: J BRADDOCK
ATTN: J CONANT
ATTN: R BUCHANAN

COMPUTER SCIENCES CORP
ATTN: F EISENBARTH

DATA MEMORY SYSTEMS, INC
ATTN: T DUPUY

KAMAN SCIENCES CORP
ATTN: E CONRAD

KAMAN SCIENCES CORPORATION
ATTN: DASIAC

KAMAN TEMPO
ATTN: DASIAC

KAMAN TEMPO
ATTN: D PIRIO

PACIFIC-SIERRA RESEARCH CORP
2 CYS ATTN: G ANNO
ATTN: H BRODE, CHAIRMAN SAGE

PACIFIC-SIERRA RESEARCH CORP
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2 CYS ATTN: G MCCLELLAN

R & D ASSOCIATES
ATTN: C MCDONALD
2 CYS ATTN: DOCUMENT CONTROL
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R & D ASSOCIATES
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SCIENCE APPLICATIONS INTL CORP
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ATTN: E SWICK
ATTN: J MARTIN
ATTN: J WARNER
ATTN: M DRAKE
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SCIENCE APPLICATIONS INTL CORP
ATTN: B BENNETT
ATTN: DOCUMENT CONTROL
ATTN: J FOSTER
2 CYS ATTN: J PETERS
ATTN: J SHANNON
ATTN: L GOURE

DNA-TR-85-269 (DL CONTINUED)

2 CYS ATTN: M A ARCHER
ATTN: M FINEBURG
2 CYS ATTN: M J MOYER
ATTN: W LAYSON

SCIENCE APPLICATIONS INTL CORP
ATTN: R CRAVER

SYSTEMS RESEARCH & APPLICATION CORP
ATTN: R STEELE
ATTN: S GREENSTEIN

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