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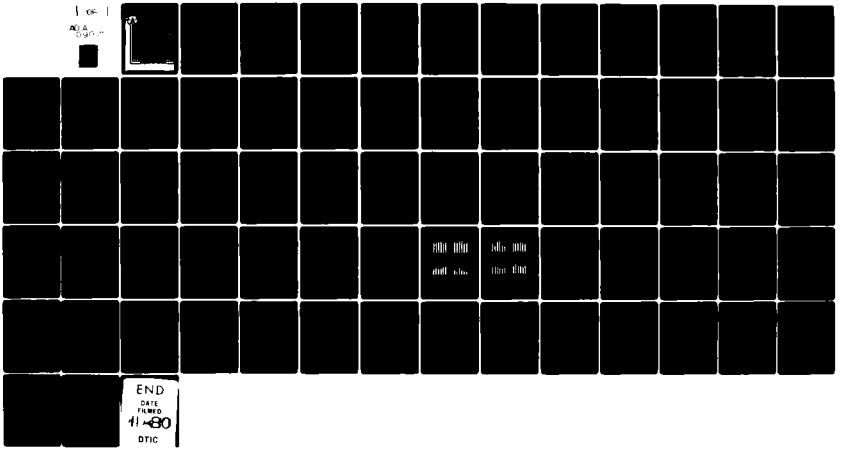

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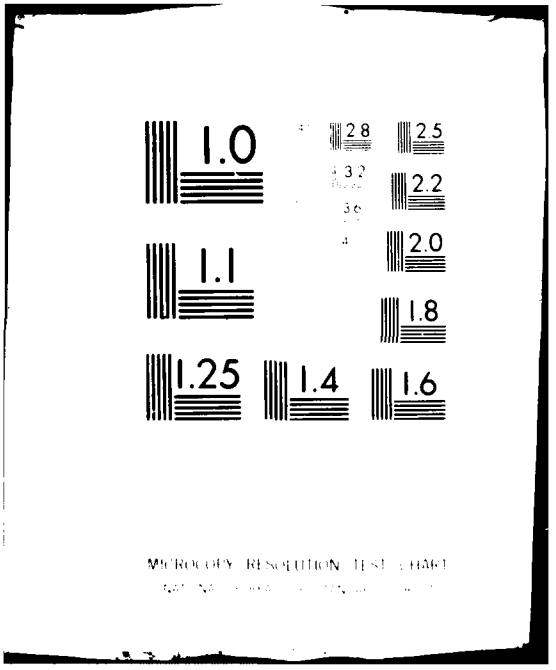
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USAARL REPORT NO. 80-8

EVALUATION OF ARMY AVIATOR HUMAN FACTORS (FATIGUE) IN A HIGH THREAT ENVIRONMENT

Chester E. Duncan
Michael G. Sanders
Kent A. Kimball

FIELD RESEARCH AND BIOMEDICAL APPLICATIONS DIVISION

September 1980

U.S. ARMY AEROMEDICAL RESEARCH LABORATORY
FORT RUCKER, ALABAMA 36362

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Reviewed:

KENT A. KIMBALL, Ph.D.
Director
Field Research & Biomedical
Applications Division

Isaac Behar
Chairman, Scientific Review
Committee

Released for Publication:

STANLEY C. KNAPP
Colonel, MC
Commanding

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20. ABSTRACT:

Questionnaire data received from student and instructor pilots located at ~~Fort Rucker, Alabama,~~ indicate significant levels of fatigue when flying in different flight altitudes and profiles; the lower the altitude flown, the more rapidly pilots experience fatigue. These data suggest night standard flight is 1.4 times as fatiguing as day standard flight; day terrain flight is 1.3 times as fatiguing as day standard flight; and night terrain flight, the most difficult flight profile examined, is 1.97 times as fatiguing as day standard flight. Army Regulation 95-1, 1 January 1980, sets a maximum of 140 hours per month per aviator of day flight in a combat environment. Existing doctrine emphasizes nap-of-the-earth techniques, and if so accomplished for 140 hours could possibly result in an unsafe and severely fatigued helicopter pilot. Field commanders utilizing the guidelines presented in this report may organize and more effectively continue their mission in Army aviation.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to the aviators who participated so enthusiastically in the completion of the questionnaire data.

A special note of sincere thanks to Mrs. Betty Dyess and Mrs. Judy Howell for their service in the preparation and typing of this report.

Dr. Michael G. Sanders is now with the US Army Research Institute Field Unit located at Fort Rucker, Alabama.

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Reg 70-25 on Use of Volunteers in Research.

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INTRODUCTION

Current intelligence doctrine projecting the source and strength of enemy threat has postulated that the initial onset of hostilities leading to war will be mid-intensity in scope, with enemy surge operations directed toward areas of opportunity in an attempt to seize and hold strategic natural, industrial, and military resources and subsequently utilize them as a base from which to extend and increase the tempo of more massive, continuous, offensive operations, or negotiate the acquisition of significant portions of these gained resources as a settlement for suspension of such hostilities. Enemy deployment will be massed against carefully chosen defense points, thus insuring the potential for maximum enemy penetration in these selected areas.

Enemy deployment will consist of both day and nighttime operations, thus permitting no periods of inactivity in allied defense reinforcement, resupply and organization. Weather and darkness will influence both enemy and allied activity during the conflict, but their effect will be of diminishing importance as technology advances are applied to tactical problems and resultant hardware is fielded.

The projected time table for this first enemy offensive is from 1 to 3 days duration. That is, within this time period after initial contact, intelligence estimates are that the enemy will have achieved its initial objectives or its offensive actions will be neutralized. A ready and immediately responsive force of considerable strength must be available on site to effectively halt initial enemy advances, take the initiative from the enemy and begin counteroffensive operations as required.

If conventional allied strength is sufficient to blunt and subsequently halt enemy advances, or at least selected fronts, the character of the war will change in a number of ways. First, round-the-clock operations will continue but the enemy will attempt to capitalize on the mobility of its ground and air forces to seize targets of opportunity considered to be useful for negotiations or vital to their further war efforts.

Second, this mobility will require a defense posture which allows force massing at such points simultaneous to projected enemy buildups. Continuous operations will, of necessity, require the utmost from both man and materiel, and subsequent attrition from not only hostile fire but task overload and fatigue must be considered in determining effective defense strengths.

In response to concern over this threat and its potential requirement for increased immobilization of combat personnel, the Department of the Army through the US Army Training and Doctrine Command, tasked the Directorate of Combat Developments (DCD), United States Army Aviation Center, to provide input to a study advisory group addressing the problems of Army Aviation Personnel Requirements for Sustained Operations (AAPRSO-SAG). In turn, DCD requested the US Army Aeromedical Research Laboratory (USAARL) (1978) to provide information on the human factors (i.e., medical, physiological and performance limits) of Army aircrews during sustained operations, particularly as these factors relate to the workload and fatigue aspects associated with aircrew functioning and relate to personnel staffing requirements.

Existing modern doctrine to counter the threat requires both present and future rotary wing flight be conducted as close to the earth's surface as possible in the combat environment. It must be recognized that unlike previous combat situations, where the majority of rotary wing flight was accomplished during daylight, a significant amount of night low-level flight will be necessary in order to effectively complete the aviation mission in a modern battlefield environment.

Different modes of flight require varying work amounts from the modern aviator. Straight and level flight 1500 feet above ground level cannot be considered as difficult to the pilot as night nap-of-the-earth (NOE) flight. It was necessary to examine these various modes of flight and to determine their potential impact upon the aviator before resolving the question of how many aviators should be assigned to various aviation organizations. USAARL considered the amount of difficulty and the time associated with specific profiles as a means of developing a subjective estimate of aviator "fatigue" associated with various missions.

METHOD

Certain guidelines were established by Directorate of Combat Developments, Fort Rucker, and taken into consideration by USAARL in order to evaluate the effects of aviator fatigue under varying flight conditions. The assumptions were as follows:

a. All aviators would be well-nourished and rested at the beginning of the operation.

b. A turbulent day versus turbulent night model would be used.

c. All aviators would be considered to be at the same level of qualification and proficiency, i.e., instrument rated, current and proficient in their unit's organic aircraft, and nap-of-the-earth qualified, if applicable.

d. Nuclear, biological, and chemical aspects of flight would not be addressed.

e. Fatigue effects of night vision goggles wear would not be taken into consideration as there are presently no data available to determine definitively their effect.

The method for the evaluation is illustrated in Figure 1. Existing data provided the starting point for the evaluation. All known sources of applicable information were considered to ensure meaningful results. The flight hours per aviator for the various time periods of 1, 2, 3, and 30 days were extrapolated from these sources.

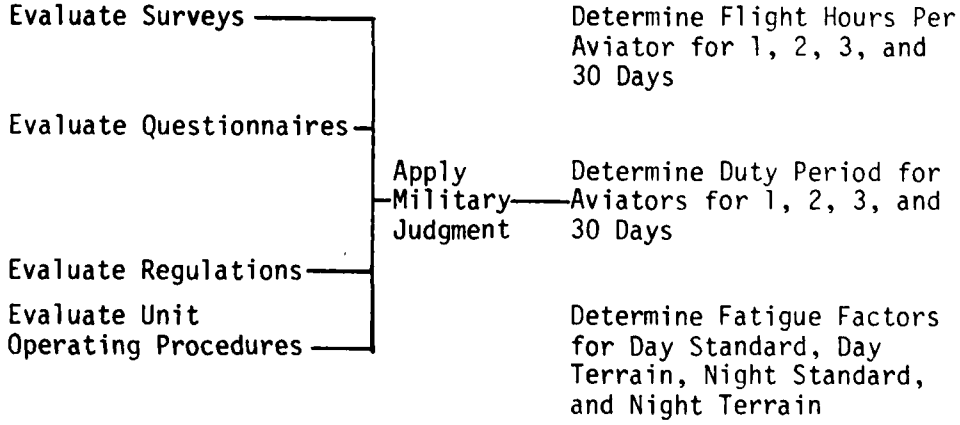

Figure 1. Method

The initial phases of the study entailed a review of available data sources. There were three primary data sources. Army Regulation 95-1 (Army Aviation: General Provisions and Flight Regulations 1980) established maximum flight hours. The U.S. First Armored Division, Ansbach, W. Germany, has a crew rest policy or flight hours limitations designed to decrease flight crew fatigue (Wood 1978). Its subordinate units are given specific guidelines for maximum flight times under garrison or tactical flight conditions. A survey conducted by the U.S. Army Aeromedical Research Laboratory concerning fatigue and flight time and crew rest requirements was the third primary source of data.

A previous survey (Appendixes A-E) conducted by USAARL was used. The questionnaires involved flight time and crew rest limits and explored six phases of initial rotary wing training. These had been administered to instructor pilots in the Initial Entry Rotary Wing Course (IERW) and to student pilots who had just completed the course of instruction. The six phases included were: (1) primary, (2) instrument (aircraft only), (3) transition, (4) tactics/day (excluding NOE), (5) tactics/night, and (6) tactics/NOE. Tactics was taught as a single unit and not three distinguishable parts as denoted in the questionnaire.

Another questionnaire was used to study the fatigue ranking of training phases in which subjects were asked to rank order the six phases of initial entry rotary wing training according to the degree of fatigue associated with each (see Appendix C). Since not all instructor pilots were totally familiar with each phase, two instructor pilots' and five student pilots' responses were deemed unacceptable.

In order to determine the applicable factors contribution to fatigue, subjects were requested to select contributing fatigue factors for each phase of training. Twenty-eight items were listed as possibly contributing to fatigue and subjects were requested to add any additional items they deemed important. No limit was placed on the number of factors subjects could select per training phase. Appendix A contains a list of the 28 factors. Appendix D is a discussion of the most applicable factors.

Addressing flight time and crew rest limits, the questionnaires enumerated six combat missions: assault, attack, heavy lift, medical evacuation, scout/reconnaissance, and support (Appendix E). For each mission with which they were familiar, the subjects were asked to provide hourly limits for day flight only and night flight only to the following six questions: (A) maximum flight hours per duty period, (B) maximum hours of duty period for 24 hours, (C) minimum hours of rest between duty periods, (D) maximum flight hours (total) for a 72-hour period, (E) maximum flight hours (total) for a 30-day period, and (F) maximum number of consecutive days of flight in which 5 hours of

flight time were logged each duty period.

In an effort to identify some of the factors contributing to fatigue, subjects were then asked to select those factors contributing to fatigue for each specific type of mission (see Appendix E). Twenty-four items were listed as possibilities and subjects were requested to write in any additional ones they considered important. The 24 items were given letter designations and these designations are used on the tables that show the rankings from the questionnaire.

RESULTS AND DISCUSSION

The review of AR 95-1 showed that the permissible duty cycle decreases significantly when considering a 24-, 48-, or 72-hour period of maximum duty for the aviator. Starting with a recommended duty of no more than 16 hours for the first 24-hour period, it decreases to a total of 27 hours of duty in 48 hours and further decreases to a maximum recommended duty of 37 hours in a 72-hour period. Table 1, p.11, shows the AR 95-1 scheduling standards. These established time schedules are most likely adequate for actual flight time, mission planning, mission coordination, standby time, and required administrative time.

In the current AR 95-1 (1980), during a 30-day mobilization period the maximum number of day flight hours is 140 and the maximum number of night flight hours is 100. The U.S. Army Aeromedical Research Laboratory regards the limit of 140 flight hours in a 30-day mobilization period as the maximum number of flight hours permitted under standard flight conditions. The fatiguing effects of terrain flight (which includes nap-of-the-earth, contour, and low level) were not originally considered in arriving at the 140 hour limitation. FM 1-1 (1975) emphasizes "it is likely that these limits will have to be reduced in those units which habitually conduct terrain flight."

The U.S. First Armored Division, Ansbach, W. Germany, has an aviation program (Table 2, p.12) designed to decrease flight crew fatigue. The aviation units are given specific guidelines for maximum flight times under varying conditions. It should be noted the maximum number of hours per 24-hour period is 8 hours of day or 6 hours of night flight. However, when aircrews are participating in NOE flight, 4 hours total is maximum flight time allowed, with no flight period in excess of 2 hours. There is a mandatory minimum of 1 hour ground time between NOE training periods. Night NOE flights are limited to a maximum of 2 hours per 24-hour period with 1 hour being the maximum flight period and a mandatory minimum of 2 hours ground time between training periods.

Using first Armored Division guidelines, we compared day standard to night standard flight. Day and night standard flights are defined as any day or night flight other than terrain flights. Under tactical conditions, when comparing day standard to night standard flight, a ratio of 1.4 is derived. Under garrison conditions, the ratio is increased to 1.8 day standard versus night standard. Day NOE is considered 2.0 times as fatiguing as day standard flight. Night NOE flight is considered by the First Armored Division to be 4.0 times at fatiguing as day standard (see Table 3, p.13).

TABLE 1

SCHEDULING STANDARDS (TABLE 5-1), AR 95-1, 1 JAN 80

1 Time Period (Hours)	2* Maximum Duty Period	3 Maximum Flight Time-Day	4 Maximum Flight Time-Night	5 Maximum Flight Time-Day and Night
24	16	8	6	7
48	27	15	12	13
72	37	22	18	20
168 (7 days)	72	37	30	33
720 (30 days) (Peace)	288	90	70	80
720 (30 days) (Mobilization	360	140	100	110

*Inclusive of columns 3, 4, and 5.

NOTE: Maximum duty period is the period between departing residence for duty and time released from duty.

Surveys conducted by USAARL were reviewed and evaluated. Results from those surveys were the basis for many of our computations to determine fatigue factor weights.

Examples of the survey questionnaire used by USAARL are at Appendix A with results shown and discussed at Appendixes B-E. Table B-1 gives the results of data collected for flight time and crew rest for the initial entry rotary wing (IERW) instructor pilots and IERW students. The questionnaire separated tactics into three separate parts although they are taught as one subject. This separation can be seen in Figures B-1 and B-2, p. 46-47. This distinction was important because night NOE flights are generally considered more taxing than day flights.

TABLE 2

FLIGHT HOURS LIMITS

GARRISON FLIGHT HOUR LIMITATIONS FOR AVIATION UNITS
OF THE US FIRST ARMORED DIVISON

Time Period	Maximum Duty Hours	Maximum Flight Hours Day Dual/Solo	Night Dual/Solo	Day-Night Dual/Solo
24 hours	12	8/6	6/4	6/5
48 hours	24	16/12	8/6	11/9
72 hours	36	22/16	12/9	15/12
7 days	60	35/25	20/15	25/20
30 days	240	90/70	50/40	70/60

TACTICAL FLIGHT HOUR LIMITATIONS FOR AVIATION UNITS
OF THE US FIRST ARMORED DIVISION

Time Period	Maximum Duty Hours	Maximum Flight Hours Day Dual/Solo	Night Dual/Solo	Day-Night Dual/Solo
30 days	320	140/100	70/70	100/100

MAXIMUM FLIGHT HOUR LIMITS BY MISSION TYPE UNDER GARRISON CONDITIONS

1. Night Missions: Maximum of 6 hours total night flight during the duty day period.

2. NOE (Nap-of-the-Earth) Missions: Four hours total flight time during the duty day period. Training period not to exceed 2 hours. At least 1 hour ground time between periods. During NOE training, the NOE segment of the total flight period should rarely exceed 75 minutes.

3. Instrument Missions and/or Instrument Training: Maximum of 4 hours per duty day period.

4. Night NOE Flights: Maximum of 2 hours during duty day period. Night NOE flights are limited to 1-hour periods with at least 2 hours ground time between periods.

MAXIMUM FLIGHT HOUR LIMITS BY MISSION TYPE UNDER TACTICAL CONDITIONS

1. Eight flying hours per duty day is maximum allowed except when approved by the aviation unit commander.

2. Maximum flight hour limitations per crew duty day must be adjusted by the aviation unit commander when flight will be conducted in the proximity of unusual weather phenomena, hazardous terrain or while in high stress situations (formation flight, extreme hot weather or cold weather operations).

TABLE 3

US FIRST ARMORED DIVISION CREW REST POLICY
(COMPUTATION OF FATIGUE FACTORS)

Time Period	Maximum Flight Hours (Dual) Day	Night
30 days (Garrison)	90	50
30 days (Tactical)	140	100

Day NOE - 4 hours total flight time during the duty day (Garrison)

Night NOE - Maximum of 2 hours during duty day period (Garrison)

	Day Standard		Night Standard		
Garrison -	90	:	50	= 1.80	Fatigue Factor for Day VS Night Standard

	Day Standard		Night Standard		
Tactical	140	:	100	= 1.40	Fatigue Factor for Day VS Night Standard

Day Standard		Day NOE		
8 hours per duty day	:	4 hours per duty day	= 2.0	Fatigue Factor Associated with Day Standard VS Day NOE

Day Standard		Night NOE		
8 hours per duty day	:	2 hours per duty day	= 4.0	Fatigue Factor Associated with Day Standard VS Night NOE

Separate hours for NOE flight were derived because of NOE's growing importance for future mission readiness.

The next item addressed in the survey was flight time and crew rest limits for combat missions (Appendix B). Table B-2, p.48, shows the flight hour limitations and need for crew rest as subjectively given by instructor pilots for six categories of flight.

The evaluation of fatigue ranking of training phases (Appendix C) are illustrated in Figures C-1 and C-2. These factors were used to arrive at the weighted factors found in Table 5, p.17.

Twenty-eight items were listed in the USAARL questionnaire as possible factors contributing to fatigue. Appendix A lists the 28 factors and Appendix D discusses the applicable factors. Tables D-1 and D-2 show the ten highest ranked factors for both instructor pilots and student pilots.

Instructor pilots gave the fatigue rankings of combat missions and two training missions. Subjects selected those factors contributing to fatigue for each specific type of mission (Appendix E, p.59). Subjects' responses are summarized in Table E-1, p.63. It should be noted that exposure to hostile action dominated those categories related to combat flying. The monotony associated with routine support flying (heavy lift and support) was chosen as a major consideration. In comparison, IPs ranked high mental workload during day flight and night flight as the number one contributor to pilot fatigue in a training environment (see Table E-2, p.64).

After a review of these data sources, it was apparent that different types of flight were considered more fatiguing than others. However, it was difficult to decide how much more fatiguing one flight condition was as compared to another, i.e., night flight versus day flight. Since the periods of time spent flying in the modes of day, night, terrain, and standard flight varied, a method to adequately evaluate the overall effect of fatigue on an aviator was required.

USAARL developed a method of deriving fatigue factors for the most frequently experienced types of helicopter flight. The method incorporated a "fatigue factor," defined as a numerical ratio, based upon aircrew responses to questionnaires and developed to quantify the relative complexity associated with differing flight regimes. Information from the available data was used in developing a fatigue factor for the following four basic types of flight.

1. Day standard (other than terrain flight).

2. Day terrain flight (this includes NOE, low level, and contour flight as defined in FM 101 1975).

3. Night standard.

4. Night terrain flight.

Day standard flight was used as the baseline figure and given a factor/weight of 1.0. This gave us a way to compare the other three types of flight with the day standard baseline.

To derive a fatigue factor for day standard flight versus night standard flight, we divided allowable day standard flight hours, 140, by allowable night standard flight hours, 100. Therefore, the fatigue factor for night standard flight is 1.4 or .4 greater each hour than the day standard flight fatigue factor.

In determining flight hours per aviator for 1, 2, 3 and 30 days, certain facts must be taken into consideration. A well-nourished, well-rested aviator obviously can safely fly more hours in one 24-hour period than is possible for a sustained 48- or 72-hour period. After the first day of extensive flying, such as would be encountered in a surge or continuous combat situation, fatigue would become a limiting factor. The maximum number of hours an aircrew can safely perform their mission will normally decrease each 24-hour period until a significant reduction in flight hours occurs. In sustained operations a pilot may be able to continuously fly a certain number of hours per day over a 30-day period without endangering himself, his crew, or his mission and still obtain an adequate amount of rest to counteract the effects of flight fatigue. Should he attempt to continuously fly a maximum number of hours per day indefinitely, his efficiency would decrease rapidly and his productivity, in turn, would decrease (Kimball and Anderson 1975).

Krueger and Jones (1978) indicated 21 of 134 pilots involved in fatigue-indicated and fatigue-related accidents during the period 1970-1977 had accumulated over 90 flight hours in the 30 days preceding the accident. In recognizing the more fatiguing effect of night terrain flight versus day flight, Berliner says, "adequate crew rest, no additional daytime duties, and a reasonable approach to the number of hours being flown per night should be definite planning considerations."

USAARL, through the use of questionnaire data, asked instructor pilots to respond to eight questions concerning flight time and crew rest data involving training missions as pertains to the following

areas: (A) maximum flight hours per duty period, (B) maximum hours of duty per 24 hours, (C) minimum hours of rest between duty periods, (D) maximum flight hours (total for a 72-hour period), (E) maximum flight hours (total for a 30-day period), (F) maximum number of consecutive days of flight in which 5 hours of flight time were logged each duty period, (G) maximum duty time (total) per 7-day period, and (H) maximum study time (total) per 7-day period. The results are presented graphically in Figures B-1 and B-2, p.46-47.

Row E of Table B-2 was utilized as an aid in determining a subjective estimate of the maximum flight hours (total) for a 30-day period a pilot felt he could safely fly under two separate circumstances--day flight and night flight. The average of the total of day hours pilots felt they could safely fly was 103.90 hours. The average of the total of night hours pilots felt they could safely fly was 74.16 hours. This equates to a ratio of 1.4 hours day flight versus night flight (see Table 4, p.16).

TABLE 4

FLIGHT TIME AND CREW REST DATA: COMBAT MISSIONS
(Expanded Row E, Table B-2)

Question	Mission Type	Day			Night		
		Mean	SD	N	Mean	SD	N
Maximum Flight	Assault	100.61	31.62	114	67.85	30.54	108
Hours (Total)	Attack	98.72	30.00	43	70.90	29.05	41
for a 30-Day	Heavy Lift	105.29	28.80	17	73.14	49.05	14
Period	Medevac	112.95	29.05	22	79.86	34.74	22
	Scout/Recon	100.81	30.47	37	74.68	33.31	32
	Support	105.03	34.77	60	78.51	44.50	56
Total Average		103.90			74.16		

Ratio 1.4

The 147 subjects were instructed to respond only to missions with which they were familiar. This accounts for the varying number of subjects among missions.

By weighting the various rankings and estimates of instructor pilots and students and utilizing the results of the U.S. First Armored Division and AR 95-1 (1980), USAARL determined the overall weighted factors to compare day standard flight to night standard flight, day standard flight to day terrain flight, and day standard flight to night terrain flight (Table 5). These weighted factors were averaged to give a mean weight for the three flight conditions. It should be noted that since AR 95-1 (1980) is the sole authority as to flight hour limitations for a continuous period of up to 30 days, and the computations generally support a 140-hour limitation in that environment, a weighted factor of 1.40 was used to compare day standard flight to night standard flight rather than the weighted factor of 1.48 shown in Table 5.

TABLE 5

WEIGHTINGS OF TYPES OF FLIGHT

	Day Standard VS Night Standard	Day Standard VS Day Terrain	Day Standard VS Night Terrain
IP IERW (69/79 Phase Rankings	1.82	2.05	3.72
SP IERW (114/119) Phase Rankings	1.34	1.57	2.17
IP IERW (79/119) Flt Hour Estimate	1.20	1.15	1.38
SP IERW (79/119) Flt Hour Estimate	1.20	1.25	1.51
IP Flt Time Estimate Day Versus Night	1.40		
1st Armd Div Combat Flt Hours	1.40		
1st Armd Div Garrison Flt Hours	1.80	2.0	4.0
1st Armd Div Tactical Flt Hours	2.0		
AR 95-1 Peacetime	1.29		
AR 95-1 Mobilization	1.40		
	1.48	1.60	2.55

Day terrain with a weighted factor of 1.60 was combined with day standard flight having a weighted factor of 1.00 and averaged for a 1.30 day terrain fatigue factor. Night terrain with a weighted factor of 2.55 was added to night standard with a weighted factor of 1.40 and averaged to form a 1.97 night terrain fatigue factor (Fig. 2). The resulting fatigue factors for the four designated flight regimes are shown in Table 6.

$$\frac{\text{DAY TERRAIN } (1.60 + \text{DAY STANDARD } 1.00)}{2} = 1.30 \text{ DAY TERRAIN FATIGUE FACTOR}$$

$$\frac{\text{NIGHT TERRAIN } (2.55 + \text{NIGHT STANDARD } 1.40)}{2} = 1.97 \text{ NIGHT TERRAIN FATIGUE FACTOR}$$

FIGURE 2. Terrain Flight Computations.

TABLE 6

USAARL'S FATIGUE FACTORS

Flight	Fatigue Factor
DAY STANDARD FLIGHT	1.00
DAY TERRAIN FLIGHT	1.30
NIGHT STANDARD FLIGHT	1.40
NIGHT TERRAIN FLIGHT	1.97

These fatigue factors, when applied against actual flight time, show the equivalent flying hours in terms of fatigue. For example, in a 30-day period an aviator flew 100 hours in a combat environment. Thirty-eight percent of his flight time was considered day standard flight, 42% day terrain flight, 9% night standard flight, and 11% night terrain flight (Table 7, p.19). Although his actual flight time was 140 hours for the 30-day period, the fatigue effects upon the aviator were equal to 177.5 hours of flight time.

TABLE 7

FATIGUE FACTORS APPLIED TO FLIGHT HOURS

Type of Flight	Percentage of Actual Flight Hours	Actual Flight Hours	Fatigue Factor	Equivalent Flight Hours
DAY STANDARD	(38%)	53	1.00	53.0
DAY TERRAIN	(42%	59	1.30	76.7
NIGHT STANDARD	(9%)	13	1.40	18.2
NIGHT TERRAIN	(11%)	15	1.97	29.6
TOTAL		140		177.5

CONCLUSIONS

USAARL has provided fatigue factors as a method of delineating potential fatigue levels for aircrews operating during varying mission profiles. A technique such as this, when applied to the operational environment, may be useful in determining crew strengths, readiness, and mission success reliability. Further studies must still be directed at unique problems in the combat environment such as nuclear, chemical, and biological threat and countermeasures which this model does not address. As more objective data become available, this model will be validated empirically.

However, the fatigue factor method presented here does give commanders a way of determining flight fatigue.

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APPENDIX A

QUESTIONNAIRE EXAMPLES

IERW TRAINING AND COMBAT MISSIONS

(FLIGHT TIME AND CREW REST LIMITS)

FLIGHT TIME/CREW REST QUESTIONNAIRE

IERW TRAINING

Studies of flight time/crew rest are few in number and inconclusive in their results. The amount of crew rest necessary is directly related to the degree of fatigue encountered during crew duty time. In a recent NATO AGARD report, "for the 50 accidents on which a full report was available, it was concluded that in some 20% aviator fatigue was a major cause of the accident."

The U.S. Army Aeromedical Research Laboratory, Aviation Psychology Division, would like to know what you, who are most involved in IERW training, consider to be optimum crew rest periods under the various phases. Of course, your participation is voluntary and we have no way of identifying you, so you can be candid with your answers. However, we would like to stress that you answer all questions because blank or partially complete questions cannot be used for analysis.

Your time, cooperation, and concern are appreciated. Inquiries on the results of this project can be directed to CPT Michael G. Sanders, U. S. Army Aeromedical Research Laboratory, Ft. Rucker.

Thank you.

FLIGHT TIME/CREW REST QUESTIONNAIRE

BIOGRAPHICAL DATA

1. Present Grade _____ 2. Age _____

3. a. Aircraft you are now flying the most _____

   b. Cumulative total number of hours _____

4. a. Aircraft you have flown the most _____

   b. Cumulative total number of hours _____

5. Cumulative total number of flying hours regardless of aircraft type _____

6. Approximate number of hours currently flown per week _____

7. Aeronautical Designation:

Army Aviator	_____
Senior Army Aviator	_____
Master Army Aviator	_____
IP/SIP	_____
Student Pilot	_____
Other (specify)	_____

*8. Rotary Wing Ratings:

Tactical Ticket	_____
Standard Ticket	_____
Special Ticket	_____
IP/SIP	_____
Instrument Examiner	_____
Other (specify)	_____

*9. Fixed Wing Ratings:

Single Engine	_____
Multiengine	_____
Standard Ticket	_____
IP/SIP	_____
Instrument Examiner	_____
Other (specify)	_____

*10. What is your current duty assignment? _____

*11. Does your current assignment require you to fly? Yes ____ No ____

*12. Number of years on flight status as a pilot? _____

*13. Did you fly in Vietnam? Yes _____ No _____

*14. If you flew in Vietnam, which type(s) of mission(s)?

Assault _____	Medical Evacuation _____	Attack _____
Heavy Lift _____	Scout/Reconnaissance _____	Support _____

*IP/SIP's only, student pilots disregard.

FLIGHT TIME/CREW REST QUESTIONNAIRE

PART I

We would like your opinion concerning flight time limits and crew rest requirements under the phases of IERW training. For purposes of this project, use the definitions given below as guidelines in answering questions A through H below.

Flight time: Actual flying time (not to include pre- and post-flight activity).

Duty period: Flight time + assigned ground duty + pre- and post-flight activity.

Study time: Minimum number of hours required for average student to be adequately prepared.

* *

(A) Maximum flight hours per duty period
(B) Maximum hours of duty period per 24 hours
(C) Minimum hours of rest between duty periods
(D) Maximum flight hours (total) for a 72-hour period
(E) Maximum flight hours (total) for a 30-day period
(F) Maximum number of consecutive days of flight in which 5 hours of flight time logged each duty period
(G) Maximum duty time (total) per seven day period
(H) Maximum study time (total) per seven day period

1. PRIMARY

(A)_____
(B)_____
(C)_____
(D)_____
(E)_____
(F)_____
(G)_____
(H)_____

2. INSTRUMENT--A/C only, excluding simulator

(A)_____
(B)_____
(C)_____
(D)_____
(E)_____
(F)_____
(G)_____
(H)_____

3. TRANSITION (Contact)

(A)_____
(B)_____
(C)_____
(D)_____
(E)_____
(F)_____
(G)_____
(H)_____

4. TACTICS--DAY (excluding NOE)

(A)_____
(B)_____
(C)_____
(D)_____
(E)_____
(F)_____
(G)_____
(H)_____

5. TACTICS--NIGHT

(A)_____
(B)_____
(C)_____
(D)_____
(E)_____
(F)_____
(G)_____
(H)_____

6. TACTICS--NOE

(A)_____
(B)_____
(C)_____
(D)_____
(E)_____
(F)_____
(G)_____
(H)_____

FLIGHT TIME/CREW REST QUESTIONNAIRE

PART II

In this segment, please rank order the listed phases of IERW training according to the degree of fatigue associated with each--i.e., the most fatiguing mission would receive a "1," the least fatiguing would receive a "6." Please rank all of them.

Once you have assigned each type of mission a rank, select the fatigue factor(s) that you feel apply to each phase of training. Put the letter(s) of the factor(s) to the right of each. Feel free to write in additional factors which you feel are important, but which are unlisted.

Rank (Most fatiguing = 1, least = 6)	IERW Training Phase	Applicable Factor(s) Contributing to Fatigue
_____	PRIMARY	_____
_____	INSTRUMENT--A/C only, excluding simulator	_____
_____	TRANSITION (Contact)	_____
_____	TACTICS--DAY (excluding NOE)	_____
_____	TACTICS--NIGHT	_____
_____	TACTICS--NOE	_____

FACTORS CONTRIBUTING TO FATIGUE

(A) Additional duties unrelated to flying

(B) Aircraft vibration

(C) Command pressure for mission completion

(D) Daily rest, lack of

(E) Day formation flight

(F) Disruption of normal wake/sleep cycle due to irregular work hours required by mission

(G) Exposure to hostile action

(H) High number of takeoffs & landings

(I) Inadequate sleep/rest facilities

(J) Instrument flying

(K) Limited visibility

(L) Long or frequent standby periods

(M) Mental workload: Requires high level of alertness & processing of information

(N) Monotony of mission

(O) Night flight

(P) Night formation flight

(Q) Noise--radio traffic, etc.

(R) Restrictions to vision--sun glare or position

(S) Seating comfort

(T) Sleep, lack of

(U) Temperature variations

(V) Weather--high winds, turbulence, etc.

(W) Uncomfortable life support equipment

(X) IP/Student ratio

(Y) Student proficiency, lack of; related tension & danger

(Z) Autorotations

(YY) Insufficient study & preparation time

(ZZ) Change of IP and/or stick buddy

FLIGHT TIME/CREW REST QUESTIONNAIRE

PART III

In this last segment, we would like to afford you the opportunity to make additional comments and remarks which you feel are relevant to this project. Your critical evaluation of the questionnaire itself would be appreciated. Again, our thanks.

* *

FLIGHT TIME/CREW REST QUESTIONNAIRE

COMBAT MISSIONS

Studies of flight time/crew rest are few in number and inconclusive in their results. The amount of crew rest necessary is directly related to the degree of fatigue encountered during crew duty time. In a recent NATO AGARD report, "for the 50 accidents on which a full report was available, it was concluded that in some 20% aviator fatigue was a major cause of the accident."

The U.S. Army Aeromedical Research Laboratory, Aviation Psychology Division, would like to know what you, who are most involved in IERW training, consider to be optimum crew rest periods under the various phases. Of course, your participation is voluntary and we have no way of identifying you, so you can be candid with your answers. However, we would like to stress that you answer all questions because blank or partially complete questions cannot be used for analysis.

Your time, cooperation, and concern are appreciated. Inquiries on the results of this project can be directed to CPT Michael G. Sanders, U. S. Army Aeromedical Research Laboratory, Ft. Rucker.

Thank you.

FLIGHT TIME/CREW REST QUESTIONNAIRE

BIOGRAPHICAL DATA

1. Present Grade_____ 2. Age_____ 3. Aircraft you are now flying the most and number of hours_____

4. Aircraft you have flown the most and number of hours_____

5. Total number of flying hours regardless of aircraft type_____

6. Approximate number of hours flown per week (currently)_____

7. Aeronautical Designation:
   _____Army Aviator
   _____Senior Army Aviator
   _____Master Army Aviator
   _____IP/SIP
   _____Other (Specify)_____

8. Rotary Wing Ratings:
   _____Tactical Ticket
   _____Standard Ticket
   _____Special Ticket
   _____IP/SIP
   _____Instrument Examiner
   _____Other (Specify)_____

9. Fixed Wing Ratings:
   _____Single Engine
   _____Multiengine
   _____Standard Ticket
   _____IP/SIP
   _____Instrument Examiner
   _____Other (Specify)_____

10. What is your current duty assignment?_____

11. Does your current assignment require you to fly? Yes____ No_____

12. Years on flight status as a pilot?_____

13. Did you fly in Vietnam? Yes_____ No_____

14. If you flew in Vietnam, which type(s) of mission(s):

    _____Assault
    _____Attack
    _____Heavy Lift
    _____Medical Evacuation
    _____Scout/Reconnaissance
    _____Support

FLIGHT TIME/CREW REST QUESTIONNAIRE:

PART I

We would like your opinion concerning flight time limits and crew rest requirements under different flight conditions and/or missions. Since the types of aviation units and flight missions are quite varied, we do not expect you to be familiar with the problems involved in each of the missions listed. In this segment, please give estimates only on those missions or conditions (p.4) with which you are familiar. For purposes of this project, use the definitions given below as guidelines in answering these questions. Use response sheet (p.5) for your estimates.

Flight time: Actual flying time (not to include pre- and post-flight activity).

Duty period: Flight time + assigned ground duty + pre- and post-flight activity.

FLIGHT TIME/CREW REST QUESTIONNAIRE

Part I: Questions

1. ASSAULT - What would be your estimate of the flight limits and crew rest requirements for an aviator flying a UH-1H in an Assault Helicopter Platoon which is part of an Assault Helicopter Company? His flight mission is as follows: to provide tactical mobility for combat troops, weapons, equipment, and supplies and conduct air assault or airmobile operations throughout the battle area (includes formation flight).

2. ATTACK - What would be your estimate of the flight limits and crew rest requirements for an aviator flying an AH-1G/AH-1Q in an Attack Helicopter Platoon which is part of an Attack Helicopter Company? His flight mission is as follows: to destroy or disrupt enemy armor and mechanized forces by aerial firepower.

3. HEAVY LIFT - What would be your estimate of the flight limits and crew rest requirements for an aviator flying a CH-54 in a Heavy Helicopter Platoon which is part of a Heavy Helicopter Company? His mission is as follows: to provide aerial movement of troops, supplies and oversized cargo within the area of operation.

4. MEDICAL EVACUATION - What would be your estimate of the flight limits and crew rest requirements for an aviator flying a UH-1H in a Medical Evacuation Platoon which is part of a Medical Evacuation Company? His mission is as follows: to provide aeromedical evacuation of selected patients and provision for air crash rescue.

5. SCOUT/RECONNAISSANCE - What would be your estimate of the flight limits and crew rest requirements for an aviator flying an OH-58 in an Aeroscout Platoon which is part of an Air Cavalry Troop? His mission is as follows: to provide detailed and timely reconnaissance movement to contact.

6. SUPPORT - What would be your estimate of flight limits and crew rest requirements for an aviator flying a CH-47C in a Helicopter Platoon which is part of an Assault Support Helicopter Company? His mission is as follows: to provide air transport of personnel and supplies for combat support and combat service support operation and rapid battlefield displacement of fire support elements.

FLIGHT TIME/CREW REST QUESTIONNAIRE

Part I: Response Sheet

For the missions with which you are familiar, please respond to questions A - F below, once for day flight only and once for night flight only. If you feel no limit exists, please fill in a zero to so indicate.

(A) Maximum flight hours per duty period.

(B) Maximum hours of duty period per 24 hours.

(C) Minimum hours of rest between duty periods.

(D) Maximum flight hours (total) for a 72-hour period.

(E) Maximum flight hours (total) for a 30-day period.

(F) Maximum number of consecutive days of flight in which 5 hours of flight time logged each duty period.

1. Mission - ASSAULT

	Day Flt Only	Night Flt Only
(A)		
(B)		
(C)		
(D)		
(E)		
(F)		

2. Mission - ATTACK

	Day Flt Only	Night Flt Only
(A)		
(B)		
(C)		
(D)		
(E)		
(F)		

3. Mission - HEAVY LIFT

	Day Flt Only	Night Flt Only
(A)		
(B)		
(C)		
(D)		
(E)		
(F)		

4. Mission - MEDICAL EVACUATION

	Day Flt Only	Night Flt Only
(A)		
(B)		
(C)		
(D)		
(E)		
(F)		

5. Mission - SCOUT/RECON

	Day Flt Only	Night Flt Only
(A)		
(B)		
(C)		
(D)		
(E)		
(F)		

6. Mission - SUPPORT

	Day Flt Only	Night Flt Only
(A)		
(B)		
(C)		
(D)		
(E)		
(F)		

FLIGHT TIME/CREW REST QUESTIONNAIRE

PART II

In this segment, please rank order the listed types of missions, as described on p.4, according to the degree of fatigue associated with each--i.e., the most fatiguing mission would receive a "1," the least fatiguing would receive an "8." Regardless of your familiarity with each type of mission, please rank all of them in this segment.

Once you have assigned each type of mission a rank, select the fatigue factor(s) from the next page that you feel apply to each type of mission. Put the letter(s) of the factor(s) to the right of each mission type listed above. Feel free to write in additional factors which you feel are important, but which are unlisted.

Rank (Most fatiguing = 1, Least = 8)	Mission Type	Applicable Factor(s) Contributing to Fatigue
_____	ASSAULT	_____
_____	ATTACK	_____
_____	HEAVY LIFT	_____
_____	MEDICAL EVACUATION	_____
_____	SCOUT/RECONNAISSANCE	_____
_____	SUPPORT	_____
_____	IP/IERW (Day Only)	_____
_____	IP/IERW (Day & Night)	_____

FACTORS CONTRIBUTING TO FATIGUE

(A) Additional duties unrelated to flying

(B) Aircraft vibration

(C) Command pressure for mission completion

(D) Daily rest, lack of

(E) Day formation flight

(F) Disruption of normal wake/sleep cycle due to irregular work hours required by mission

(G) Duration of flying duty day

(H) Exposure to hostile action

(I) High number of takeoffs & landings

(J) Inadequate sleep/rest facilities

(K) Instrument flying

(L) Limited visibility

(M) Long or frequent standby periods

(N) Mental workload: Requires high level of alertness & processing of information

(O) Monotony of mission

(P) Night flight

(Q) Night formation flight

(R) Noise--Radio traffic, etc.

(S) Restrictions to vision--sun glare or position

(T) Seating comfort

(U) Sleep, lack of

(V) Temperature variations

(W) Weather--High winds, turbulence, etc.

(X) Uncomfortable life support equipment

(Y) Other: Write in as applicable to right of mission type

FLIGHT TIME/CREW REST QUESTIONNAIRE

PART III

In this last segment, we would like to afford you the opportunity to make additional comments and remarks which you feel are relevant to this project. Your critical evaluation of the questionnaire itself would be appreciated. Again, our thanks.

* *

APPENDIX B

QUESTIONNAIRES RESULTS

IERW TRAINING AND COMBAT MISSIONS

(FLIGHT TIME AND CREW REST LIMITS)

INTRODUCTION

The purpose of this appendix is to discuss the procedures used to obtain information regarding flight time and crew rest limits.

A survey was conducted by the US Army Aeromedical Research Laboratory from approximately October 1975 through April 1976 to provide data points for the computation of fatigue factors. The intent of the survey was to investigate certain aspects of fatigue which are/were not practical for flight testing. The objectives of the survey were as follows:

1. To obtain subjective estimates of the appropriate flight time and crew rest requirements for the different phases of Initial Entry Rotary Wing (IERW) training.

2. To obtain a differential fatigue ranking of the IERW training phases.

3. To obtain a differential fatigue ranking and flight hour limit associated with different combat missions.

4. To obtain a listing of the variables which contributed the most to fatigue.

METHODS AND PROCEDURES

Two separate questionnaires were administered (IERW and Combat) and will be presented and discussed separately. The questionnaires were administered by the authors and care was taken to provide uniform instructions. Subjects were informed verbally that completion of the questionnaire was voluntary and then given background information on the project. Questions were answered and subjects were encouraged to write comments relating to the project in the section provided. Questionnaires were collected by the authors following completion.

IERW QUESTIONNAIRE

Subjects

The subjects for the Initial Entry Rotary Wing (IERW) questionnaire consisted of two basic groups--IERW instructor pilots (IP) and IERW student pilots (SP).

Instructor pilots. All IP were from the Department of Undergraduate Flight Training (DUFT), Advanced Division, Fort Rucker, Alabama. Seventy-nine IP participated in the project. All were male and the mean number of years on flight status was 6.62 (SD = 3.88) with a range from 1.5 to 34 years. Distribution by rank was as follows: 1 MAJ, 21 CPT, 1 1LT, 1 2LT, 3 CW3's, 48 CW2's, and 4 Department of the Army Civilians (DAC). Further descriptive data are shown in Table 1.

TABLE 1

DESCRIPTIVE DATA ON IERW QUESTIONNAIRE SUBJECTS

	Instructor Pilots	Student Pilots	
		Officers	WOC
No.	79	71	48
Age Range	23-58	22-31	19-29
Age Mean (SD)	30.15 (5.27)	25.11 (1.92)	23.81 (2.73)
UH-1 Flt Hrs Mean (SD)	1933.00 (697.00)	139.23 (39.44)	138.77 (43.33)
Total Flt Hrs Mean (SD)	2590.00 (1360.00)	269.26 (379.85)	238.21 (108.84)

Student pilots. All SP had completed all phases of training in the IERW program at DUFT, Advanced Division. The 114 subjects were either officers or Warrant Officer Candidates (WOC) and all were males except one. Distribution by rank was as follows: 9 CPT, 36 1LT, 26 2LT, and 48 WOC. Further description data are contained in Table 1.

Administration

The questionnaire was administered to IP at a monthly safety meeting. With the exception of a few absences, all IP within the division (DUFT, Advanced Division) were polled. Four classes of student pilots were administered the questionnaire just prior to graduation from the IERW course. All flight training had been completed before testing.

COMBAT MISSIONS QUESTIONNAIRE

Subjects

The subjects for the Combat Missions questionnaire were IP from the Department of Graduate Flight Training (DGFT) and DUFT, Advanced Division, at Fort Rucker, Alabama. All of the 147 IP were male and the age range was from 23 to 45 years with a mean age of 30.65 (SD = 4.88). Distribution by rank was as follows: 1 LTC, 1 MAJ, 46 CPT, 6 CW4's, 11 CW3's, 77 CW2's, 2 WO1's, and 3 DAC. Eighty-two percent (N = 120) of the subjects had flown in Vietnam.

Administration

This questionnaire was administered to IP from DUFT, Advanced Division, and from DGFT at division safety meetings. Except for a few absences, all IP within the two divisions were polled.

FINDINGS

IERW QUESTIONNAIRE

The results and discussion of the IERW questionnaire and the combat missions questionnaire are dealt with separately. The IERW results are presented section by section along the lines of the questionnaire format and compare IP data with SP data for each section.

Flight Time and Crew Rest Limits

The questionnaire enumerated six phases of IERW training: (1) primary, (2) instruments (aircraft only), (3) transition, (4) tactics/day (excluding NOE), (5) tactics/night, and (6) tactics/NOE. (Tactics was taught as a single unit and not in three distinguishable parts as denoted in the questionnaire. However, such distinction was important because night and NOE flights are generally considered more taxing than

day flight, and separate hours for NOE flight were desired due to its growing importance for future mission readiness.)

For each phase, subjects were asked to answer the following eight questions: (1) maximim flight hours per duty period; (2) maximum hours of duty period per 24 hours; (3) minimum hours of rest between duty periods; (4) maximum flight hours (total) for a 72-hour period; (5) maximum flight hours (total) for a 30-day period; (6) maximum number of consecutive days of flight in which five hours of flight time were logged each duty period; (7) maximum duty time (total) per 7-day period; and (8) maximum study time (total) per 7-day period.

The results for each of the eight questions are presented individually and include the following information for both the IP and SP: (1) the most fatiguing phase of training, i.e., the lowest mean for maximum flight hours, duty period, etc.; (2) the least fatiguing phase of training, i.e., the highest mean; and, (3) the mean number of flight or duty hours across all six phases of training.

Maximum flight hours per duty period. Both IP and SP indicated that tactics/night was the most fatiguing of the six phases of training (mean = 3.24 and 3.05 hours, respectively) and each reported tactics/day as being the least fatiguing (mean = 4.09 and 3.53 hours, respectively). Across all six phases of training, the mean number of maximum flight hours per duty period was 3.64 for IP and 3.22 for SP.

Maximum hours of duty per 24 hours. Both IP and SP reported tactics/night as the most fatiguing training phase (mean = 7.72 and 8.06 hours, respectively). IP indicated tactics/day the least fatiguing (mean = 8.49); SP indicated transition (mean = 9.03). Across the six phases of training the mean number of hours of duty per 24 hours was 8.17 for IP and 8.49 for SP.

Minimum hours rest between duty periods. Tactics/night, according to the IP, required the most rest between duty periods (mean = 11.99 hours) with tactics/NOE requiring the second most amount of rest (mean = 11.65). The SP indicated tactics/NOE required the most rest (mean = 9.52) with tactics/night in second place (mean = 9.22). Instrument flight required the least amount of rest between duty periods for IP (mean = 10.51) and transition the least for SP (mean = 8.72).

Across the six phases of training the mean number of minimum hours of rest between duty periods was 11.26 hours for IP and 9.04 hours for SP. The difference between the two groups may well be explained by the difference in position. The students are stationed at Fort Rucker for a specific length of time (approximately 9 months) during which they don't expect to lead a "normal" life. They are "psychologically set" for a transitory period in their lives. On the other hand, the IP are

stationed at Fort Rucker for longer periods of time (2 to 3 years as a general minimum). Their families are settled in the area (Ft Rucker is "home") and they expect to lead "normal" lives within the framework of their occupation. Thus, while the "psychological set" and the reality of the students' situation tend to converge, the expectation of the IP for living a "normal" life and the reality of their work situation tend to diverge.

Minimum flight hours (total) for a 72-hour period. Tactics/night was again the most fatiguing phase of training for IP (mean = 11.08 hours) and tactics/day the least fatiguing (mean = 13.32). Over a 3-day period, SP indicated tactics/NOE to be most fatiguing (mean = 8.66) and transition least fatiguing (mean = 10.82). Across all six phases of training, the mean number of maximum flight hours for a 72-hour period was 12.10 for IP and 9.43 for SP.

Maximum flight hours (total for a 30-day period). For IP, tactics/night was the most fatiguing phase (mean = 55.34 hours) and transition the least fatiguing (mean = 68.70). The most fatiguing phase for SP over a 30-day period was tactics/NOE (mean = 48.98) and tactics/day was the least fatiguing (mean = 61.15). Across all six phases of training the mean number of maximum flight hours for a 30-day period was 62.86 for IP and 54.38 for SP.

Maximum number of consecutive days of flight in which 5 hours of flight were logged each duty period. The IP reported tactics/night as the most fatiguing phase with a maximum of 2.97 consecutive days of duty in which 5 hours of flight were logged, while primary was the least fatiguing phase with a mean of 4.30 days. Student pilots stated that instrument training was the most fatiguing (mean = 3.50 days) and tactics/day the least fatiguing (mean = 4.35). Across all six phases of training, the mean number of consecutive days in which 5 hours of flight were logged was 3.48 for IP and 3.89 for SP.

Maximum duty time (total) per 7-day period. Tactics/night was the most fatiguing phase for IP over a 7-day period of duty (mean = 42.73 hours) and instruments the least fatiguing (mean = 47.00). Across the six phases of training, the mean of maximum duty hours per 7-day period was 45.00 for IP and 48.47 for SP.

Minimum study time (total) per 7-day period. This question was directed to student study time and IP were asked to estimate how much time they thought the average student needed to be adequately prepared for each phase. While IP's estimates tended to be 2 to 3 hours higher than those of the SP, the IP rank order was identical to that of their students; instruments requiring the most study time, then primary, transition, tactics/day, tactics/NOE, and lastly, tactics/night. Instruments required a mean of 23.31 hours of study a week as estimated by

IP and 20.88 hours according to students. Tactics/night on the other hand was estimated at 17.40 hours by IP and 15.49 hours by SP.

Across all six phases of training, the mean number of hours per week (7 days) for student study time was 19.57 as estimated by IP and 17.07 according to SP. Using these means, students need an average of 2.44 to 2.80 hours a day for study in order to be adequately prepared for IERW training.

IERW flight time and crew rest data are presented in Table B-1 and Figures B-1 and B-2.

COMBAT QUESTIONNAIRE

The purpose of this annex is to obtain appropriate flight time and crew rest data as pertains to combat missions.

Flight Time and Crew Rest Limits

The questionnaire enumerated six combat missions: assault, attack, heavy lift, medical evacuation (MEDEVAC), scout/reconnaissance, and support.

For each mission with which subjects were familiar, they were asked to give hour limits for day flight only and for night flight only to the following six questions: (A) maximum flight hours per duty period; (B) maximum hours of duty period for 24 hours; (C) minimum hours of rest between duty periods; (D) maximum flight hours (total) for a 72-hour period; (E) maximum flight hours (total) for a 30-day period; and (f) maximum number of consecutive days of flight in which 5 hours of flight time was logged each duty period.

The most fatiguing mission for day flight only was attack (mean = 6.11 hours) and the least fatiguing was MEDEVAC (mean = 7.45). For night flight only, scout/recon was the most fatiguing (mean = 3.78) and support the least fatiguing mission (mean = 5.33).

The mean percentage of the total 147 subjects responding to each of the six combat missions was as follows: assault--76.5%, attack--29.9%, heavy lift--11.4%, medical evacuation--14.6%, scout/reconnaissance--24.8%, and support--40.3%.

Maximum flight hours per duty period. Across all six missions, the mean number of maximum flight hours per duty period was 6.62 for day flight and 4.45 for night flight.

Maximum hours of duty period for 24 hours. Attack was the most fatiguing mission for day flight only (mean = 9.60 hours) and MEDEVAC the least fatiguing (mean = 11.52). Heavy lift was the most fatiguing for night flight only (mean = 7.21) and MEDEVAC the least fatiguing mission (mean = 8.95). Across all six missions, the mean number of duty hours per 24 hours was 10.34 for day flight only and 7.78 for night flight only.

Minimum hours of rest between duty periods. MEDEVAC requires the greatest amount of rest between duty periods for both day and night flight (mean = 10.72 and 11.27 hours, respectively). The data suggest that this mission requires the most rest because it and support are the onset of fatigue. Support requires the least amount of rest for day flight only (mean - 9.77). Across all six missions, the mean number of minimum hours rest between duty periods was 9.47 for day flight and 10.38 for night flight.

Maximum flight hours (total) for a 72-hour period. Scout/reconnaissance was the most fatiguing mission for both day only and night only flight (mean = 18.81 and 12.68 hours, respectively). Support was the least fatiguing for both day and night flight (mean = 22.05 and 17.01 hours, respectively). Across all six missions, the mean number of flight hours per 72-hour period was 20.42 for day flight only and 14.49 for night flight.

Maximum flight hours (total) for a 30-day period. Attack was the most fatiguing mission for day flight only (mean = 98.72 hours) and assault for night flight only (mean = 67.85). MEDEVAC was the least fatiguing for both day only and night only flight (mean = 112.95 and 79.86, respectively). Across all six missions, the mean number of flight hours for a 30-day period was 120.46 for day flight and 72.53 for night flight.

Maximum number of consecutive days of flight in which 5 hours of flight were logged each duty period. Subjects responding stated assault was the most fatiguing for both day only and night only flight (mean = 8.80 and 6.78 days, respectively) and MEDEVAC was the least fatiguing in both cases (mean = 14.65 and 12.38, respectively).

Across all six missions, the mean number of consecutive days in which 5 hours of flight logged each day was 9.90 for day flight only and 8.08 for night flight only.

Combat mission flight time and crew rest data are presented in Table B-2.

TABLE B-1

FLIGHT TIME AND CREW REST DATA: IERW TRAINING

	Question	Training Phase	Instructor Pilots Mean	IP SD	IP N	Student Pilots Mean	SP SD	SP N
A	Maximum flight hours per duty period	Primary	3.46	1.05	40[1]	3.19	4.44	119[2]
		Instrument[3]	3.59	1.32	39	3.06	4.48	118
		Transition	3.86	1.50	79	3.39	4.44	118
		Tactics/Day[4]	4.09	1.55	74	3.53	4.53	117
		Tactics/Night	3.24	0.98	74	3.05	4.51	117
		Tactics/NOE	3.47	1.25	72	3.13	4.93	117
B	Maximum hours of duty per 24 hours	Primary	8.08	2.32	40	8.53	3.50	119
		Instrument	8.25	2.37	39	8.25	3.41	119
		Transition	8.46	2.23	79	9.03	3.15	118
		Tactics/Day	8.49	2.26	74	8.75	3.06	117
		Tactics/Night	7.72	2.17	74	8.06	3.44	117
		Tactics/NOE	8.01	2.41	72	8.34	3.39	117
C	Minimum hours rest between duty periods	Primary	10.56	2.62	39	8.77	3.54	119
		Instrument	10.51	3.10	39	9.18	3.73	119
		Transition	11.07	2.96	79	8.72	3.53	118
		Tactics/Day	11.10	2.94	74	8.85	3.60	117
		Tactics/Night	11.99	3.16	74	9.22	3.71	117
		Tactics/NOE	11.65	3.12	72	9.52	4.19	117
D	Maximum flight hours (total) for a 72-hour period	Primary	11.98	4.87	39	9.41	3.38	118
		Instrument	12.10	4.94	39	8.78	3.36	118
		Transition	12.64	4.30	79	10.82	6.55	117
		Tactics/Day	13.32	5.76	74	9.98	3.52	116
		Tactics/Night	11.08	4.51	74	8.95	3.24	116
		Tactics/NOE	11.39	5.64	72	8.66	3.32	116
E	Maximum flight hours (total) for a 30-day period	Primary	66.15	23.89	39	56.62	28.79	118
		Instrument	63.74	20.56	39	49.66	19.61	118
		Transition	68.70	22.86	79	59.17	25.46	117
		Tactics/Day	66.56	23.20	74	61.15	25.45	116
		Tactics/Night	55.34	21.04	73	50.71	23.29	116
		Tactics/NOE	57.99	23.28	72	48.98	21.02	116
F	Maximum number consecutive days with five hours flight time per duty period	Primary	4.30	4.98	39	3.72	3.16	100
		Instrument	3.71	2.79	39	3.50	3.61	103
		Transition	3.55	2.41	76	4.24	3.20	105
		Tactics/Day	3.72	2.41	72	4.35	3.58	107
		Tactics/Night	2.97	1.96	73	3.81	3.61	103
		Tactics/NOE	3.08	1.72	70	3.70	3.35	101
G	Maximum duty hours (total) per seven-day period	Primary	45.92	9.42	39	50.24	21.58	118
		Instrument	47.00	8.73	39	48.31	21.24	118
		Transition	46.06	13.93	79	50.63	20.40	116
		Tactics/Day	45.89	13.83	74	49.81	20.31	116
		Tactics/Night	42.73	14.54	73	45.96	22.40	116
		Tactics/NOE	43.62	13.85	72	45.84	20.71	116
H	Maximum study time (total) per seven-day period[5]	Primary	22.05	17.16	37	16.90	11.61	119
		Instrument	23.13	17.83	37	20.88	14.33	119
		Transition	19.74	14.65	70	16.89	12.48	117
		Tactics/Day	19.04	14.58	65	16.50	13.51	117
		Tactics/Night	17.40	10.66	66	15.49	12.27	117
		Tactics/NOE	18.67	14.33	64	15.67	11.91	116

[1]Total number of 79 subjects. Since these IP's were from Advanced Division of IERW training and not therefore involved in teaching either Primary or Instruments, the number of subjects responding to questions relating to these two phases of training was largely decreased.

[2]Total number of 119 subjects.

[3]Aircraft only.

[4]Excluding NOE.

[5]This question applied to student study time requirements.

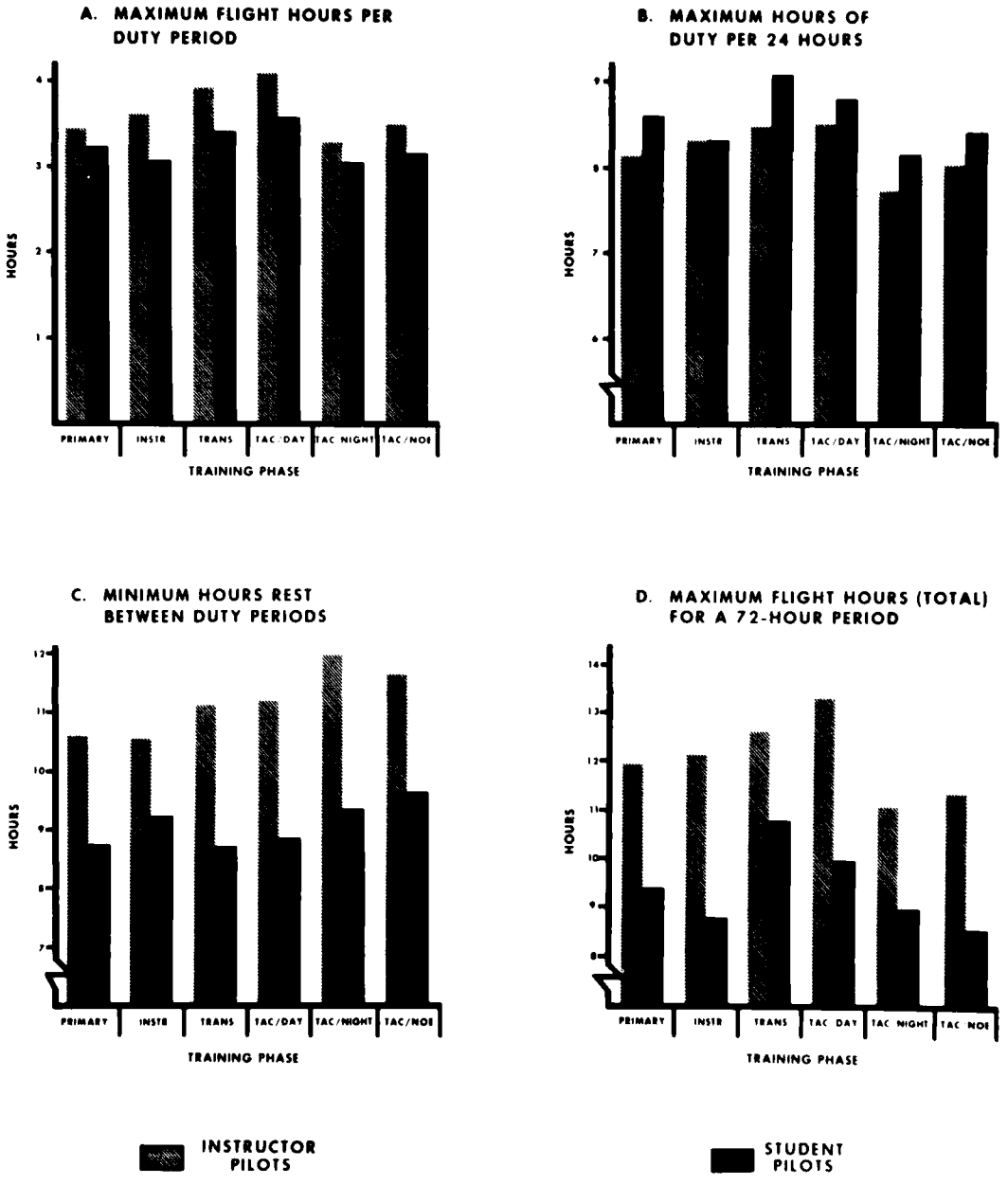


FIGURE B-1. Graphic Presentation of Flight Time & Crew Rest Data (A-D).

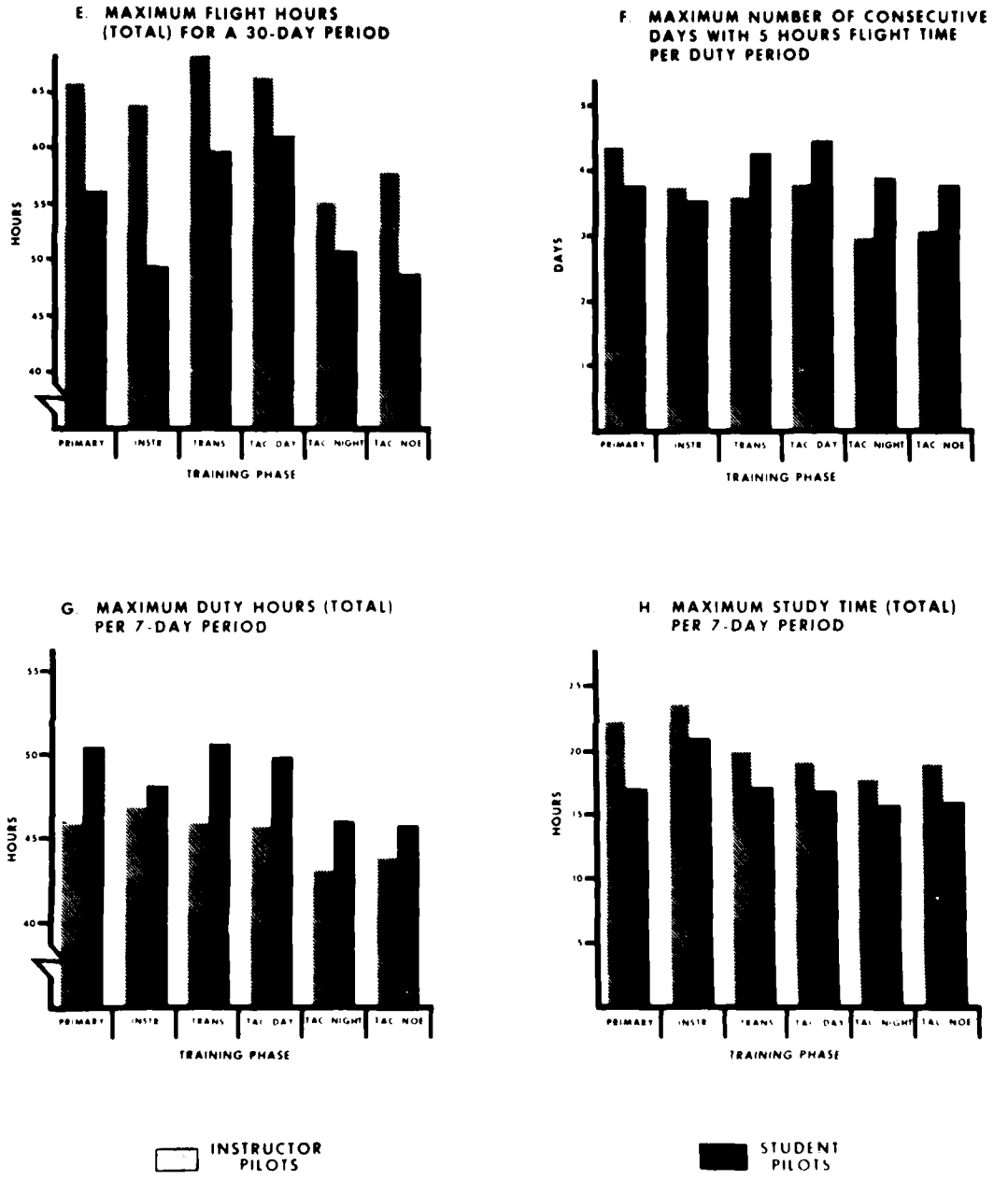


FIGURE B-2. Graphic Presentation of Flight Time & Crew Rest Data (E-H).

TABLE B-2

FLIGHT TIME AND CREW REST DATA: COMBAT MISSIONS

	Question	Mission Type	Day Mean	Day SD	Day N	Night Mean	Night SD	Night N
A	Maximum flight hours per duty period	Assault	6.47	2.08	114[1]	4.16	1.47	110
		Attack	6.11	1.65	43	4.14	1.19	41
		Heavy Lift	6.52	1.90	17	4.35	1.90	14
		Medical Evacuation	7.45	2.15	22	5.31	2.23	22
		Scout/Reconnaissance	6.13	2.08	37	3.78	1.13	33
		Support	7.31	2.41	60	5.33	2.27	57
B	Maximum hours of duty per 24 hours	Assault	10.36	2.79	113	7.67	2.38	107
		Attack	9.60	2.61	43	7.34	2.42	41
		Heavy Lift	10.11	2.05	17	7.21	2.19	14
		Medical Evacuation	11.52	3.89	21	8.95	4.28	21
		Scout/Reconnaissance	9.89	2.90	37	7.53	2.43	32
		Support	10.77	2.55	59	8.17	2.69	56
C	Minimum hours rest between duty periods	Assault	9.16	3.35	114	10.43	3.98	109
		Attack	9.13	3.32	43	9.77	2.84	40
		Heavy Lift	9.88	4.32	17	11.00	6.01	14
		Medical Evacuation	10.72	5.18	22	11.27	4.47	22
		Scout/Reconnaissance	10.45	3.55	37	10.96	2.82	32
		Support	9.11	3.40	60	9.87	4.42	57
D	Maximum flight hours (total) per 72-hour period	Assault	20.04	5.86	113	13.39	4.90	108
		Attack	19.92	6.20	42	14.52	4.97	40
		Heavy Lift	21.41	5.19	17	15.35	6.82	14
		Medical Evacuation	20.90	7.89	22	15.54	6.57	22
		Scout/Reconnaissance	18.81	5.11	37	12.68	3.34	32
		Support	22.05	6.85	59	17.01	7.80	56
E	Maximum flight hours (total) for a 30-day period	Assault	100.61	31.62	114	67.85	30.54	108
		Attack	98.72	30.00	43	70.90	29.05	41
		Heavy Lift	105.29	28.80	17	73.14	49.05	14
		Medical Evacuation	112.95	29.05	22	79.86	34.74	22
		Scout/Reconnaissance	100.81	30.47	37	74.68	33.31	32
		Support	105.03	34.77	60	78.51	44.50	56
F	Maximum number consecutive days with five hours flight time per duty period	Assault	8.80	10.63	107	6.78	7.02	102
		Attack	11.16	14.86	42	7.94	8.13	39
		Heavy Lift	12.18	21.48	16	12.07	23.19	14
		Medical Evacuation	14.65	19.62	20	12.38	19.24	21
		Scout/Reconnaissance	9.14	8.11	34	7.09	5.51	32
		Support	9.19	12.63	57	8.51	12.96	54

[1] The 147 subjects were instructed to respond only to missions with which they were familiar. This is the reason for the varying number of subjects among missions.

APPENDIX C

FATIGUE RANKING OF TRAINING PHASES

BY INSTRUCTOR PILOTS AND STUDENT PILOTS

INTRODUCTION

The purpose of this appendix is to determine the fatigue ranking of various training phases by both instructor pilots and student pilots.

Subjects were asked to rank order the six phases of IERW training according to the degree of fatigue associated with each. The most fatiguing phase was to be assigned a "1" and the least fatiguing a "6".

Subjects were instructed that all six phases had to be ranked (this caused some problems for a small number of the IP since they did not teach primary or instruments and felt unqualified to rank these two phases) and that each number from 1 through 6 was to be used (initially some questionnaires were returned with a "1" assigned to 3 or 4 phases and a "2" or "3" to the others). Inappropriate answering of this question caused 10 IP and 5 SP responses to be unacceptable.

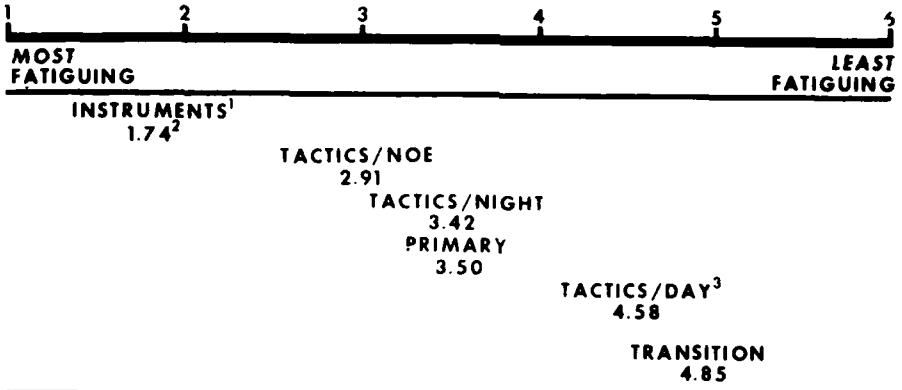
STUDENT PILOTS

The results of the SP are shown in Figure C-1. Instrument training was ranked as the most fatiguing (mean = 1.74) phase of training and transition as the least fatiguing (mean = 4.85). These findings were in general agreement with the results of the previous section.

INSTRUCTOR PILOTS

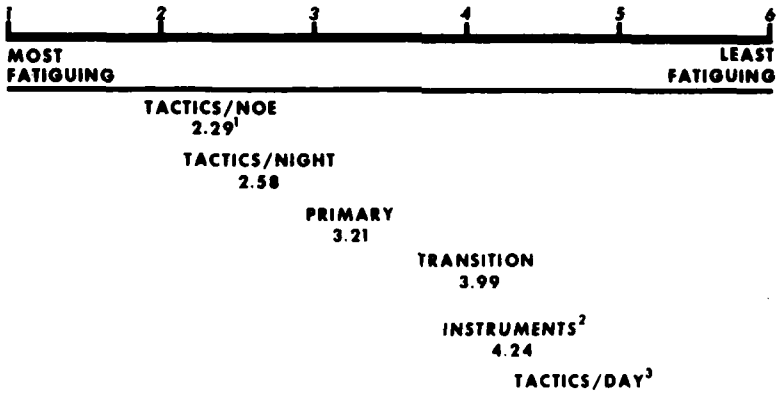
The results of the IP are shown in Figure C-2. Tactics/NOE was ranked as the most fatiguing phase of training (mean rank = 2.29). This is at some discrepancy with the results of the previous section where tactics/night was consistently accorded the lowest number of flight hours before the onset of fatigue and the highest number of hours rest between duty periods in order to recouperate from the effects of fatigue. Tactics/night, however, did follow tactics/NOE closely in rank (*mean* = 2.58).

Tactics/day was rank ordered by IP as the least fatiguing (mean = 4.69) phase of training which is largely consistent with the results of the previous section, i.e., it was accorded the highest or second highest number of flight hours before the onset of fatigue in five out of the first seven questions. The eighth question on study time did not apply to IP and cannot be related directly to fatigue.



[1]AIRCRAFT ONLY.
[2]MEAN RANK OF 114 RESPONSES OUT OF 119 SUBJECTS.
[3]EXCLUDING NOE FLIGHT.

FIGURE C-1. Fatigue Ranking of IERW Training Phases by Students.



[1]MEAN RANK OF 69 RESPONSES OUT OF 79 SUBJECTS.
[2]AIRCRAFT ONLY.
[3]EXCLUDING NOE FLIGHT.

FIGURE C-2. Fatigue Ranking of IERW Training Phases by IPs.

APPENDIX D

FACTORS CONTRIBUTING TO FATIGUE

INTRODUCTION

The purpose of this appendix is to determine the most applicable factors contributing to fatigue.

FACTORS CONTRIBUTING TO FATIGUE

Subjects were requested to select those major factors contributing to fatigue for each phase of training. Twenty-nine items were listed as possibly contributing to fatigue and subjects were requested to write in any additional factors which they felt were important. No limit was placed on the number of factors subjects could select per training phase.

The IP consistently cited IP/SP ratio and mental workload, requiring a high level of alertness and information processing, as important factors contibuting to fatigue. Also cited across all phases of training and within the top ten factors contributing to fatigue were aircraft vibration; noise, such as radio traffic; and seating comfort. It is worth noting that these last three factors are all human factors engineering problems and are not exclusively related to IERW training.

Other important factors contained within the top ten across four or five phases of training were: additional duties unrelated to flying, weather, such as high winds and turbulence, and tension and danger related to the lack of student proficiency.

Other factors within the top ten are generally training phase related: (1) high number of takeoffs and landings to primary and instruments; (2) instrument flying to instruments; (3) monitoring of mission to primary, instruments, and transition; (4) autorotations to transition; (5) day formation flight to tactics/day; (6) restrictions to vision such as sun glare or position to tactics/day and tactics/NOE; and (7) night formation flight, night flight, limited visibility, and lack of daily rest to tactics/night.

When considering tactics as an unit (day, night, and NOE), disruption of normal wake/sleep cycle due to irregular work hours required by mission ranks within the top ten in the case of tactics/night (rank = 4.5) and tactics/NOE (rank = 10.5) and within the top eleven including tactics/day. This factor is very important since tactics is taught as a single unit, and, in the real training situation, tactics/day is often combined with tactics/night. This frequently results in day departure/

night return; a situation for which there is substantial evidence of a high level of fatigue.

Command pressure for mission completion was ranked by IP across all six phases in the top twelve factors contributing to fatigue and in the top ten for tactics/day (rank = 9.5) and tactics/NOE (rank = 8).

Two factors contributing to fatigue were ranked with the top ten across all phases of training--seating comfort and additional duties unrelated to flying. High mental workload, IP/SP ratio, lack of daily rest, and disruption of normal wake/sleep cycle due to irregular work hours required by mission were ranked within the top ten factors contributing to fatigue for four or five phases of training.

Additional factors which were ranked with the top ten but only for two or three phases were weather, aircraft vibration, and noise such as radio traffic. These three factors were not ranked within the top ten across the majority of phases and they do not appear to be logically training-phase related. They are important overall factors with their ranks, having been replaced in the phases in which they did not rank within the top ten by more relevant phase-related factors.

As with the IP, the remaining high ranked factors were generally training-phase related as follows: (1) lack of student proficiency and the related tension and danger, high number of takeoffs and landings, monotony of mission, and lack of sleep in primary; (2) instrument flying, lack of sleep, change of IP and/or stick buddy, and insufficient study and preparation time in instruments; (3) high number of takeoffs and landings, monotony of mission, autorotations, lack of student proficiency, and change of IP and/or stick buddy in transition; (4) day formation flight and monotony of mission in tactics/day; (5) night flight, night formation flight, limited visibility, and lack of sleep in tactics/night; and, (6) command pressure for mission completion, restrictions in vision such as sun glare or position, change of IP and/or stick buddy, and limited visibility in tactics/NOE.

The ten highest ranked fatigue factors for IERW students are shown in Tables D-1 and D-2.

TABLE D-1

TEN HIGHEST RANKED FATIGUE FACTORS: IERW INSTRUCTOR PILOTS

	PRIMARY	INSTRUMENTS	TRANSITION	TACTICS/DAY	TACTICS/NIGHT	TACTICS/NOE
1	(N) HIGH MENTAL WORKLOAD	(K) INSTRUMENT FLYING	(Y) IP/STUDENT RATIO	(Y) IP/STUDENT RATIO	(Q) NIGHT FORMATION FLIGHT	(Y) IP/STUDENT RATIO
2	(Y) IP/STUDENT RATIO[1]	(N) HIGH MENTAL WORKLOAD	(I) HIGH NO. TAKEOFFS & LANDINGS	(E) DAY FORMATION FLIGHT	(Y) IP/STUDENT RATIO	(N) HIGH MENTAL WORKLOAD
3	(Z) LACK OF STUDENT PROFICIENCY	(B) AIRCRAFT VIBRATION	(N) HIGH MENTAL WORKLOAD	(N) HIGH MENTAL WORKLOAD	(P) NIGHT FLIGHT	(S) RESTRICTIONS TO VISION
4	(I) HIGH NO. TAKEOFFS & LANDINGS	(O) MONOTONY OF MISSION	(T) SEATING COMFORT	(R) NOISE--RADIO TRAFFIC, ETC	(F) DISRUPTION OF NORMAL WAKE/SLEEP CYCLE	(T) SEATING COMFORT
5	(O) MONOTONY OF MISSION	(Y) IP/STUDENT RATIO	(R) NOISE- RADIO TRAFFIC ETC	(T) SEATING COMFORT	(N) HIGH MENTAL WORKLOAD	(B) AIRCRAFT VIBRATION
6		(R) NOISE--RADIO TRAFFIC,ETC	(B) AIRCRAFT VIBRATION	(B) AIRCRAFT VIBRATION	(L) LIMITED VISIBILITY	(W) WEATHER--HIGH WINDS & TURBULENCE
7	(B) AIRCRAFT VIBRATION (R) NOISE--RADIO TRAFFIC, ETC (T) SEATING COMFORT	(W) WEATHER--HIGH WINDS & TURBULENCE	(Z) LACK OF STUDENT PROFICIENCY	(A) ADDITIONAL NON-FLYING DUTIES	(D) LACK OF DAILY REST	(R) NOISE--RADIO TRAFFIC,ETC
8		(T) SEATING COMFORT	(A) ADDITIONAL NON-FLYING DUTIES	(S) RESTRICTIONS TO VISION	(T) SEATING COMFORT	(C) COMMAND PRESSURE
9	(W) WEATHER--HIGH WINDS & TURBULENCE	(A) ADDITIONAL NON-FLYING DUTIES	(XX) AUTOROTATIONS	(C) COMMAND PRESSURE	(B) AIRCRAFT VIBRATION	(Z) LACK OF STUDENT PROFICIENCY
10	(A) ADDITIONAL NON-FLYING DUTIES	(Z) LACK OF STUDENT PROFICIENCY	(O) MONOTONY OF MISSION	(W) WEATHER--HIGH WINDS & TURBULENCE	(R) NOISE--RADIO TRAFFIC, ETC.	(A) ADDITIONAL NON-FLYING DUTIES (F) DISRUPTION OF NORMAL WAKE/SLEEP CYCLE

[1] FATIGUE FACTORS OF EQUAL RANK ARE GROUPED, i.e., IN THIS INSTANCE, FACTORS Y AND Z EACH HAVE A RANK OF 2.5

NOTE: Letters on table correspond to list of choices found in the original questionnaire.

TABLE D-2

TEN HIGHEST RANKED FATIGUE FACTORS: IERW STUDENT PILOTS

	PRIMARY	INSTRUMENTS	TRANSITION	TACTICS/DAY	TACTICS/NIGHT	TACTICS/NOE
1	(Z) LACK OF STUDENT PROFICIENCY	(N) HIGH MENTAL WORKLOAD	(T) SEATING COMFORT	(E) DAY FORMATION FLIGHT	(P) NIGHT FLIGHT	(N) HIGH MENTAL WORKLOAD
2	(T) SEATING COMFORT	(K) INSTRUMENT FLYING	(I) HIGH NO. TAKEOFFS & LANDINGS	(T) SEATING COMFORT	(F) DISRUPTION OF NORMAL WAKE/SLEEP CYCLE	(T) SEATING COMFORT
3	(A) ADDITIONAL NON-FLYING DUTIES	(A) ADDITIONAL NON-FLYING DUTIES	(O) MONOTONY OF MISSION	(Y) IP/STUDENT RATIO	(Q) NIGHT FORMATION FLIGHT	(C) COMMAND PRESSURE
4	(I) HIGH NO. TAKEOFFS & LANDINGS	(T) SEATING COMFORT	(Y) IP/STUDENT RATIO	(A) ADDITIONAL NON-FLYING DUTIES	(T) SEATING COMFORT	(S) RESTRICTIONS TO VISION
5	(N) HIGH MENTAL WORKLOAD	(D) LACK OF DAILY REST	(XX) AUTOROTATIONS	(N) HIGH MENTAL WORKLOAD	(D) LACK OF DAILY REST	(W) WEATHER--HIGH WINDS & TURBULENCE
6	(D) LACK OF DAILY REST	(R) NOISE--RADIO TRAFFIC, ETC.	(A) ADDITIONAL NON-FLYING DUTIES	(W) WEATHER--HIGH WINDS & TURBULENCE	(L) LIMITED VISIBILITY	(Y) IP/STUDENT RATIO
7	(Y) IP/STUDENT RATIO	(U) LACK OF SLEEP	(F) DISRUPTION OF NORMAL WAKE/SLEEP CYCLE	(F) DISRUPTION OF NORMAL WAKE/SLEEP CYCLE	(N) HIGH MENTAL WORKLOAD	(A) ADDITIONAL NON-FLYING DUTIES
8	(W) WEATHER--HIGH WINDS & TURBULENCE	(F) DISRUPTION OF NORMAL WAKE/SLEEP CYCLE	(Z) LACK OF STUDENT PROFICIENCY	(O) MONOTONY OF MISSION	(U) LACK OF SLEEP	(ZZ) CHANGE OF IP AND/OR STICK BUDDY
9	(O) MONOTONY OF MISSION	(ZZ) CHANGE OF IP AND/OR STICK BUDDY	(D) LACK OF DAILY REST	(R) NOISE--RADIO TRAFFIC, ETC	(Y) IP/STUDENT RATIO	(B) AIRCRAFT VIBRATION
10	(U) LACK OF SLEEP[1]	(YY) INSUFFICIENT STUDY TIME	(B) AIRCRAFT VIBRATION (ZZ) CHANGE OF IP AND/OR STICK BUDDY	(B) AIRCRAFT VIBRATION (D) LACK OF DAILY REST	(A) ADDITIONAL NON-FLYING DUTIES	(L) LIMITED VISIBILITY

[1] FATIGUE FACTORS OF EQUAL RANK ARE GROUPED, i.e., IN THIS INSTANCE, FACTORS O AND U EACH HAVE A RANK OF 9.5

NOTE: Letters on table correspond to list of choices found in the original questionnaire.

APPENDIX E

FATIGUE RANKING OF COMBAT MISSIONS AND INSTRUCTOR PILOT INITIAL ENTRY ROTARY WING FLIGHT (DAY AND NIGHT)

INTRODUCTION

The purpose of this appendix is to determine the fatigue ranking of the six shown combat missions and instructor pilot initial entry rotary wing flight (day and night).

Subjects were asked to rank order the six combat missions and two training missions categorized as IP/IERW (day only) and IP/IERW (day and night) according to the degree of fatigue associated with each. The most fatiguing mission was to be assigned a "1" and the least fatiguing an "8." Subjects were instructed that all eight missions had to be ranked (whether or not they were familiar with a particular mission or missions) and that each number from one through eight was to be used. Inappropriate answering of this question caused six responses to be unacceptable.

RANK ORDER OF MISSIONS

The IP/IERW (day & night) mission was ranked as the most fatiguing mission (mean rank = 2.44) despite the fact that it was competing for placement with combat missions.

Assault was ranked as the second most fatiguing mission (mean = 3.20). This is somewhat at variance with the results in the flight time and crew rest limits section where assault was generally in the third position of six missions in terms of length of possible flight hours per given periods of time. With the addition of the two training missions and the high ranking of IP/IERW (day & night), it seemed likely that assault would drop back to the number four position in rank ordering the missions.

Scout/reconnaissance was the third most fatiguing mission (mean = 3.61). This finding generally agrees with the data from the previous section.

IP/IERW (day only) and attack were ranked closely as the fourth and fifth most fatiguing missions (mean = 3.74 and 3.76, respectively). From the data in the previous section, it would have been expected that attack would rank in the number two position.

MEDEVAC ranked sixth (mean = 5.58), heavy lift seventh (mean = 6.71), and support was ranked eighth or the least fatiguing mission

(mean = 6.97). These latter ranks are in general agreement with the finding of the previous section on flight time and crew rest limits.

FACTORS CONTRIBUTING TO FATIGUE

After having ranked the combat and two training missions according to the degree of fatigue associated with each, subjects were requested to select applicable factors contributing to fatigue for each mission. Twenty-four items were listed as possible factors and subjects were instructed to write in any additional fatigue factors which they felt were important. No limit was put on the number of factors subjects could select per mission.

Although two training missions were included on this questionnaire--IP/IERW (day only) and IP/IERW (day & night), the results will be discussed separately from the combat missions. Seven factors ranked within the top ten across all six combat missions and can thus be considered general combat-related fatigue problems. Exposure to hostile action was by far the overall highest ranked fatigue factor; command pressure for mission completion and duration of flying duty day were the next two most important fatigue factors; followed by additional duties unrelated to flying, aircraft vibration, long or frequent standby periods, and lack of seating comfort. It is interesting to note that even in the combat situation two human design problems--aircraft vibration and seating comfort--appear within the top ten factors contributing to fatigue. An eighth factor which would appear to be combat-related (versus mission-related) and which was ranked within the top ten factors across five of the missions was disruption of normal wake/sleep cycle due to irregular work hours required by mission.

The remaining factors within the top ten appear to be mission specific: (1) day formation flight and night formation flight to assault; (2) high mental workload and noise such as radio traffic to attack; (3) monotony of mission, weather problems such as high winds and turbulence, and noise to heavy lift; (4) high mental workload and night flight to MEDEVAC; (5) high mental workload and lack of daily rest to scout/reconnaissance; and (6) monotony of mission, high number of takeoffs and landings, and noise to support.

Averaging the ranks for training missions, IP/IERW (day only) and IP/IERW (day & night), all but three factors were training-related. In order of their importance, these factors were: (1) mental workload requiring a high level of alertness and information processing; (2) additional duties unrelated to flying; (3) seating comfort; (4) high number of takeoffs and landings; (5) noise such as radio traffic; (6) duration of flying duty day; (7) command pressure for mission completion; and (8) disruption of normal wake/sleep cycle due to irregular

work hours required by mission and aircraft vibration--this latter did not appear in the top ten for IP/IERW (day & night) but was the eleventh ranked factor and its mean rank was equal to that of Factor F.

Ranked within the top ten and specific to IP/IERW (day only) training was the fatigue factor of day formation flight. Night flight and night formation flight were likewise specific to IP/IERW (day & night) training.

In comparing these findings with the IP data, it is interesting to note how extremely similar the results were despite the fact that the mission categories of IP/IERW (day only) and IP/IERW (day & night) are so vague and ill-defined in comparison to the six specific phases of training as delineated on the IERW questionnaire.

High mental workload was the highest ranked factor overall for both groups of IP (see Figure 6, page 18). Seating comfort, noise such as radio traffic, aircraft vibration, and additional duties unrelated to flying were all factors causing fatigue for the two groups of IP.

Instructor pilot to student ratio and lack of student proficiency (Factors Y and Z, respectively) were not listed on the combat questionnaire and duration of flying duty day (Factor G) was inadvertently omitted on the IERW questionnaire; therefore, these three factors cannot be compared.

Weather (Factor W) was reported only on the IERW questionnaire as being within the top ten highest ranked training-related fatigue factors. High number of takeoffs and landings (Factor I), command pressure for mission completion (Factor C), and disruption of normal wake/sleep cycle due to irregular hours required by mission (Factor F) were cited on the combat missions questionnaire only. These latter three factors, however, were highly ranked on the IERW questionnaire under phase-related (versus training-related) fatigue problems.

The ten highest ranked fatigue factors for the six combat missions and two training missions are shown in Tables E-1 and E-2.

TABLE E-1

TEN HIGHEST RANKED FATIGUE FACTORS:

COMBAT MISSIONS AND TRAINING ENVIRONMENT

	ASSAULT	ATTACK	HEAVY LIFT	MEDEVAC	SCOUT/RECON	SUPPORT	IP/DAY	IP/DAY & NIGHT
1	(H) EXPOSURE TO HOSTILE ACTION	(H) EXPOSURE TO HOSTILE ACTION	(O) MONOTONY OF MISSION	(H) EXPOSURE TO HOSTILE ACTION	(H) EXPOSURE TO HOSTILE ACTION	(O) MONOTONY OF MISSION	(N) HIGH MENTAL WORKLOAD	(N) HIGH MENTAL WORKLOAD
2	(C) COMMAND PRESSURE	(F) DISRUPTION OF NORMAL WAKE-SLEEP CYCLE	(B) AIRCRAFT VIBRATION	(M) LONG/FREQUENT STANDBY PERIODS	(N) HIGH MENTAL WORKLOAD	(A) ADDITIONAL NON FLYING DUTIES	(A) ADDITIONAL NON-FLYING DUTIES	(A) ADDITIONAL NON-FLYING DUTIES
3	(E) DAY FORMATION FLIGHT	(M) LONG/FREQUENT STANDBY PERIODS	(A) ADDITIONAL NON FLYING DUTIES	(F) DISRUPTION OF NORMAL WAKE/SLEEP CYCLE	(G) DURATION OF FLYING DUTY DAY	(T) SEATING COMFORT	(I) HIGH NO TAKEOFFS & LANDINGS	(P) NIGHT FLIGHT
4	(G) DURATION OF FLYING DUTY DAY	(C) COMMAND PRESSURE	(C) COMMAND PRESSURE	(A) ADDITIONAL NON-FLYING DUTIES	(C) COMMAND PRESSURE	(B) AIRCRAFT VIBRATION	(T) SEATING COMFORT	(T) SEATING COMFORT
5	(F) DISRUPTION OF NORMAL WAKE SLEEP CYCLE[1]	(N) HIGH MENTAL WORKLOAD	(G) DURATION OF FLYING DUTY DAY	(G) DURATION OF FLYING DUTY DAY	(T) SEATING COMFORT	(M) LONG FREQUENT STANDBY PERIODS	(R) NOISE.. RADIO TRAFFIC ETC	(I) HIGH NO TAKEOFFS & LANDING
6	(Q) NIGHT FORMATION FLIGHT	(G) DURATION OF FLYING DUTY DAY	(H) EXPOSURE TO HOSTILE ACTION	(N) HIGH MENTAL WORKLOAD	(B) AIRCRAFT VIBRATION	(G) DURATION OF FLYING DUTY DAY	(C) COMMAND PRESSURE	(Q) NIGHT FORMATION FLIGHT
7	(B) AIRCRAFT VIBRATION	(A) ADDITIONAL NON FLYING DUTIES	(W) WEATHER HIGH WINDS & TURBULENCE	(C) COMMAND PRESSURE	(F) DISRUPTION OF NORMAL WAKE SLEEP CYCLE	(C) COMMAND PRESSURE	(G) DURATION OF FLYING DUTY DAY	(R) NOISE.. RADIO TRAFFIC ETC
8	(T) SEATING COMFORT	(B) AIRCRAFT VIBRATION	(R) NOISE RADIO TRAFFIC ETC	(B) AIRCRAFT VIBRATION	(A) ADDITIONAL NON FLYING DUTIES	(H) EXPOSURE TO HOSTILE ACTION	(B) AIRCRAFT VIBRATION	(G) DURATION OF FLYING DUTY DAY
9	(M) LONG FREQUENT STANDBY PERIODS	(T) SEATING COMFORT	(M) LONG FREQUENT STANDBY PERIODS	(P) NIGHT FLIGHT	(D) LACK OF DAILY REST	(I) HIGH NO TAKEOFFS & LANDING	(E) DAY FORMATION FLIGHT	(F) DISRUPTION OF NORMAL WAKE/SLEEP CYCLE
10	(A) ADDITIONAL NON FLYING DUTIES	(R) NOISE RADIO TRAFFIC ETC	(T) SEATING COMFORT	(T) SEATING COMFORT	(M) LONG/FREQUENT STANDBY PERIODS	(F) DISRUPTION OF NORMAL WAKE/SLEEP CYCLE (R) NOISE..RADIO TRAFFIC ETC	(F) DISRUPTION OF NORMAL WAKE/SLEEP CYCLE	(C) COMMAND PRESSURE

[1]FATIGUE FACTORS OF EQUAL RANK ARE GROUPED i.e. IN THIS INSTANCE FACTORS F AND Q EACH HAVE A RANK OF 5.5.

NOTE: Letters on table correspond to list of choices found in the original questionnaire.

TABLE E-2

TEN HIGHEST RANKED FATIGUE FACTORS:
TWO GROUPS OF IP'S COMPARED

INSTRUCTOR PILOTS	
IERW Questionnaire	Combat Questionnaire
(N) High mental workload	(N) High mental workload
(Y) IP/SP ratio	(A) Additional nonflying duties
(T) Seating comfort	(T) Seating comfort
(R) Noise--radio traffic	(I) High number of takeoffs and landings
(B) Aircraft vibration	(R) Noise--radio traffic
(A) Additional nonflying duties	(G) Duration of flying duty day
(Z) Lack of student proficiency	(C) Command pressure for mission completion
(W) Weather--high winds and turbulence	(F) Disruption of normal work/sleep cycle
	(B) Aircraft vibration

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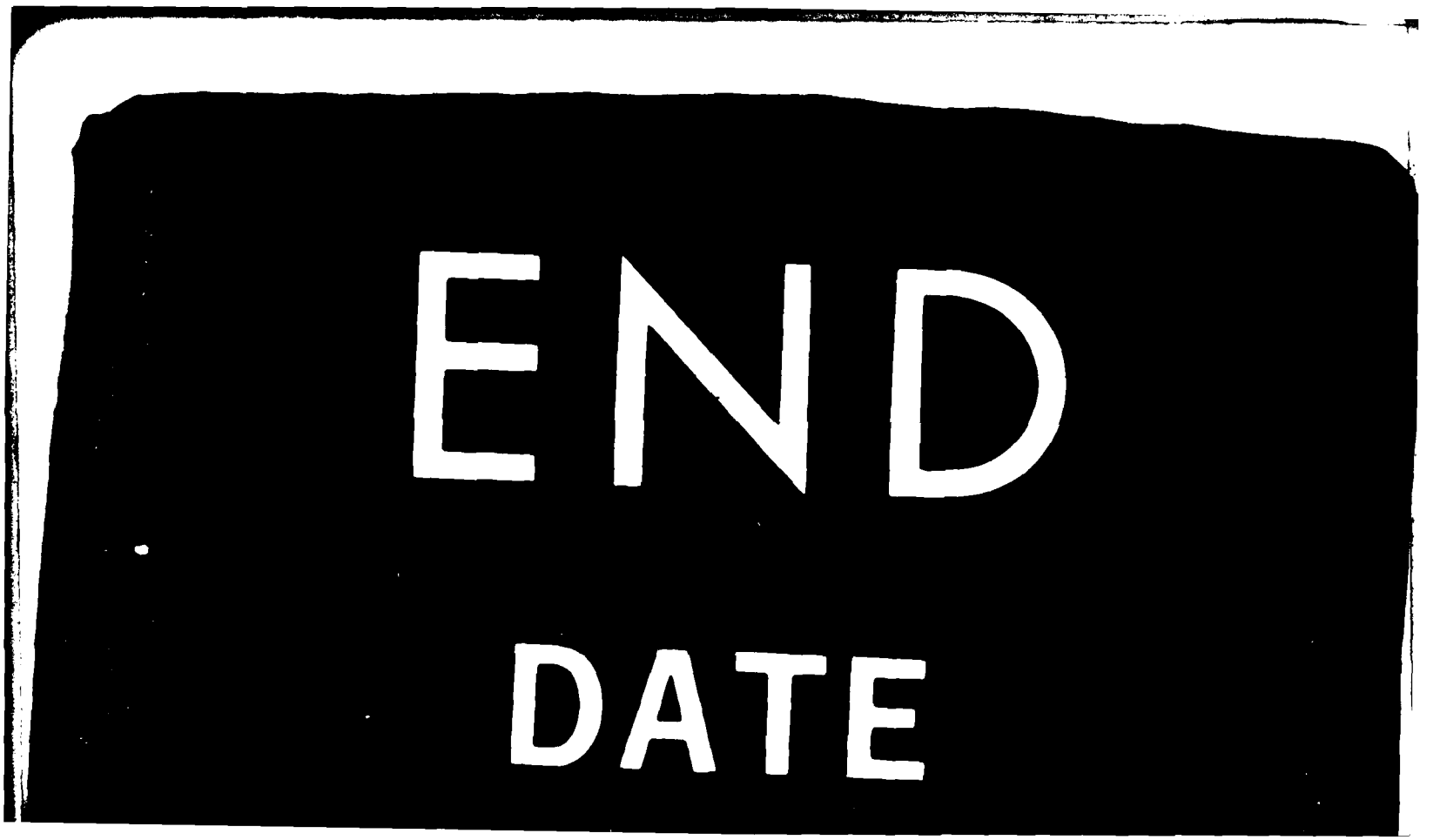
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