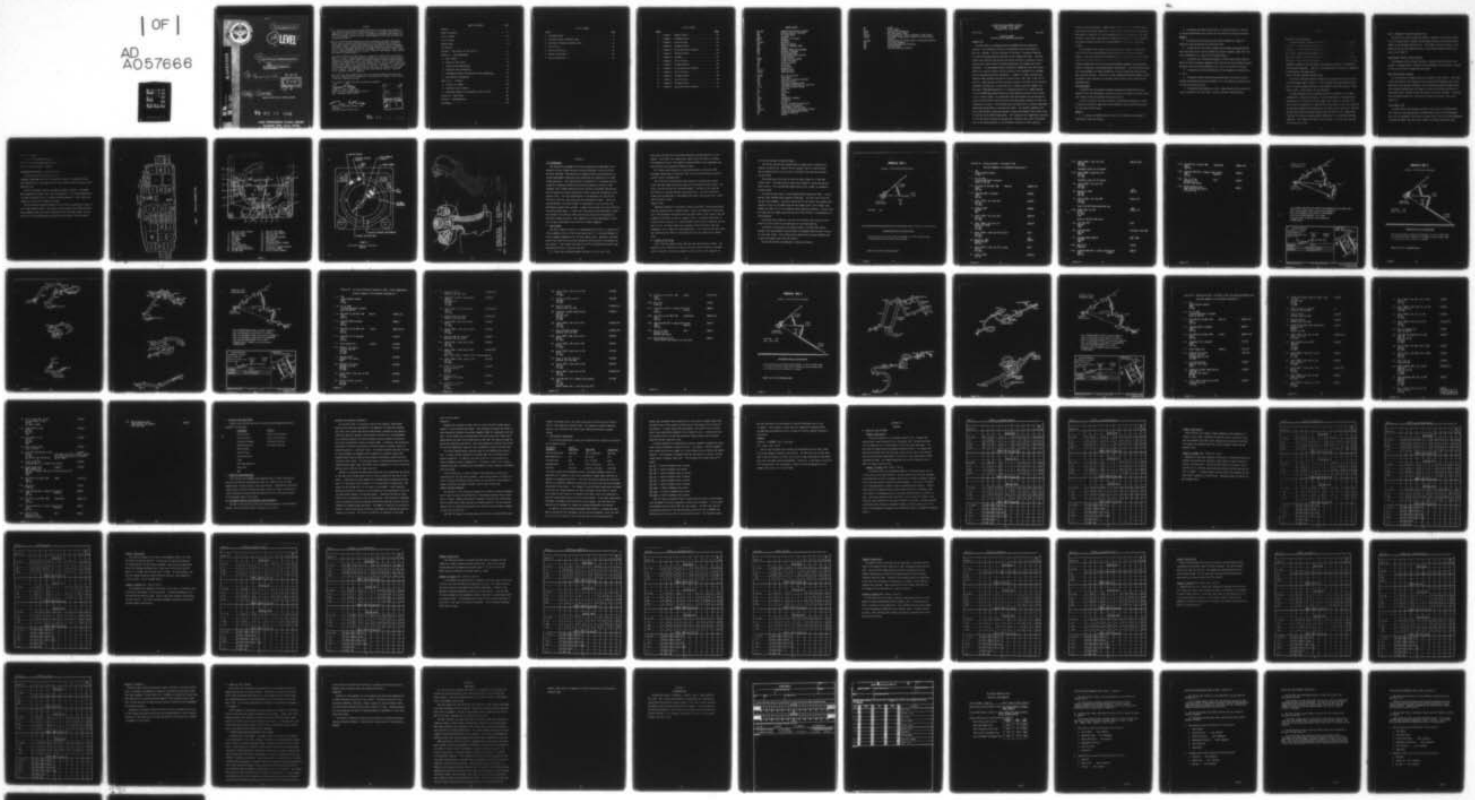
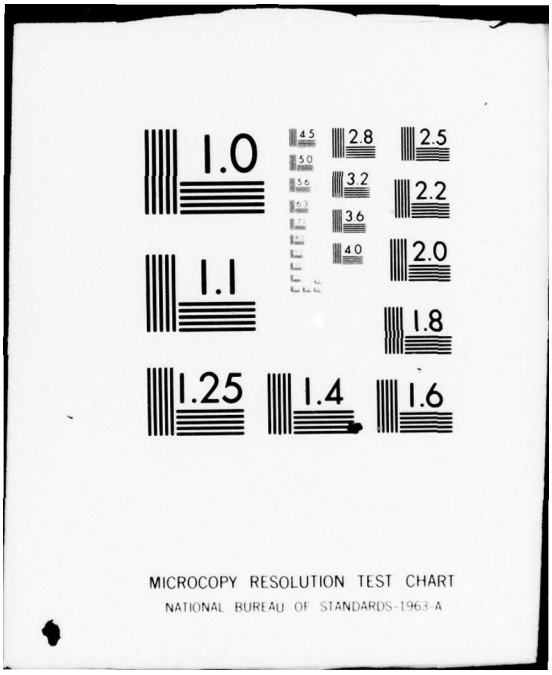
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(10) Captain Richard G. Gasparian
Project Officer

(9) Technical rept.,

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USAF INSTRUMENT FLIGHT CENTER
Randolph AFB, Texas 78148

Preface

This report covers the work accomplished during an inflight investigation of short duration operational helicopter missions. The project objective was to determine the level of pilot stress encountered by evaluating the changes in pilot performance, control activity, and biochemical levels that occurred during these missions.

Flying activities were conducted by pilots assigned to the USAF Instrument Flight Center, Research and Development Division (USAFIFC/RD), Randolph Air Force Base, Texas. Flights were conducted in the USAFIFC's TH-1F helicopter. The subject pilots participating in the study consisted of USAFIFC Instructor Pilots, pilots attending the USAFIFC Instrument Pilot Instructor School (IPIS), and U.S. Army helicopter pilots assigned to the Fort Sam Houston Flight Detachment based at Randolph AFB.

The Project Officer was Capt Richard G. Gasparian, Project Pilot was Captain Russell J. Spahr. Systems engineering support was provided by Captain James D. Balma and Mr. George Rex, USAFIFC Aerospace Engineers; project equipment maintenance was accomplished by Mr. Raoul Canamar and Mr. Orrin C. Kopff, USAFIFC Avionics Technicians; and secretarial support was provided by Mrs. Linda Wilborn. Human factors support was provided by Mr. Gerald C. Armstrong. The USAF School of Aerospace Medicine (USAFSAM) provided both technical assistance and human factors support. USAFSAM project officers were Captain Steven F. Gray and First Lieutenant Donald L. Makalous.

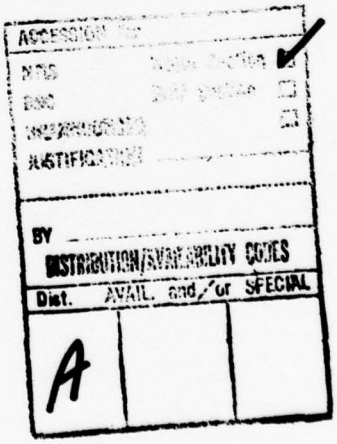
Data reduction was accomplished by the Air Training Command Data Automation Division. Appreciation is expressed to SSgt William L. Snyder for his efforts in the data reduction process.

This technical report has been reviewed and approved.

Raymond E. Trusz

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ABBREVIATIONS

AAU-19A	Counter-Drum-Pointer Altimeter
ADI	Attitude Director Indicator
AFM	Air Force Manual
ALT	Altimeter
ANOVA	Analysis of Variance
ATT	Attitude
Bio/Med	Biomedical
BPM	Beats per minute
CFI	Control Frequency Index
CMD	Command
DME	Distance Measuring Equipment
DOF	Degrees of Freedom
EKG	Electrocardiogram
F	Variance-Ratio Distribution
F/D	Flight Director
FD109	Flight Director System
FPA	Flight Path Angle
fpm	Feet per minute
GA	Go-around
GS	Glide Slope
HCl	Hydrocholoric
Hdg Sel	Heading Select
Hiqual	High Qualified
$\overline{\text{Hiqual}}$	Not High Qualified
H/R	Heart Rate
HSI	Horizontal Situation Indicator
HUD	Heads-up Display
ILS	Instrument Landing System
IMC	Instrument Meteorological conditions
J-Tec	Precision Airspeed System
K	potassium
kts	Knots
LOC	Localizer
M	Mean
Na	Sodium
Natel	Demodulator Assembly
Nav	Navigation
ND	No Data
N/L	Nav/Loc (Navigation/Localizer)
OHCS	Hydroxycorticosteriods
PAR	performance activity ratio
PiFax-H	Pilot Factors for Helicopter Program
SAS	Stability Augmentation System
SD	Standard Deviation
R	Radial

Sec	Second
SN	Serial Number
TACAN	Tactical Air Navigation
Th-1F	Bell Helicopter (Huey)
USAFIFC	United States Air Force Instrument Flight Center
IFC/RD	Instrument Flight Center, Research and Development Division
USAFSAM	United States Air Force School of Aerospace Medicine
VHF	Very High Frequency
VMC	Visual Meterological Conditions
VOR	VHF ominirange
VVI	Vertical Velocity Indicator

RESEARCH AND DEVELOPMENT DIVISION
USAF INSTRUMENT FLIGHT CENTER
Randolph AFB, Texas 78148

IFC TR 78-2 May 1978

TECHNICAL REPORT
HELICOPTER PILOT WORKLOAD EVALUATION

INTRODUCTION

The USAF School of Aerospace Medicine (USAFSAM) has been conducting research in the biochemical effects of operational stress and fatigue for well over a decade. The focus has been in two areas: biochemical measures of stress and psychobiological measures such as fatigue and sleep. The major studies have involved long duration multicycle missions in transport aircraft, long duration single mission helicopter operations, and command and control operations. The measurement battery employed by USAFSAM has been consistently sensitive to mission effects and has provided a solid foundation for recommendations regarding operational procedures. A number of studies have been performed on short duration missions on aircraft such as the F-100, F-105, FB-111, and F-15. Where mission duration has been as high as five hours or has involved substantial workload (as is occasioned by in-flight refueling), demands like low-level, high-speed penetration, or repeated periods of air combat maneuvering, the USAFSAM measurement battery has been generally sensitive but variable. In all of these studies, the comparisons have been between pre and post-mission values with the mission profile providing the operational workload to stress and challenge the aircrew. There has been only one opportunity to achieve experiment determined manipulations of workload and stress - the recently completed T-39 USAF Flight Dynamics Laboratory/Honeywell Research/Instrument Flight Center study of workload during VFR/IFR approaches. That study was only tangentially tailored to the biochemical approach to workload and, therefore, was a less satisfactory test of the appropriateness of the biochemical battery for short duration,

variable workload operations. Additionally, only three of the USAFSAM studies have involved helicopter operations. In only one of these studies was workload manipulated and measures of pilot performance and activity obtained. This constitutes a significant short-coming in establishing the utility of the biochemical/psychobiological battery for the measurement of short-term stress and fatigue.

The Instrument Flight Center (IFC) has developed a method of determining both pilot activity and performance during operational helicopter missions. However, except for the results obtained during the Three Cue Helicopter Flight Director Evaluation (IFC TR 77-3, July 77), there has been no quantitative correlation between the pilot activity and performance parameters and any physiological, biochemical, and psychobiological measurements. Such correlations would lay firm groundwork for future predictions of pilot fatigue and stress during short duration missions. With this in mind, USAFSAM and USAFIFC engaged in joint helicopter flight evaluation to provide a specific test of the utility of the USAFSAM battery.

TEST OBJECTIVES:

To quantify the relationships between biochemical/psychobiological test batteries and pilot performance, control activity, and subjective ratings within well defined stress and workload helicopter missions.

In order to achieve this basic objective, the present program had a series of general and specific objectives; the attainment of which provides the basis for the above quantification.

General:

a. To expand the USAFSAM technical base in the biomedical assessment of operational stress and fatigue.

b. To quantify the workload and stress of flying helicopters, relative to the well-established stress scales for long duration, multicycle missions.

Specific:

a. To quantify the preflight and postflight biochemical changes as a function of the defined mission difficulty levels.

b. To quantify the relationship between the biochemical/psychobiological tests and pilot control activity defined as control frequency index (CFI) and pilot performance as a function of mission difficulty.

c. To quantify the relationship between in-flight physiological measurements for specific maneuver segments within missions and the biochemical/psychobiological test and pilot performance, CFIs, and pilot difficulty ratings.

d. To determine the interrelationships of the parameters of objectives a, b, and c.

e. To determine those biochemical/psychobiological tests which provide maximum correlation with pilot performance, CFI, and subjective ratings across all mission difficulty levels.

f. To determine from objectives d and e, those measures which can be utilized as predictors of pilot stress, fatigue, workload, and performance.

SECTION I

Description of Test Vehicle

The evaluation was conducted in USAFTFC/PD, TH-1F helicopter (SN 66-1249). The TH-1F is representative of the basic, light-to-medium class unaugumented helicopter. The aircraft was specially modified to accomodate evaluations of the refined control-display elements in the overall PIFAX-H program. A complete description of all peculiar items can be found in TFC TR-77-3, Three Cue Helicopter Flight Director Evaluation, July 1977. A brief description of those components germane to the Helicopter Pilot Workload Evaluation is presented in the following paragraphs. (See Fig 1 for presentation of location of components on the modified instrument panel.)

PILOT'S ATTITUDE DIRECTOR INDICATOR (ADI)

The pilot's attitude director indicator was located on the pilot's section of the instrument panel (Figure 1). This instrument has been modified to display the flight parameters peculiar to helicopters rather than those of fixed-wing aircraft. (See Figure 2 for ADI displays.)

The ADI presented aircraft attitude and flight information on a symbolic 3-dimensional, forward-view display. Aircraft attitude was displayed by the relationship of a stationary aircraft symbol with respect to a horizon line. The horizon was presented on a tape that was servo-driven in both roll and pitch. The tape had graduated pitch markings (up and down) and was colored to represent the sky (blue) above and ground (brown) below the horizon line, respectively. Pitch and roll scale was approximately double that of a conventional attitude indicator. All flights were flown in the GYRO mode. All bars and flags were out of the pilot's view.

PILOT'S HORIZONTAL SITUATION INDICATOR (HSI)

The pilot's horizontal situation indicator, located on the pilot's section of the instrument panel, displays the horizontal position of the aircraft with respect to the selected navigation aid. (See Figure 3 for HSI displays.) The heading marker was positioned by means of a slew switch located on the pilot's cyclic grip (Figure 4).

INSTANTANEOUS VERTICAL SPEED INDICATOR

Instantaneous vertical speed indicators, located on both the pilot's and copilot's instrument panel, indicated the instantaneous rate of ascent or descent of the aircraft from 0 to 6000 feet per minute.

PRECISION AIRSPEED INDICATOR

A J-TEC Precision Airspeed System was installed in the aircraft. The installation consisted of; two indicators (one for each pilot) mounted on the instrument panel, the electronics package, and the externally mounted airspeed sensor. Each indicator operated over the range of 0 knots to 160 knots and had an airspeed marker which traveled around the outside ring of the indicator. The marker was positioned by means of a slew switch located on the pilot's cyclic grip (Figure 4).

EVENT MARKER LIGHT

An EVENT marker light had been installed in the pilot's instrument panel. This light was activated whenever the EVENT marker switch on the instrumentation rack was actuated or the button on either pilot's cyclic stick was depressed. Actuating the EVENT light also sent a signal to the data acquisition tape.

AAU-19/A ALTIMETER

An AAU-19/A Counter-Drum-Pointer Altimeter was located on the subject pilot's panel and provided the pilot with the same information as the conventional 3-pointer system it replaced.

INSTRUMENTATION RECORDER SYSTEM DESCRIPTION

An instrumentation recording system rack was installed in the cargo passenger compartment just aft of the pilot's station. An operator's seat was installed aft of the project pilot's (left seat) station facing the instrumentation rack.

The rack contained a digital incremental magnetic recorder, a 10-channel Natel demodulator assembly and a time code generator. This system enabled the in-flight recording of up to 32 control-display parameters. Each channel was sampled at a rate of five times per second.

Position sensors had been mounted in the aircraft and connected to the primary flight control system. The control position sensors and display performance parameters were electrically connected to the recording system. The versatility of the recording/sensor system allows "tailoring" for each project.

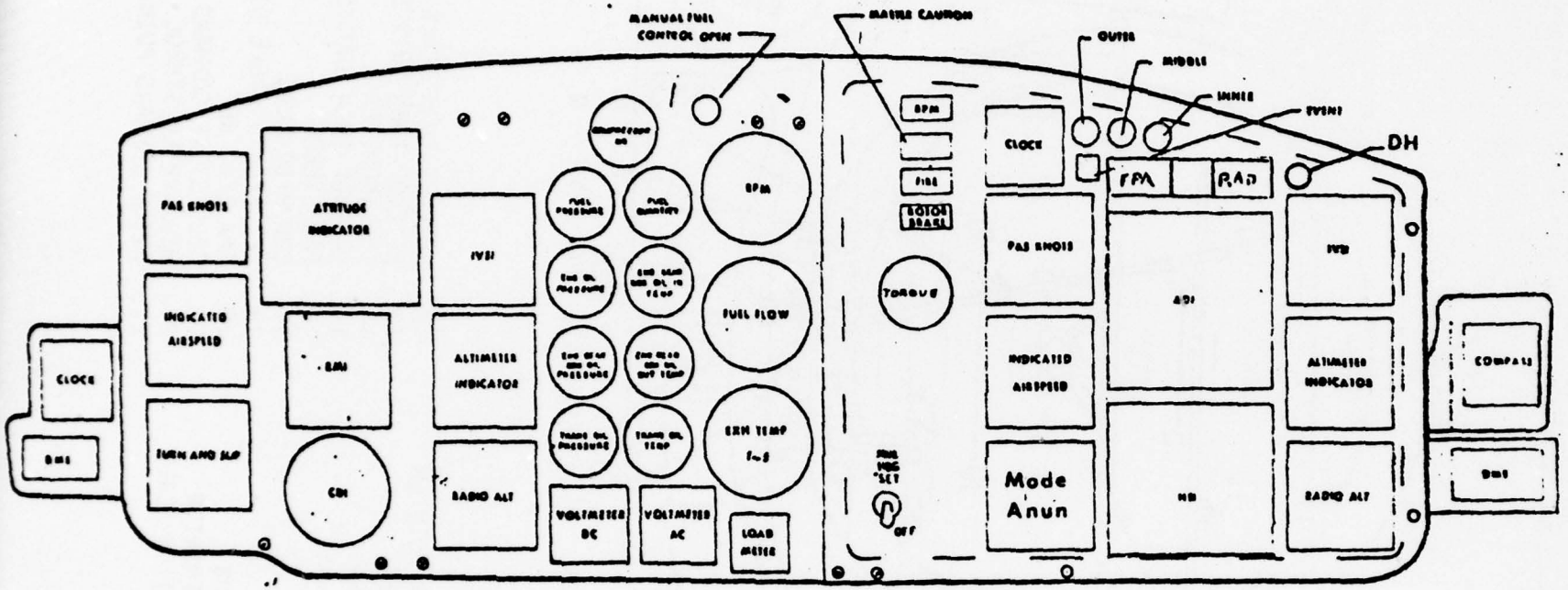
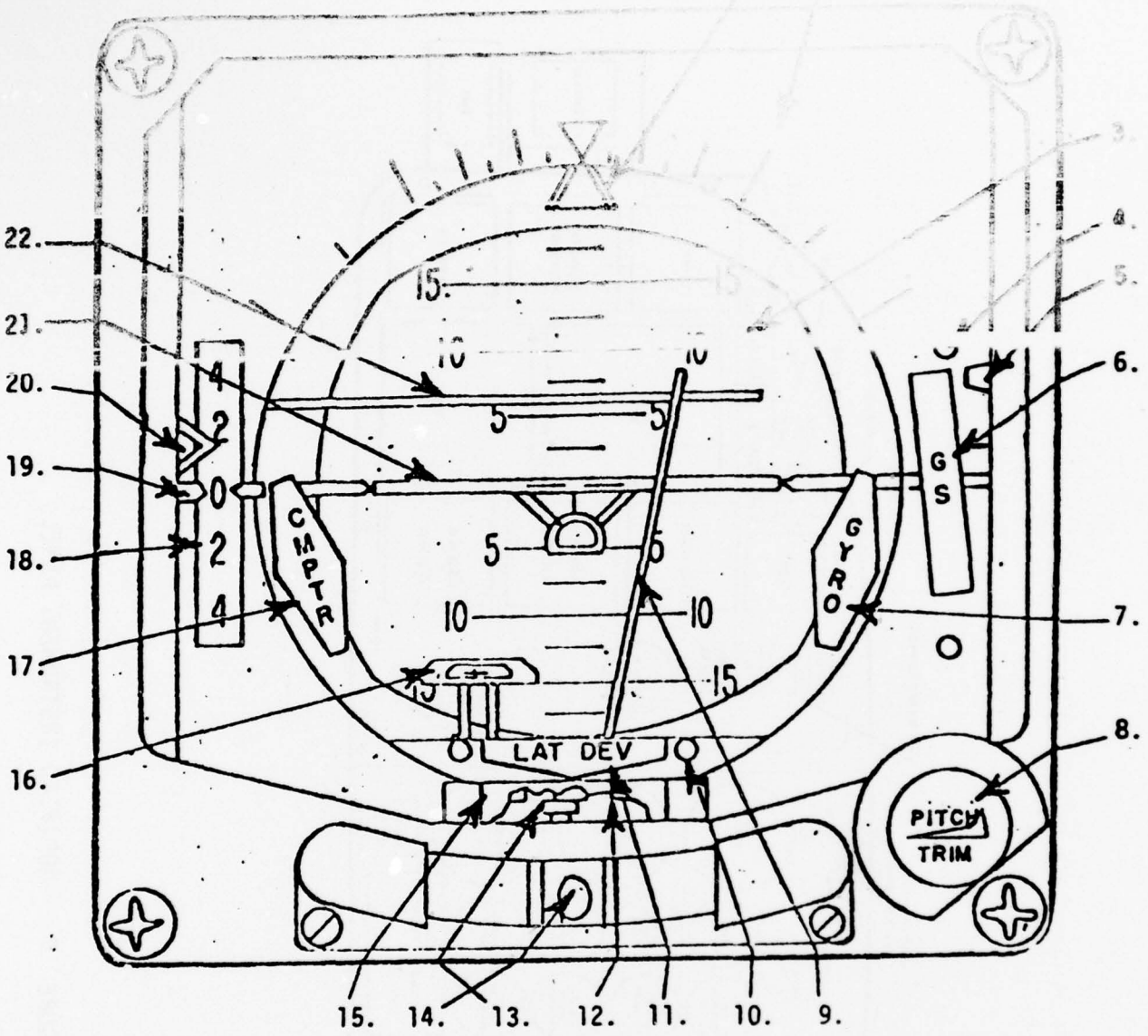


FIGURE 1 MODIFIED INSTRUMENT PANEL



1. ROLL ATT INDEX POINTER
2. ROLL ATT SCALE
3. PITCH ATT SCALE
4. GS SCALE
5. GS POINTER
6. GS FLAG
7. GYRO FLAG
8. PITCH TRIM KNOB
9. ROLL COMMAND POINTER
10. LATERAL DEVIATION SCALE
11. LAT DEV FLAG
12. RATE-OF-TURN SCALE
13. RATE-OF-TURN POINTER
14. INCLINOMETER
15. RATE-OF-TURN SHUTTER
16. PAD SYMBOL
17. COMPUTER FLAG
18. FLIGHTPATH ANGLE DISPLAY
19. FPA ZERO REF
20. COLLECTIVE COMMAND POINTER
21. HELICOPTER SYMBOL
22. PITCH COMMAND POINTER

Figure 2

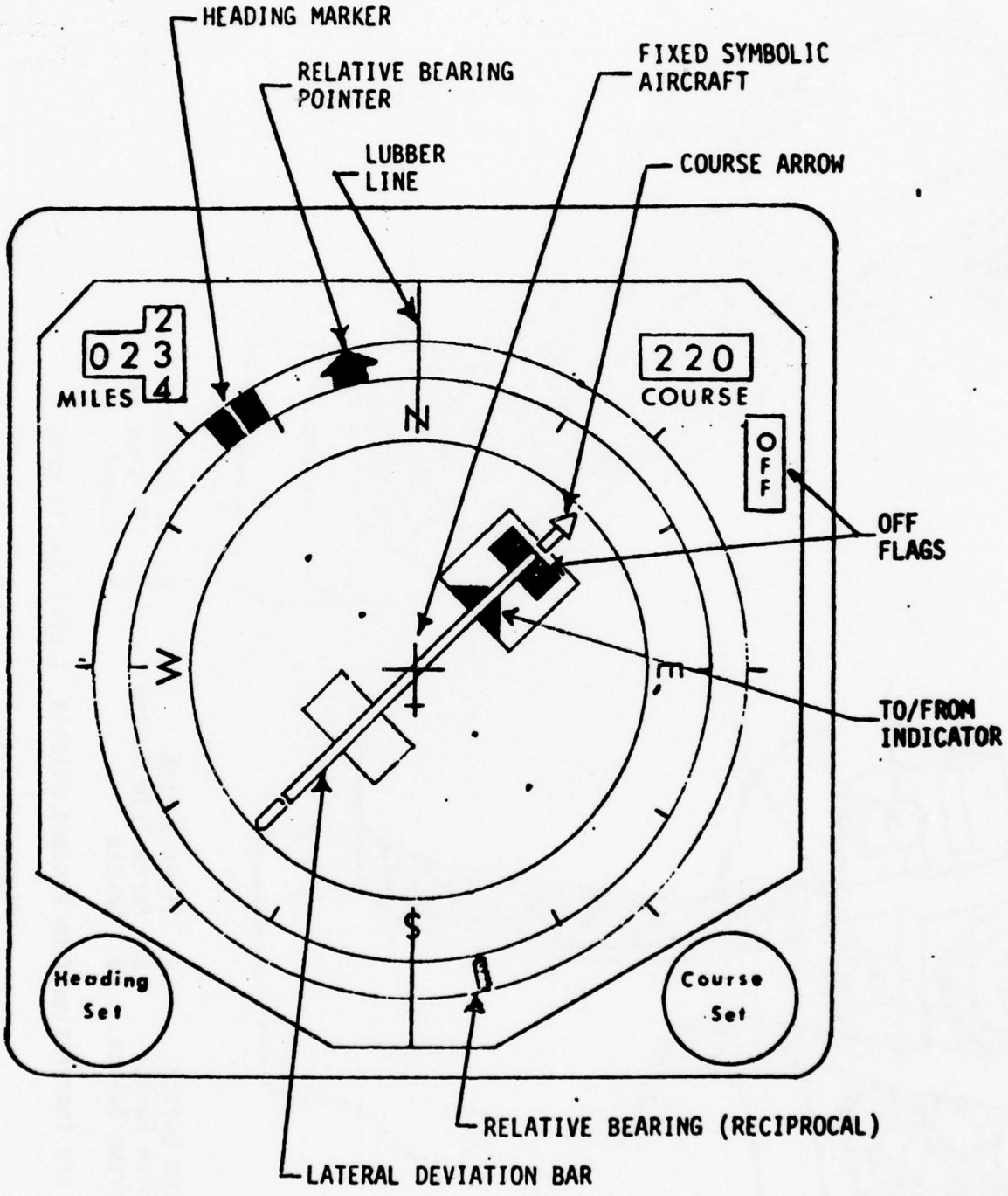
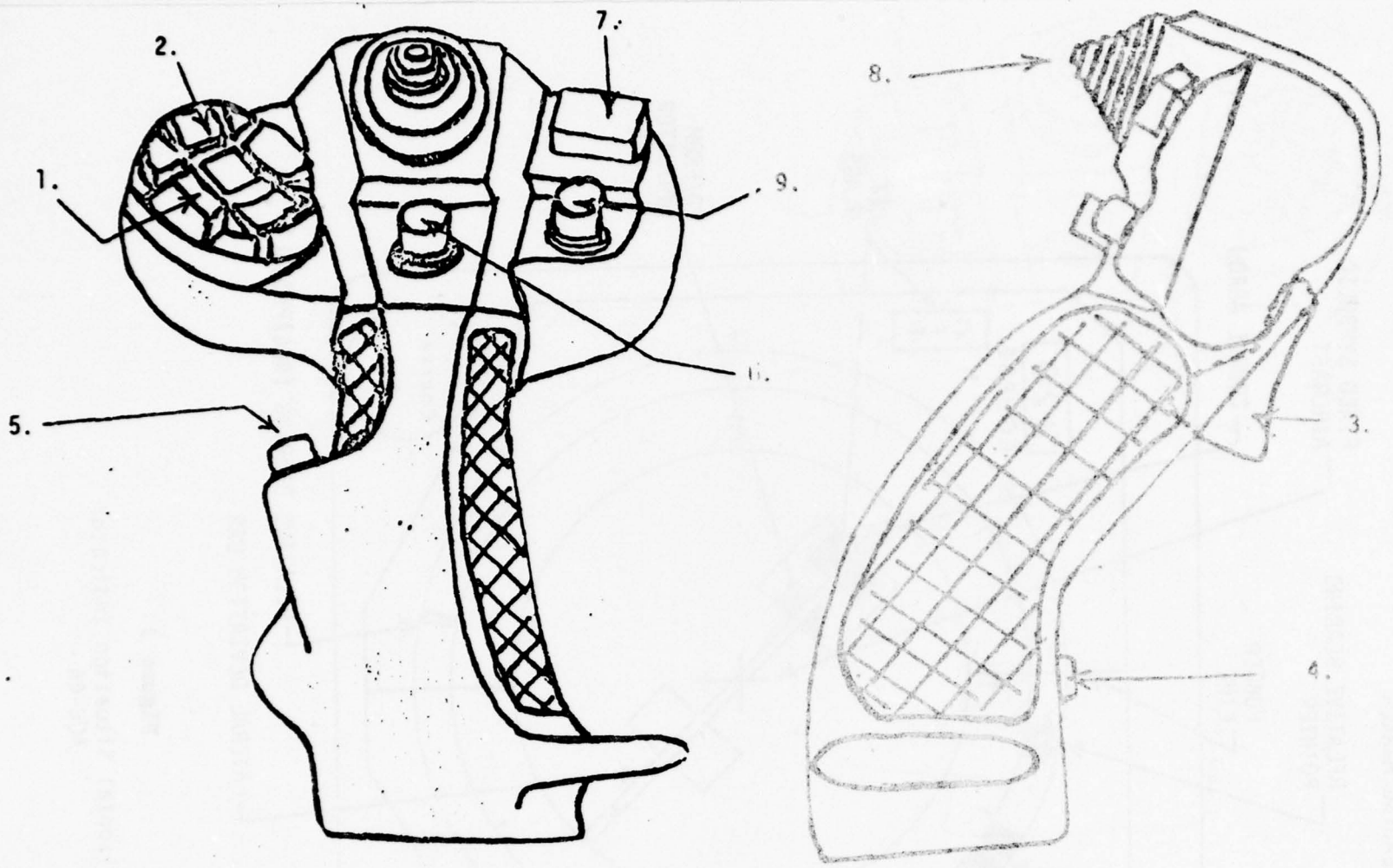


Figure 3

Horizontal Situation Indicator
AQU-4A



1. Heading Slew Switch
2. Airspeed Slew Switch
3. Radio/Intercom Switch
4. Event Switch
5. Force Trim Switch
6. Unused
7. Go Around Switch
8. FPA Slew Switch
9. Unused

NOTE: Items 7&8 are inoperative from Project Pilot's (eft) Cyclic grip.

Figure 4
PILOTS' CYCLIC GRIP

SECTION II

TEST METHODOLOGY:

The successful achievement of the test objectives was dependent on the design of various flight missions distinctly different in task difficulty and pilot workload. Each mission was conducted within well-defined and controlled experimental conditions while preserving the authenticity of actual flight operations. The flight missions are detailed in a subsequent section. Selection of maneuvers within each mission were based on previous flight programs, PFH-2, PIFAX-H Baseline Flying; and PFH-3, Helicopter Refined ADI/HSI and Supporting Displays Evaluation; and the subjective evaluations of the project pilots. The final determination of the maneuvers for each mission difficulty level was made during the pre-experimental flights. During the pre-experimental validation flights all physological, pilot activity, and performance channels were recorded. Project pilot ratings as to task difficulty and workload were taken. A "quick-look" data analysis was performed to insure the coherence of difficulty within each mission and the distinctiveness of difficulty between missions. Upon completion of the pre-experimental validation flights, experimental data collection flights commenced.

A. Data Flights:

Each data flight was flown on a time/maneuver basis; that is, subject pilot flight commenced lift-off from the helicopter pad (T = 0) and each maneuver or profile segment commenced at T+n for each subject pilot. Naturally, the exact takeoff time could not be strictly controlled, but was within five minutes for each subject. Total flight time from lift-off to the termination point on the approach/profile was 1.5 hours$\pm$ 10 minutes.

All flights were performed between the hours of 7 A.M. and 11 A.M.

These hours provided for the maximum biochemical changes apparent in urine samples. Postflight urine samples were taken within 30 minutes of landing. Close adherence to this time schedule allowed USAFSAM to more adequately analyze both the urine samples and objective data.

All flights were conducted in visual meteorological conditions (VMC). Instrument meteorological conditions (IMC) were simulated through the use of curtains and an instrument hood.

The vision restricting devices were required to eliminate any outside visual cues that might possibly be used to aid the subject during flight. The pilot's station had the only curtained windows. Clearing to the right was performed by an on-board observer and project pilot. All data collection flights were accomplished in the Randolph AFB Copter Areas except for a round-robin navigation flight.

Subject Pilots:

Impending cessation of helicopter flying at the USAFIFC required deviations from the projected pool of subject pilots. Due to the compressed flying schedule of the helicopter Instrument Pilot Instructor School (IPIS) course, only one student was available for use as a subject pilot. Six subjects were IPIS instructor pilots; two were U.S. Army helicopter pilots based at Randolph, and one was an F.A.A. helicopter check pilot assigned to the San Antonio area (See attachment C for a summary of flying experience.) All subject pilots were given one familiarization flight and the actual missions were presented in random order.

B. Conduct of the Flight

Each of the ten subject pilots flew only one familiarization flight. The purpose of this flight was to acquaint the pilots with the specific instrumentation installed in 1249 and to present a cross section of the manuevers to

be flown on the data collection flights.

The mission profiles were accomplished in random order to minimize the effects of familiarity. Nine of the ten subjects flew all three profiles. Due to nonavailability of the aircraft, the other pilot flew only missions one and three.

Each subject was instructed to treat the data flights as if they were "check rides." They were asked to make every attempt to satisfy the performance criteria. This provided the subject pilots with a "GOAL" to accomplish on each flight.

All profiles were flown in Visual Meteorological Conditions (VMC). Profile One was flown unhooded using composite techniques. The first half of Profile Two was flown unhooded. During the second half of the flight, the subjects were required to wear an instrument hood and the subject pilot's chin window, side window, and lower half of his windshield were covered by curtains. Profile Three was flown entirely hooded requiring the use of the aircraft's instrumentation as sole reference.

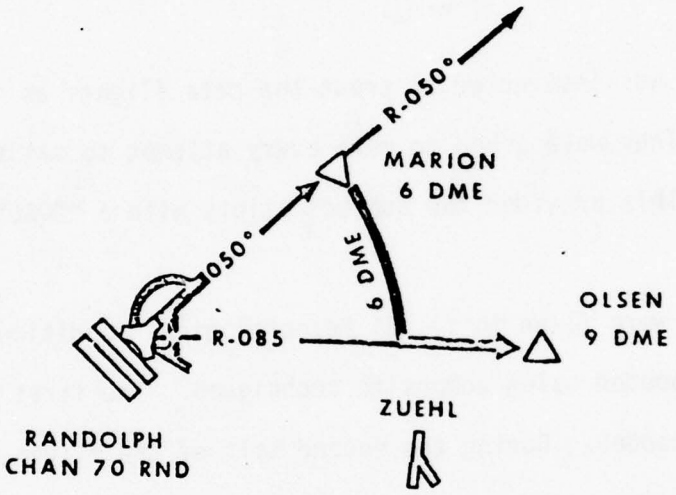
The project pilot acted as a co-pilot for the entire data flight and took control of the aircraft at the completion of the missed approach.

In addition to the project and subject pilots, an IFC/RD human factors engineer and a psychologist from the School of Aerospace Medicine were on board for each data flight. Their duties were to monitor the on-board equipment and to help the project pilot clear for traffic.

The mission profiles are depicted in Figures 5 through 7.

PROFILE NO. 1

MARION - TEN DEPARTURE (MODIFIED)



MAINTAIN 1300

DEPARTURE ROUTE DESCRIPTION

Take off and proceed out RND R-050 TO MARION Arc South Via RND 6 DME to intercept and proceed out RND R-085 to OLSEN

FOR R & D TEST PURPOSES ONLY

Figure 5

Mission #1. Minimum Workload - Performed in VMC

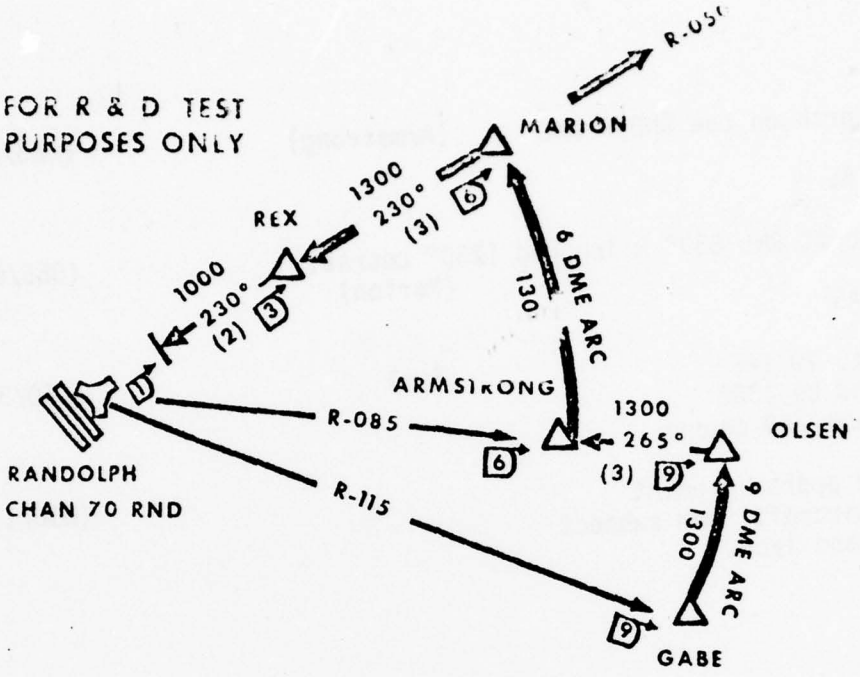
Selected segments to be analyzed indicated by *.

*	1.	ITO Climb constant heading 70 TAS		
*	2.	At L/O 1300' Intercept RND 050° R outbound Accel to 100 TAS		
*	3.	Arc South on the RND 6 DME 1300' 100 TAS	(Marion)	(050/5-1/2)
*	4.	Intercept 085° R outbound 1300' 100 TAS		(080/6)
	5.	Level (1300') left turn 332° 100 TAS 15° bank		(085/9)
	6.	Climb to 1800' 100 TAS 332°		(050/9)
	7.	Level (1800') left turn 258° 100 TAS 15° bank		(009/15)
	8.	Level (1800') left turn 217° Direct SAT VORTAC 100 TAS 15° bank		(343/14)
	9.	Level (1800') right turn 233° course 100 TAS 15° bank		(SAT)
	10.	Descend to 1600' Direct SKF VOR 100 TAS		SAT (233/3)
	11.	Level (1600') right turn 257° course 100 TAS 15° bank		(SKF)
	12.	Climb to 2000' 100 TAS		(SAT/18)

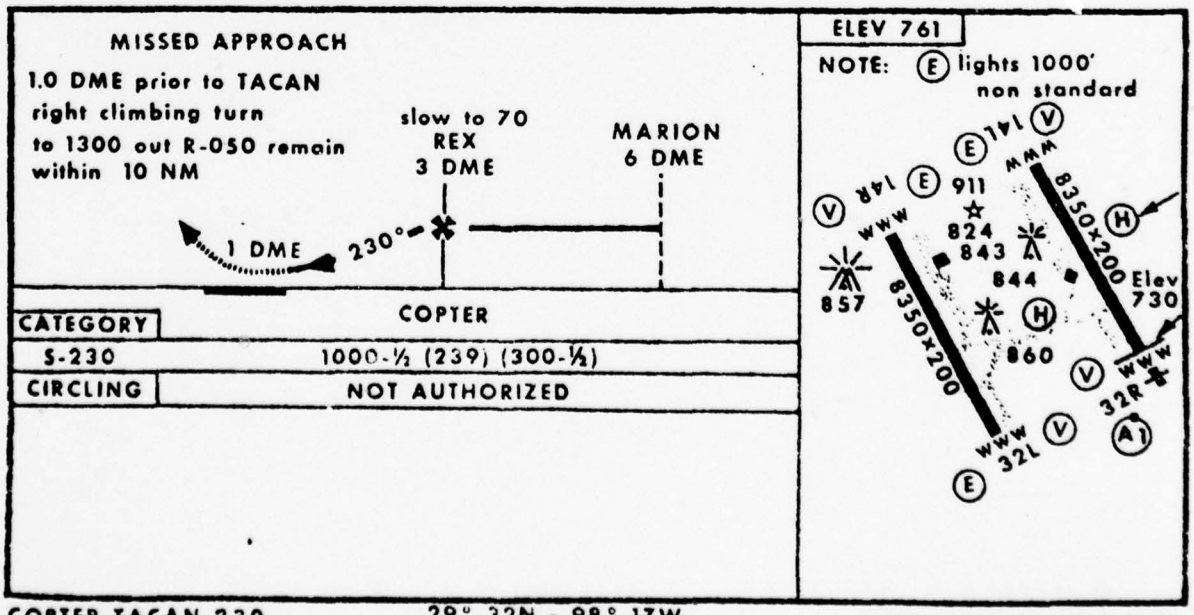
Figure 5-1

* 13.	Level (2000') right turn 067° 100 TAS 15° bank	(Medina Lake)
	Straight & Level for 20 seconds.	
* 14.	Level (2000') right turn 257° 100 TAS 15° bank	
	Straight & Level for 10 seconds.	
15.	Level (2000') left turn 130° 100 TAS 15° bank	
16.	Descend to 1300' 100 TAS 500 fpm	SKF (281/12)
17	Level (1300') left turn 086° 100 TAS 15° bank	(SKF/6-1/2)
	Slow to 60 TAS before beginning turn.	
* 18.	Right (360°) to 120° 60 TAS 30° bank 1300'	SKF (105/5-1/2)
	Accel to 100 TAS after level.	
19.	Left turn 073° 100 TAS 1300'	(SSF)
20.	Left Turn 025° 100 TAS 1300'	(Calaveras Lake Dam)
21.	Intercept RND 9 DME Arc 100 TAS 1300'	(RND 9 DME)
* 22.	RND 110° R 9 DME Arc	(110/9)
* 23.	Intercept RND 085° R inbound (265 course) 1300' (Olsen) 100 TAS	(089/9)

* 24.	Arc North on the RND 6 DME 1300' 100 TAS	(Armstrong)	(085/6-1/2)
* 25.	Intercept RND 050° R inbound (230° course) 1300' 100 TAS	(Marion)	(055/6)
* 26.	Slow to 70 TAS Descend to 1000' Maintain 230 course	(Rex)	(050/3)
* 27.	Missed approach point Take aircraft from subject pilot and land.		(050/1)



From GABE 9 DME FIX TO OLSEN VIA RANDOLPH 9 mile DME ARC
then via Randolph R-085 to Armstrong 6 DME fix,
then via Randolph 6 mile DME arc to MARION
and intercept RND TACAN course 230°
inbound to Rex 3 DME fix and termination
at RND 050/1

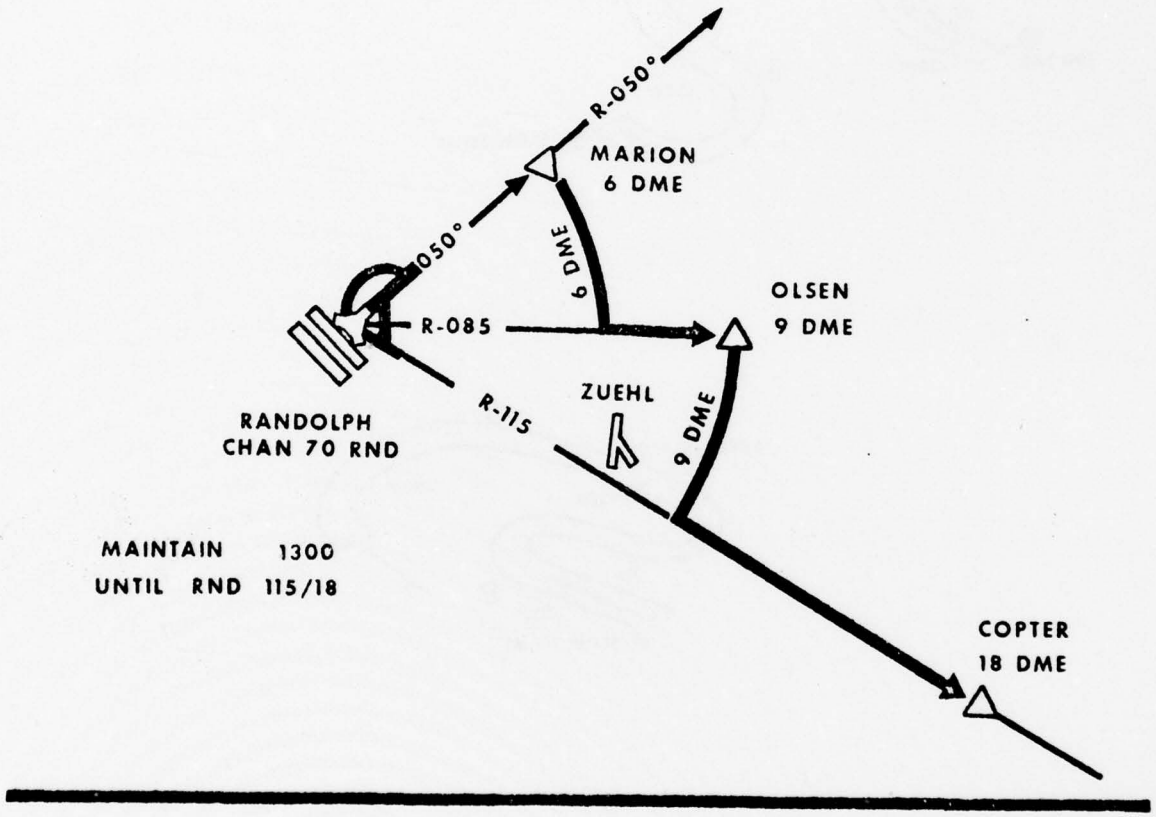


COPTER TACAN 230 29° 32N - 98° 17W SAN ANTONIO, TEXAS, RANDOLPH AFB

Figure 5-4

PROFILE NO. 2

MARION - TEN DEPARTURE (MODIFIED)

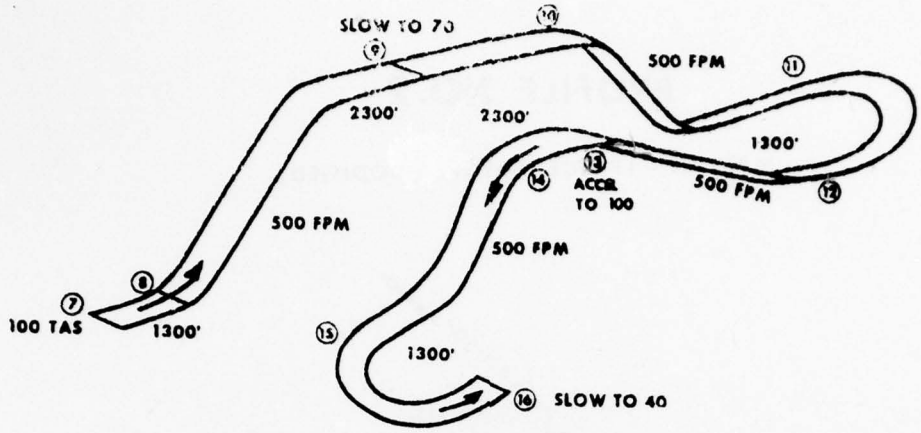


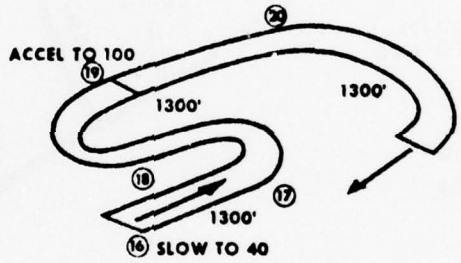
DEPARTURE ROUTE DESCRIPTION

Take off and proceed out RND R-050 TO MARION Arc South Via RND 6 DME to intercept and proceed out RND R-085 to OLSEN Arc South Via RND 9 DME to intercept and proceed out RND R-115 to COPTER.

FOR R & D TEST PURPOSES ONLY

Figure 6


SLOW TO 70
9
10
500 FPM
11
2300'
2300'
1300'
13
ACCEL
TO 100
14
500 FPM
12
500 FPM
500 FPM
8
7
100 TAS
1300'
15
1300'
16
SLOW TO 40


20
ACCEL TO 100
19
1300'
1300'
18
17
1300'
16
SLOW TO 40

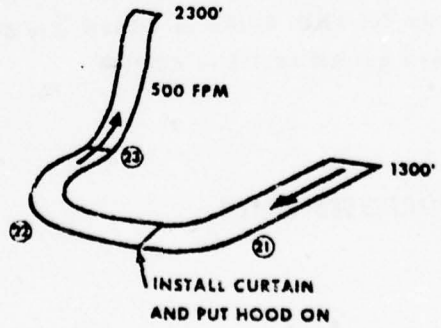
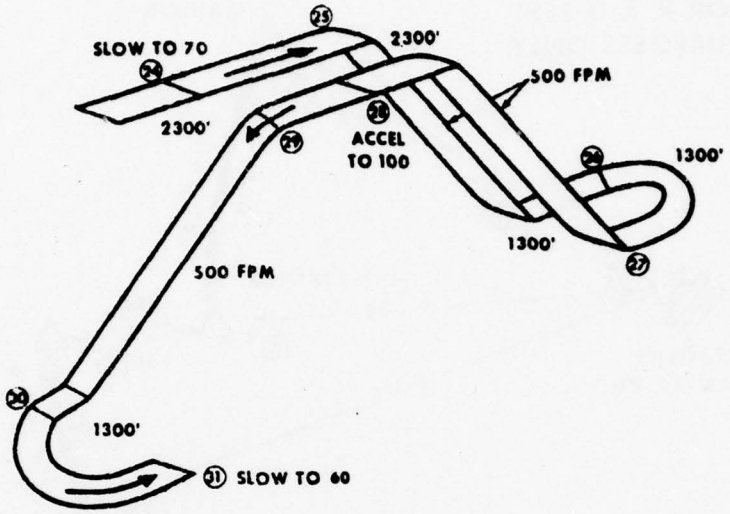
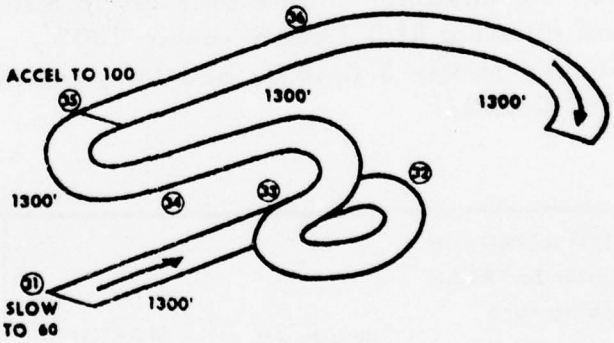

2300'
500 FPM
23
1300'
22
21
INSTALL CURTAIN
AND PUT HOOD ON

Figure 6-1


25
SLOW TO 70
24
2300'
2300'
500 FPM
26
ACCEL
TO 100
28
1300'
1300'
27
500 FPM
23
1300'
31 SLOW TO 60


30
ACCEL TO 100
25
1300'
1300'
32
1300'
34
29
31
SLOW
TO 60
1300'

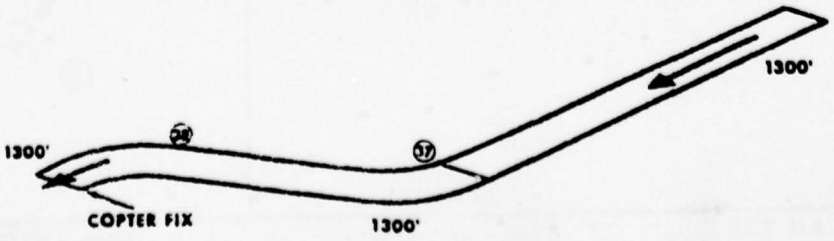
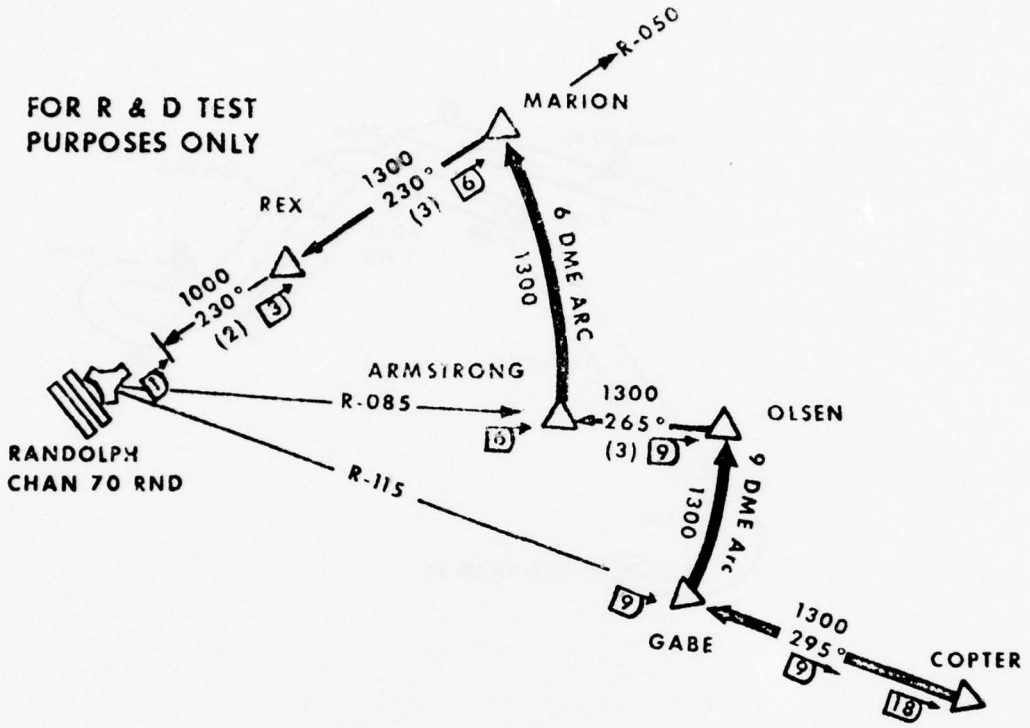
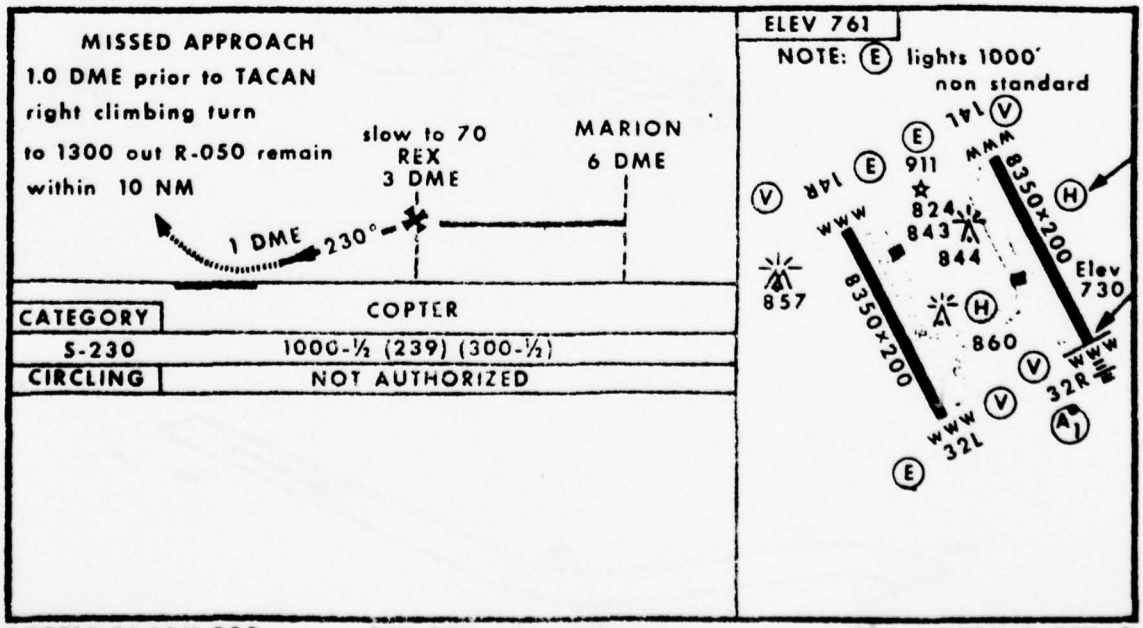

1300'
1300'
28
27
COPTER FIX
1300'

Figure 6-2



From COPTER (RND 115/18) to Gabe 9 DME fix,
then via Randolph 9 mile DME arc to Olsen,
then via Randolph R-085 to Armstrong 6 DME fix,
then via Randolph 6 mile DME arc to MARION
and intercept RND TACAN course 230°
inbound to Rex 3 DME fix and termination
at RND 050/1



COPTER TACAN 230 29° 32N - 98° 17W SAN ANTONIO, TEXAS, RANDOLPH AFB

Figure 6-3

Mission #2. Instrument Maneuvers Conducted in VMC - Visual Composite/Hc ..

Selected segments to be analyzed indicated by *.

*	1.	ITO Climb constant heading 1300' 70 TAS		
*	2.	At L/O 1300' Intercept RND 050°R outbound Accel to 100 TAS		
*	3.	ARC South on the RND 6 DME 1300' 100 TAS	(Marion	(050/5-1/2)
*	4.	Intercept 085°R outbound 1300' 100 TAS		(080/6)
*	5.	ARC South on the RND 9 DME 1300' 100 TAS	(Olsen)	(085°/8-1/2)
*	6.	Intercept 115° R outbound 1300' 100 TAS		(112°/9)
*	7.	Enter Copter Area	(Copter)	(115/18)
*	8.	Maintain 115° course Climb at 100 TAS 500 fpm to 2300'		(115/19)
	9.	Slow to 70 TAS Maintain 115° course 2300'		(115/23)
	10.	Maintain 115° course Descend at 70 TAS 500 fpm to 1300'		(115/25)
	11.	Level (1300') right turn to 300° 70 TAS 15° bank		(115/28)
	12.	Climb at 70 TAS (rollout) 500 fpm to 2300'		(118/28)

Figure 6-4

13. Accel to 100 TAS (118/24-1/2)
Maintain 300° and 2300'

14. Establish straight ahead descent (118/23)
500 fpm
Maintain 300°
100 TAS
to 1300'

15. Level (1300') left turn to 120° (118/18-1/2)
100 TAS
15° bank

16. Slow to 40 TAS (rollout) (123/18-1/2)
Maintain 120° and 1300'

17. Level (1300') left turn to 300° (123/21)
40 TAS
15° bank

18. Level (1300') right turn to 120° (121/20)
40 TAS
15° bank

19. Accel to 100 TAS (rollout) (120/20)
Maintain 120° and 1300'

* 20. Level (1300') right turn to 300° (120/22)
100 TAS
15° bank

* 21. Level (1300') right turn to 030° (124/18-1/2)
100 TAS
15° bank
NOTE: Have subject install curtain and put hood on.

22. Level (1300') right turn to 115° (117/18)
100 TAS
15° bank

23. Maintain 115° heading (115/19)
Climb at 100 TAS
500 fpm
to 2300'

24. Slow to 70 TAS (115/23)
Maintain 115° heading
2300'

25. Maintain 115° heading (115/25)
Descend at 70 TAS
500 fpm
to 1300'

Figure 6-5

26. Level (1300') right turn to 300° (115/28)
70 TAS
15° bank

27. Climb at 70 TAS (rollout) (118/28)
500 fpm
to 2300'

28. Accel to 100 TAS (118/24-1/2)
Maintain 300° and 2300'.

29. Establish straight ahead descent (118/23)
500 fpm
Maintain 300°
100 TAS
to 1300'

30. Level (1300') left turn to 120° (118/18-1/2)
100 TAS
15° bank

31. Slow to 60 TAS (rollout) (123/18-1/2)
Maintain 120° and 1300'

* 32. Level (360°) right turn to 120° (123/20)
60 TAS
30° bank

33. Level (1300') left turn to 300° (123/21)
60 TAS
15° bank

34. Level (1300') right turn to 120° (121/20)
60 TAS
15° bank

35. Accel to 100 TAS (rollout) (120/20)
Maintain 120° and 1300'

36. Level (1300!) right turn to 300° (120/22)
100 TAS
15° bank

37. Level (1300') right turn to 030° (124/18-1/2)
100 TAS
15° bank

38. Intercept RND 115° R inbound (295 course) (117/18)
1300'
100 TAS
15° bank
Depart Copter Area - time should be +74.0

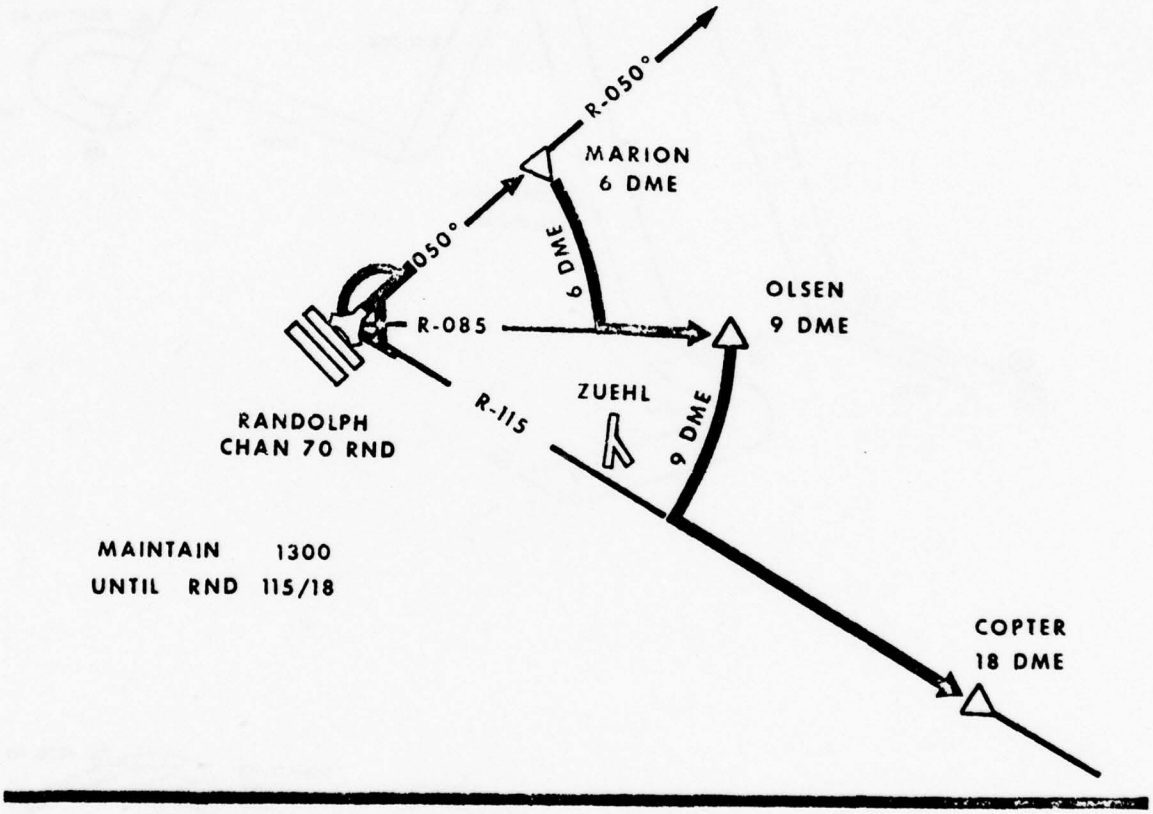
Figure 6-6

39.	Arc North on the RND 9 DME 1300' 100 TAS	(Gabe)	(115/9-1/2)
* 40.	RND 110°R 9 DME Arc		(110/9)
* 41.	Intercept RND 085° R inbound 265 course 1300' 100 TAS	(Olsen)	(089/9)
* 42.	Arc North on the RND 6 DME 1300' 100 TAS	(Armstrong)	(085/6-1/2)
* 43.	Intercept RND 050° R inbound 230 course 1300' 100 TAS	(Marion)	(055/6)
* 44.	Slow to 70 TAS Descend to 1000' Maintain 230 course	(Rex)	(050/3)
* 45.	Missed Approach Point Take aircraft from subject pilot and land.		(050/1)

Figure 6-7

PROFILE NO.3

MARION - TEN DEPARTURE (MODIFIED)



DEPARTURE ROUTE DESCRIPTION

Take off and proceed out RND R-050 TO MARION Arc South Via RND 6 DME to intercept and proceed out RND R-085 to OLSEN Arc South Via RND 9 DME to intercept and proceed out RND R-115 to COPTER.

FOR R & D TEST PURPOSES ONLY

Figure 7

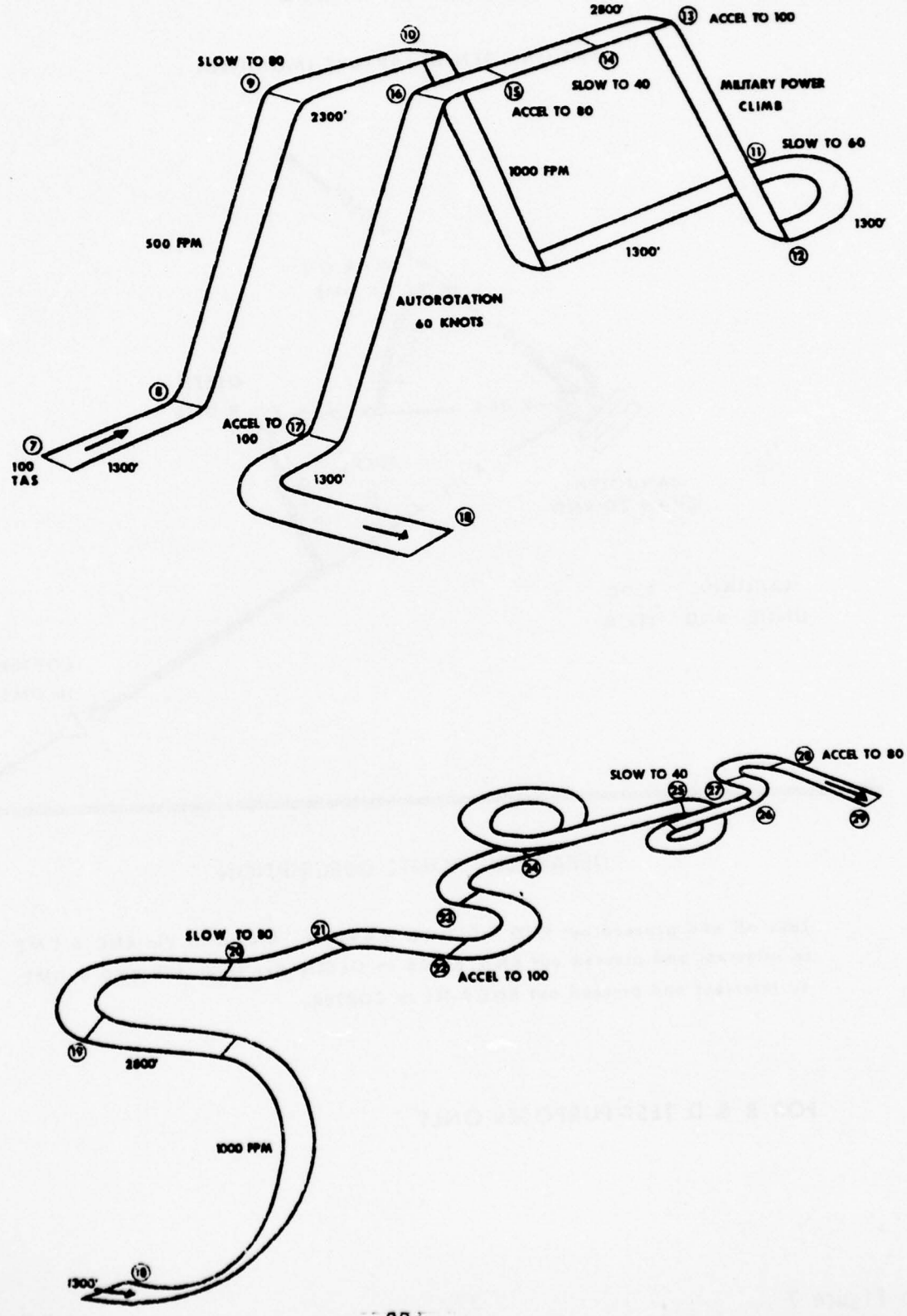
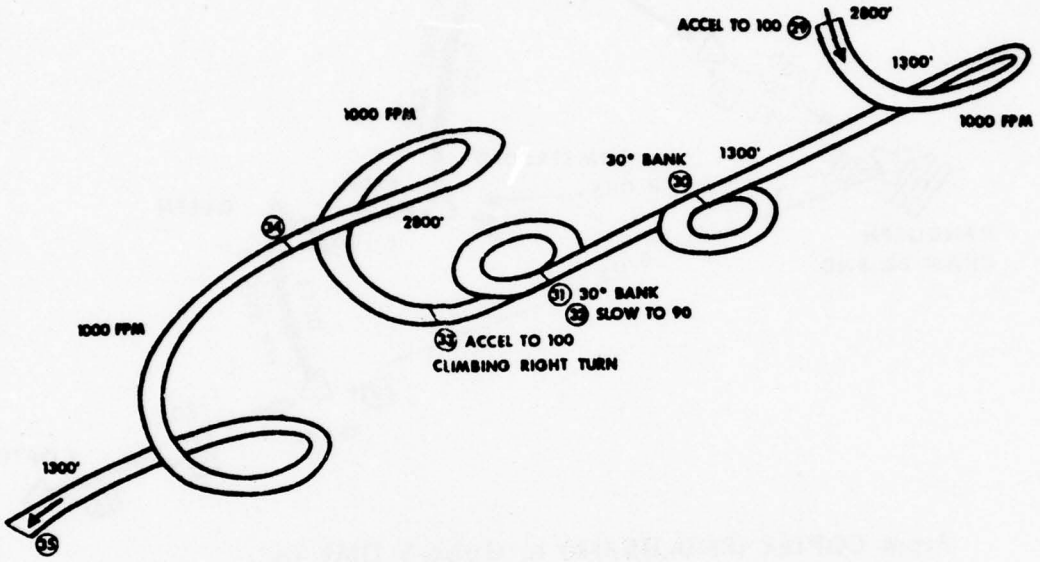

2800'
13 ACCEL TO 100
10
SLOW TO 80
9
14
SLOW TO 40
15
ACCEL TO 80
MILITARY POWER
CLIMB
16
2300'
11 SLOW TO 60
1000 FPM
1300'
500 FPM
1300'
12
AUTOROTATION
60 KNOTS
8
ACCEL TO
100
17
7
100
TAS
1300'
1300'
18
26 ACCEL TO 80
SLOW TO 40
25
27
24
29
24
23
SLOW TO 80
21
20
22 ACCEL TO 100
19
2800'
1000 FPM
1300'
18

Figure 7-1


ACCEL TO 100 29
2800'
1300'
1000 FPM
1000 FPM
30° BANK 1300'
30
2800'
24
31 30° BANK
32 SLOW TO 90
1000 FPM
33 ACCEL TO 100
CLIMBING RIGHT TURN
1300'
25

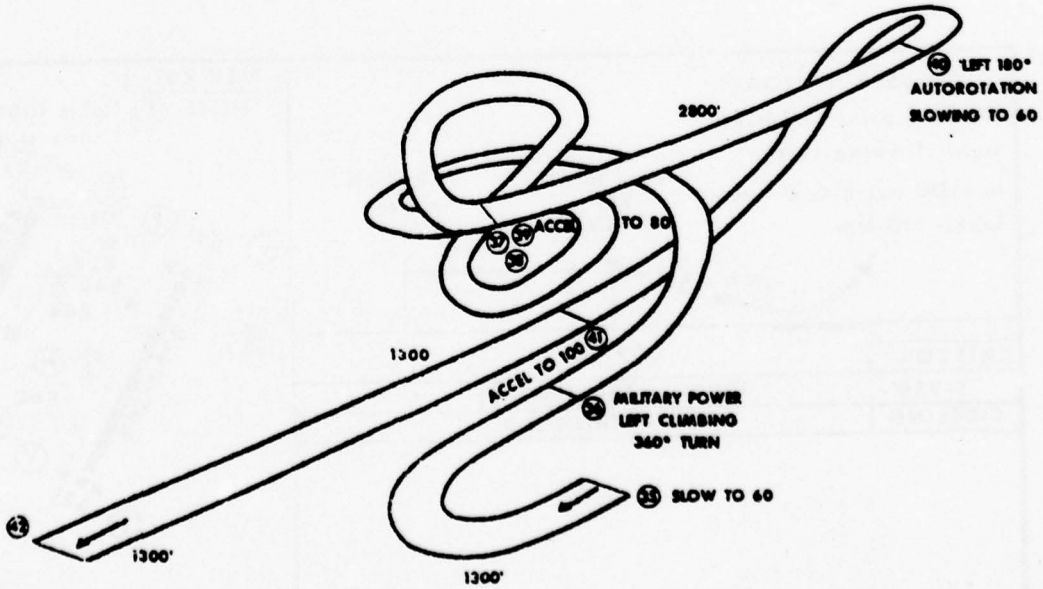
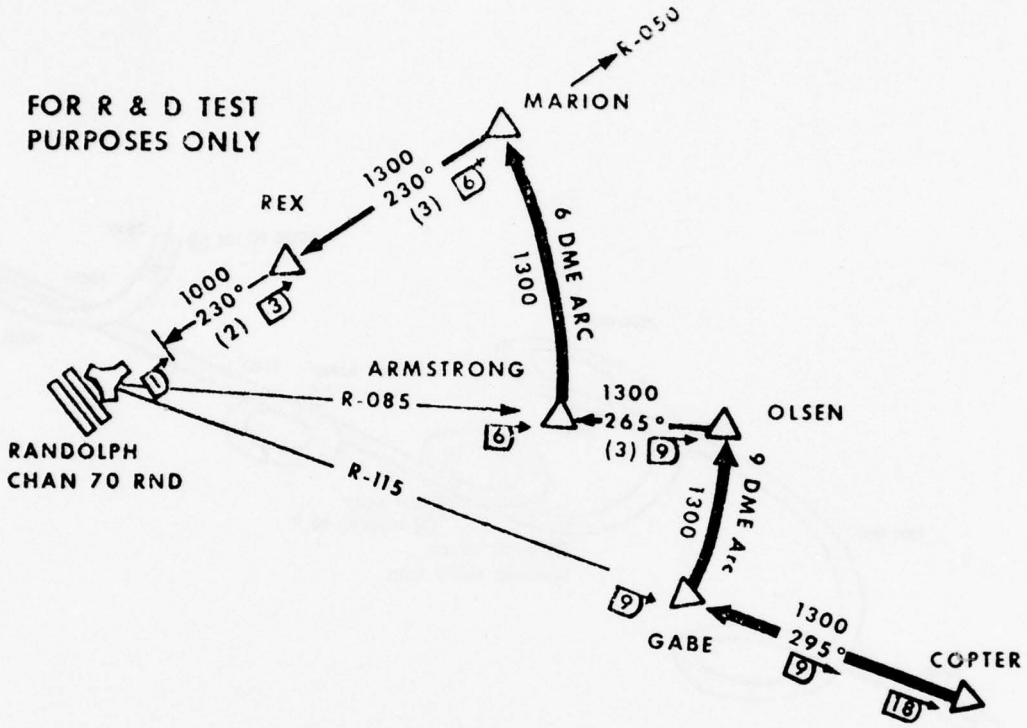
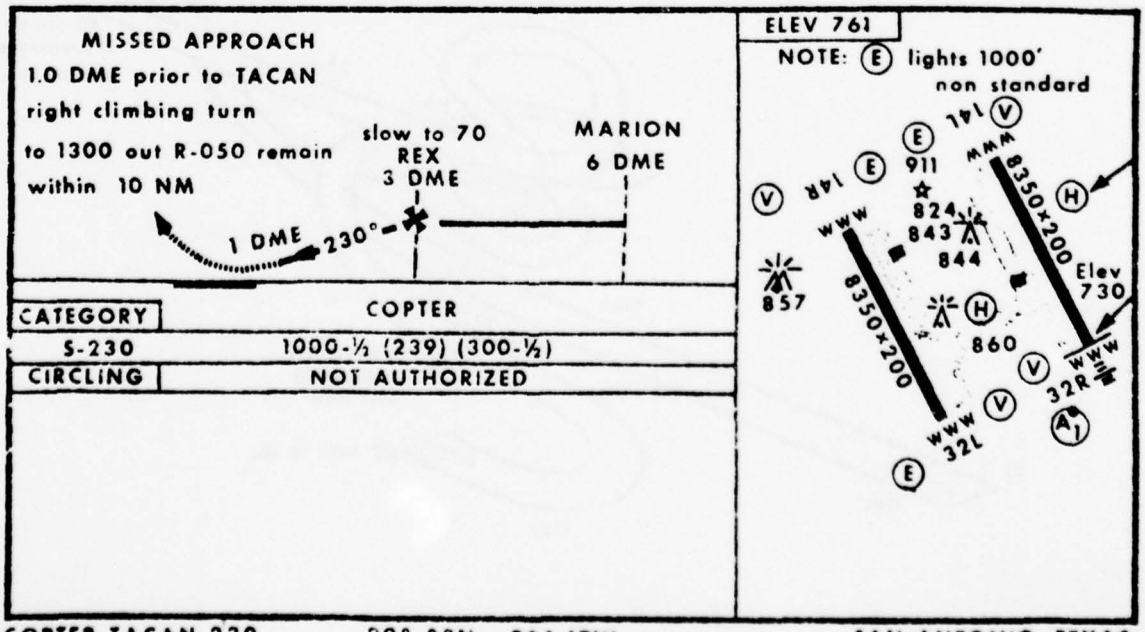

'LEFT 180°
AUTOROTATION
SLOWING TO 60
2800'
ACCEL
TO 80
1300
ACCEL TO 100 41
MILITARY POWER
LEFT CLIMBING
360° TURN
SLOW TO 60
42
1300'
1300'

Figure 7-2



From COPTER (RND 115/18) to Gabe 9 DME fix,
then via Randolph 9 mile DME arc to Olsen,
then via Randolph R-085 to Armstrong 6 DME fix,
then via Randolph 6 mile DME arc to MARION
and intercept RND TACAN course 230°
inbound to Rex 3 DME fix and termination
at RND 050/1



COPTER TACAN 230 29° 32N - 98° 17W SAN ANTONIO, TEXAS, RANDOLPH AFB

Figure 7-3

Mission #3. Maximum Workload - Performed in VMC with Hood and Window Curtai

Selected segments to be analyzed indicated by *.

*	1.	ITO Climb Constant Heading 1300' 70 TAS		
*	2.	At L/O 1300' Intercept RND 050° R outbound Accel to 100 TAS		
*	3.	Arc South on the RND 6 DME 1300' 100 TAS	(Marion)	(050/5-1/2)
*	4.	Intercept 085° R outbound 1300' 100 TAS		(080°/6)
*	5.	Arc South on the RND 9 DME 1300' 100 TAS	(Olsen)	(085°/8-1/2)
*	6.	Intercept 115° R outbound 1300' 100 TAS		(112°/9)
*	7.	Enter Copter area	(Copter)	(115°/18)
*	8.	Maintain 115° course Climb at 100 TAS 500 fpm rate of climb to 2300'		(115°/19)
	9.	L/S slow to 80 TAS Maintain 115° course 2300'		(115/22)
	10.	Establish straight ahead descent 1000 fmp Maintain 115° course 80 TAS to 1300'		(115/23)
	11.	Level (1300') right turn to 300° Slowing to 60 TAS 15° bank		(115/27)

Figure 7-4

	12.	Establish straight ahead mil power climb T_5 635 Maintain 300° 60 TAS to 2600'	(118/26)
	13.	After L/O accel to 100 TAS Maintain 300° and 2800'	L/O
	14.	Slow to 40 TAS Maintain 300° and 2800'	(118/23)
	15.	Accel to 80 TAS Maintain 300° and 2800'	(118/22)
	16.	Establish straight ahead autorotation Maintain 300° 60 TAS Recover at 1300'	(118/21)
	17.	Level (1300') left turn to 210° Accel to 100 TAS 15° bank	(118/18-1/2)
	18.	Left climbing turn to 030° 1000 fpm 100 TAS 15° bank to 2800'	(126/18)
*	19.	Level (2800') right turn to 210° 100 TAS 15° bank	(118/19)
	20.	Level (2800') left turn to 120° Slow to 80 TAS 15° bank	(120/20)
	21.	Level (2800') right turn to 210° 80 TAS 15° bank	(122/21-1/2)
	22.	Level (2800') left turn to 030° Accel to 100 TAS 15° bank	(126/22)
*	23.	Level (2800') right turn to 120° 100 TAS 15° bank	(123/23)

Figure 7-5

24.	Level (2800') left 360° turn to 120° 100 TAS 15° bank	(122/24)
25.	Level (2800') right 360° turn to 120° Slow to 40 TAS 15° bank	(122/25)
26.	Level (2800') left turn to 030° 40 TAS 15° bank	(123/26)
27.	Level (2800') right turn to 210° 40 TAS 15° bank	(120/26-1/2)
28.	Roll out heading 210° Accel to 80 TAS	(120/27)
29.	Left 270° descending turn to 300° 1000 fpm Accel to 100 TAS 15° bank to 1300'	(125/27)
30.	Level (1300') left 360° turn to 300° 100 TAS 30° bank	(122/26)
31.	Level (1300') right 360° turn to 300° 100 TAS 30° bank	(122/25)
32.	After roll out Slow to 90 TAS	(122/25)
33.	Right Climbing 360° turn to 300° 1000 fpm Accel to 100 TAS 15° bank to 2800'	(122/23-1/2)
34.	Left Descending 360° turn to 300° 1000 fpm 100 TAS 15° bank to 1300'	(122/22)
35.	Level (1300') right turn to 120° Slow to 60 TAS 15° bank	(122/21) Time should be 61.2, if early, extend leg 1/2 the amount early.

Figure 7-6

36.	Left Climbing 360° to 120° Military power (T_5 635°) 60 TAS 15° bank to 2800'		(118/22)
* 37.	Right (360°) to 120° 60 TAS 30° bank 2800'		(118/22)
38.	Left (360°) to 120° 60 TAS 30° bank 2800'		(118/22)
39.	After rollout (120°) Accel to 80 TAS		(118/22)
40.	Left 180° autorotation to 300° 60 TAS 15° bank Recover at 1300' and 60 TAS	Time should be +70.0, if early, extend leg 1/2 the amount early or maintain 60 TAS longer.	(118/23)
41.	Accel to 100 TAS Intercept RND 115° R inbound (295 course)		(115/22)
42.	Depart Copter area Return Marion Ten RND 115° R inbound (295 course) 100 TAS 1300'	(Copter) Time should be +74.0	(115/18)
43.	Arc North on the RND 9 DME 1300' 100 TAS	(Gabe)	(115/9-1/2)
* 44.	RND 110° R 9 DME Arc		(110/9)
* 45.	Intercept RND 085° R inbound (265 course) 1300' 100 TAS	(Olsen)	(089/9)
* 46.	Arc North on the RND 6 DME 1300' 100 TAS	(Armstrong)	(085/6-1/2)
* 47.	Intercept RND 050° R inbound (230 course) 1300' 100 TAS	(Marion)	(055/6)
* 48.	Slow to 70 TAS Descend to 1000' Maintain 230 course	(Rex)	(050/3)

Figure 7-7

* 49. Missed approach point
Take aircraft from subject
pilot and land. (050/1)

Figure 7-8

C. Objective Data Methodology

A digital tape recorder was used to record the performance and activity parameters listed below:

PERFORMANCE	ACTIVITY
Roll Attitude	Cyclic Pitch Position
Pitch Attitude	Cyclic Roll Position
Precision Airspeed	Collective Position
Heading Deviation	Tail Rotor Position
Baro Attitude	
Vertical Rate	
Course Deviation	
Event	
Time Code Generator	
Heart Rate	
DME	

D. Subjective Data Methodology

Pilot opinions and judgments were gathered using in-flight observations and pre and postflight questionnaires (Atch C-I). Subject pilot in-flight comments were recorded using an audio tape recorder. Comprehensive debriefing sessions were conducted following each data collection flight to extract pertinent information concerning the workload the pilot felt was being imposed on him through stages of the flight.

E. Psychophysiological and Biochemical Data Methodology

The data in this portion of the test plan was gathered by three different methods, electrocardiogram (EKG), urinalysis, and survey.

HEARTRATE AND HEARTRATE VARIABILITY

During each flight, a continuous record of the subject's beat-by-beat heartrate was made onto one channel of the magnetic in-flight tape recorder. The signal from a three-lead EKG electrode harness, attached to the subject's chest, was amplified through a Holter Monitor recorder to a cartiotachometer. The cardiotach measured the interval between successive beats and converted this value to heartrate in beats per minute (BPM). In addition, the analog tape recording of the entire EKG trace on the Holter Monitor provided a backup to check the quality of cardiotach values. The digital heartrate data was collated by flight elements and segments after treatment by a computer program that smoothed data values by removing radio magnetic interference spikes and other transient signal spikes. This editing process is continuing because some of the smoothed values appear lower than normal cardiac responses for similar situations, and may require limiting for signal drop out.

Analysis of heartrate and heartrate variability will proceed when the editing of the data can be accomplished, but will not be available at the time of this report. A mean rate for each element will be established by computing the average of all cardiotach values recorded in a 30-second epoch (5 samples/sec, 150/epoch) and the average rate for all epochs in the element. After smoothing, heartrate variability related to sinus arrythmia will be determined by analizing the beat-by-beat changes in cardiotach output. A Heartrate Variability Index (HRVI) will be established for each 30 second epoch. Each successive cardiotach value is subtracted from the preceding value and the absolute values of the subtrahends are summed through each epoch. The number of reversals in direction of change is found by multiplying successive subtrahends and counting the negative products as reversals. The ratio of variability to reversals is the index

score for each epoch.

URINALYSIS

Subjects were required to force void all urine from their bladder approximately 1 1/2 hours before the flight. This procedure eliminates the effect of some intervening variables and assures adequate volume for subsequent urine samples. A urine sample was collected within 30 minutes after each flight and at approximately the same time on three baseline days when the subject did not fly during the responding time period. Each urine sample was collected into dilute HCl acid and immediately frozen for later biochemical analysis at Brooks AFB.

The urinary determinations routinely used for the USAFSAM stress battery are: (1) Urea, protein catabolism; (2) Sodium (NA); and (3) Potassium (K), mineral metabolism. In addition, the ratio of NA to K is calculated as an index of metabolic balance (hemeostasis). Increases in some or all of these variables have been correlated with environmental stresses, physical, and mental work and fatigue.

Urinary Creatinine, a close correlate of lean body mass is used as an adjusting factor for the other variables. Each urinary measure is stated in a ratio to 100 mg of Creatinine, which corrects for variations in the timing of sample collection and subject variables such as body size and age.

SURVEYS AND QUESTIONNAIRES

The subjects in this study were expected to be normally rested and healthy, but in order to assess the possibility of intervening variables such as night work or illness, subjects were asked to complete a SAM Form 154, Sleep Survey (Atch A) before each flight and base line sampling period. The form requires them to list all sleep during the past 30 to 48 hours and asks them to comment on the value of their rest.

SAM Form 136 Subjective Fatigue Checkcards (Atch B) were completed by each

subject at the same time as the sleep survey and at the end of each flight or time of urine sampling on baseline days. The subjective fatigure checkcard yields a score from 0-20 with lower scores indicating feelings of greater fatigue.

F. DATA ANALYSIS METHODOLOGY

The following performance criteria was established for reduction and analysis of the objective data.

Performance Parameter	Highly Qualified*	Qualified*	Unqualified
Vertical Rate Error	±100 fpm	±101 to ±200 fpm	±200 fpm
Bank Angle Error	±3°	±4° to ±5°	±5°
Altitude Error	±50'	±51' to ±100'	±100'
Airspeed Error	±5 kts	±6 kts to ±10 kts	±10 kts
CDI Error	±.25 dot	±.26 to ± 1.00 dot	±1.00 dot

*In order to apply the performance criteria, the above parameters had to be maintained for 5 seconds or more to be considered a steady state condition (as opposed to a momentary deviation). This time restriction limited the transitory effects of turbulence, momentary distractions, and short-time real world problems encountered in the cockpit. The judgment of several highly experienced instrument instructors and flight examiners was that a deviation of more than 15 seconds would identify such things as an improper cross-check, poor pilot technique, or possible display deficiency of real world significance. Since highly experienced helicopter instrument pilots were used as test subjects, the time factor was reduced from 15 seconds to 5 seconds to increase differential criticality.

In addition to the performance parameter data analysis, a program was developed to analyze the four helicopter control activity parameters: cycle roll position, cyclic pitch position, tail rotor position, and collective position.

Steady state bandwidths were established for each control parameter based upon the sensitivity of each channel (normally one to two percent of full travel of the control). To meet steady state requirements, the control had to be held within the predetermined bandwidth for one second or more. A steady state control condition held less than one second was termed "steady state transient" condition and was compiled as such.

A control movement was sensed when the control parameter exceeded the steady state criteria bandwidth in either direction. The number of control movements were counted and the total number for a given element were divided by the element duration. This provided a frequency index for the respective controls, and was termed Control Frequency Index (CFI). The following chart shows relative CFI Values.

CFI .01 = 1 Control movement every 2 minutes

CFI .02 = 1 Control movement every minute

CFI .06 = 1 Control movement every 25 seconds

CFI .13 - 1 Control movement every 8 seconds

CFI .25 = 1 Control movement every 4 seconds

CFI .50 = 1 Control movement every 2 seconds

CFI 1.00 = 1 Control movement every second

CFI 1.50 = 1.5 Control movement every second

CFI 2.00 = 2 Control movements every second

The CFI's were an important factor in qualifying the quality of performance with the degree of activity necessary to attain the performance. This provided a Performance Activity Ratio (PAR) for each element. The PAR's were derived by taking the percent of time the performance was not Hi Qual (% $\overline{\text{H/Qual}}$) and multiplying this value by CFI of the associated control. The resultant factor

was then subtracted from the percent of time the performance was Hi Qual (% H/Qual). This produced a single value for comparative evaluation which included both performance and activity terms for various elements selected in the profile.

EXAMPLES:

% H/Qual - (% $\overline{\text{H/Qual}}$ X CFI) = PAR Index

75% - (25% X .25) = 68.75

Each of the following charts present the Performance Activity Ratio (PAR) for various elements selected in the profile. The PAR index will be high (near 100) if the CFI (control activity) was low and a large percentage of the element was within the highly qualified bandwidth. Conversely, a high amount of activity (CFI) coupled with a low percentage of highly qualified performance for the element would result in a low PAR index.

SECTION III

FINDINGS

A. OBJECTIVE DATA FINDINGS

Element 1 Description:

- Pilot was tasked with an instrument takeoff (ITO). Manuever was started from a stabilized position on the ground (740' indicated altitude). Lift off power was set at 50-75 pounds of fuel flow above hoverpower. The pilot task included maintaining heading and establishing a five degree nose down pitch attitude after the pilot was certain he was clear of the ground. The aircraft was then accelerated to 70 kts and a climb established to 1300' indicated altitude. The element ended when the aircraft reached 70 kts or 1000', whichever occurred first.

Element 1 Findings (Ref: Tables 1 and 2):

- During the ITO, pilot performance appears to have been better on Profile One than on the other profiles. On this profile, the pilot was unhooded, and although the aircraft instruments were to be his primary reference, outside visual cues were integral factors in the performance. This fact is reflected in an increased amount of control inputs to achieve desired results. Profile Three, which was conducted totally under hooded conditions, reflected a poor cross check of instrumentation with a slow and decreased amount of control inputs. Helicopter heading control during this critical phase of flight is traditionally poor regardless of the cues available to the pilot. Airspeed control, on the other hand, required a comparable number of control inputs on all profiles, but performance achievement was considerably better as compared to heading control.

TABLE 1. ELEMENT 1. (Heading Control)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual	63.3	51.0	X	56.9	X	64.3	36.8	52.7	X	58.5	54.8
CFI	.18	0.40	X	.01	X	.01	.01	.50	X	.10	.17
PAR	56.7	31.4	X	56.5	X	63.9	36.2	29.0	X	54.3	46.9
HRVI	.20	.21	X	.03	X	ND	.02	ND	X	ND	.12
			AVERAGE DURATION			80.3 Sec.					
					PROFILE TWO						
% Hi Qual	X	56.3	X	ND	X	X	23.1	25.2	X	X	34.9
CFI	X	.03	X	ND	X	X	.02	.02	X	X	.02
PAR	X	55.0	X	ND	X	X	2.16	23.7	X	X	33.4
HRVI	X	.06	X	ND	X	X	.03	ND	X	X	.05
			AVERAGE DURATION			68.1 Sec.					
					PROFILE THREE						
% Hi Qual	X	56.0	81.8	39.2	70.5	77.2	20.1	37.6	32.5	32.4	49.7
CFI	X	.01	.06	.05	.01	.20	.01	.08	.11	.10	.07
PAR	X	55.6	80.9	36.0	70.2	72.6	19.3	32.6	25.1	25.6	46.4
HRVI	X	.19	.06	.02	.10	.01	.04	ND	ND	ND	.08
			AVERAGE DURATION			90.4 Sec.					
% Hi Qual =	Percent Highly Qualified										
CFI =	Control Frequency Index										
PAR =	Performance Activity Ratio										
HRVI =	Heart Rate Variability Index										
X =	Not Accomplished										
N.D. =	No Data Tape										

TABLE 2. ELEMENT 1. (Airspeed Control)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual	57.7	83.3	X	95.9	X	100	55.2	78.3	X	65.2	76.5
CFI	.05	.07	X	.29	X	.16	.08	.06	X	.03	.11
PAR	55.6	82.1	X	94.7	X	99.8	51.6	77.0	X	64.2	75.0
HRVI	.20	.21	X	.03	X	ND	.03	ND	X	ND	.12
			AVERAGE DURATION			80.3 Sec.					
					PROFILE TWO						
% Hi Qual	X	92.6	X	ND	X	X	52.9	74.2	X	X	73.2
CFI	X	.11	X	ND	X	X	.11	.09	X	X	.10
PAR	X	84.6	X	ND	X	X	47.7	71.9	X	X	68.1
HRVI	X	.06	X	ND	X	X	.03	ND	X	X	.05
			AVERAGE DURATION			68.1 Sec.					
					PROFILE THREE						
% Hi Qual	X	54.4	92.1	84.5	0	73.4	86.1	61.9	64.1	47.3	62.6
CFI	X	.09	.08	.11	.14	.04	.09	.11	.28	.17	.12
PAR	X	50.3	91.5	82.8	.14	72.3	84.8	57.7	54.1	38.3	57.5
HRVI	X	.19	.06	.02	.10	.01	.04	ND	ND	ND	.07
			AVERAGE DURATION			90.4 Sec.					

% Hi Qual = Percent Highly Qualified

CFI = Control Frequency Index

PAR = Performance Activity Ratio

HRVI = Heart Rate Variability Index

X = Not Accomplished

N.D. = No Data Tape

Element 2 Description:

- Data collection for Element 2 began immediately upon completion of Element 1 and at 1300' indicated altitude. The pilot's task was to intercept the Randolph Tacan 050° Radial outbound and accelerate to 100 KTAS. The element was terminated when the aircraft reached 5 miles from the Randolph Tacan.

Element 2 Findings (Ref: Tables 3,4, and 5):

- Regardless of the cues available to the pilot, altitude and heading performance was mediocre and reflected a great number of control inputs to achieve a desired result. The PAR and HRVI appear to disclose a closer attention to all available cues and greater control activity than was present in Element 1. Airspeed control was much better than heading and altitude control, especially on Profile One. Altitude control on Profile Two was extremely poor.

TABLE 3. ELEMENT 2. (SERVO ALT)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual	1.1	22.0	0	0	X	39.4	53.8	0	X	0	14.5
CFI	.01	.11	.04	.03	X	.06	.01	.02	X	.01	.04
PAR	.1	13.4	-4.0	-.30	X	35.8	53.3	-2	X	-1	11.6
HRVI	.10	.29	.12	.15	X	.11	.18	ND	X	ND	15.8
			AVERAGE DURATION 83.6 Sec.								
					PROFILE TWO						
% Hi Qual	X	0	X	0	X	X	100.0	0	0	X	20
CFI	X	.03	X	0	X	X	.01	.04	ND	X	.02
PAR	X	-3.0	X	0	X	X	100.0	-4	ND	X	23.3
HRVI	X	.15	X	.04	X	X	.23	ND	.14	X	.14
			AVERAGE DURATION 79.9 Sec.								
					PROFILE THREE						
% Hi Qual	X	61.5	.6	68.6	48.1	1.3	38.4	09	15.2	92.2	36.2
CFI	X	.01	.01	.17	.14	.01	.01	.03	.01	.01	.04
PAR	X	61.1	-.6	63.3	40.8	.3	37.8	-3	14.3	92.1	34.0
HRVI	X	.13	.21	.11	.03	.15	.17	ND	.13	ND	.13
			AVERAGE DURATION 84.0 Sec.								
% Hi Qual =	Percent Highly Qualified										
CFI =	Control Frequency Index										
PAR =	Performance Activity Ratio										
HRVI =	Heart Rate Variability Index										
X =	Not Accomplished										
N.D. =	No Data Tape										

TABLE 4. ELEMENT 2. (Airspeed Control)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual	92.8	77.3	100	98.3	X	100	84.4	100	X	98.1	93.9
CFI	.32	.29	.19	.53	X	.06	.14	.11	X	.09	.22
PAR	90.5	70.7	100	97.4	X	100	82.2	100	X	97.9	92.3
HRVI	.10	.29	.12	.15	X	.11	.18	ND	X	ND	.16
			AVERAGE DURATION			83.6 Sec.					
					PROFILE TWO						
% Hi Qual	X	83.3	X	100	X	X	99.7	0	73.8	X	71.4
CFI	X	.26	X	.39	X	X	.54	.30	ND	X	.37
PAR	X	79.0	X	100	X	X	99.5	-30	ND	X	62.1
HRVI	X	.15	X	.04	X	X	.23	ND	.14	X	.14
			AVERAGE DURATION			79.9 Sec.					
					PROFILE THREE						
% Hi Qual	X	63.8	92.7	56.2	71.7	67.3	52.0	87.9	95.5	0	56.5
CFI	X	.31	.36	.50	.43	.06	.38	.19	.14	.04	.27
PAR	X	52.6	90.1	34.3	59.5	65.3	33.8	85.5	94.9	-4	56.9
HRVI	X	.13	.21	.11	.02	.15	.17	ND	.13	ND	.13
			AVERAGE DURATION			84.0 Sec.					

% Hi Qual = Percent Highly Qualified

CFI = Control Frequency Index

PAR = Performance Activity Ratio

HRVI = Heart Rate Variability Index

X = Not Accomplished

N.D. = No Data Tape

TABLE 5. ELEMENT 2. (CDI)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual	48.8	13.5	62.1	44.5	X	38.4	63.3	35.1	X	31.4	42.1
CFI	.21	.60	.18	.64	X	.59	.54	.38	X	.28	.43
PAR	38.2	-38.4	55.2	9.0	X	2.1	43.4	10.4	X	12.2	16.5
HRVI	.10	.29	.12	.15	X	.11	.18	ND	X	ND	.16
			AVERAGE DURATION		83.6 Sec.						
					PROFILE TWO						
% Hi Qual	X	49.7	X	51.2	X	X	63.9	35.4	36.6	X	47.4
CFI	X	.67	X	.45	X	X	.41	.54	ND	X	.52
PAR	X	16.0	X	29.2	X	X	49.1	.5	ND	X	23.7
HRVI	X	.15	X	.04	X	X	.23	ND	.14	X	.14
			AVERAGE DURATION		79.9 Sec.						
					PROFILE THREE						
% Hi Qual	X	65.2	26.6	64.3	59.6	57.7	57.8	36.4	45.8	31.6	49.4
CFI	X	.56	.06	.64	.07	.02	.48	.66	.67	.38	.39
PAR	X	45.7	22.2	41.5	56.8	56.9	37.5	-5.6	9.5	5.6	30.0
HRVI	X	.13	.21	.11	.03	.15	.17	ND	.13	ND	.13
			AVERAGE DURATION		84.0 Sec.						

% Hi Qual = Percent Highly Qualified

CFI = Control Frequency Index

PAR = Performance Activity Ratio

HRVI = Heart Rate Variability Index

X = Not Accomplished

N.D. = No Data Tape

Element 3 Description:

- The pilot was tasked to arc South on the Randolph 6 DME arc at 1300' indicated altitude and 100 KTAS. His task was to position the aircraft for interception of the 085° Radial outbound. Data collection began when the pilot's heading performance was Hi Qual while tracking out the 050° Radial or 5 1/2 DME, but no sooner than 5 1/2 DME. For data purposes, the task was completed when the Course Deviation Indicator (CDI) showed the aircraft within 7 1/2°of the 085° Radial.

Element 3 Findings (Ref: Tables 6 and 7):

- The increase in the degree of difficulty of this task is reflected in the overall poor performance in altitude control. Airspeed performance on all the profiles was basically good. Control input data indicate a great amount of pilot activity. The large discrepancy between airspeed and altitude performance appears contradictory.

TABLE 6. ELEMENT 3. (SERVO ALTITUDE)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual	0	0	0	0	X	6.7	38.7	.6	X	0	5.8
CFI	.10	0	.02	.03	X	.10	.19	.08	X	.10	.07
PAR	-10	0	-2	-3	X	-2.6	27.1	-7.4	X	-1	1.4
HRVI	.14	.24	.15	.12	X	.06	.17	ND	X	ND	.15
			AVERAGE DURATION			152.2 Sec.					
					PROFILE TWO						
% Hi Qual	X	15.6	X	0	X	X	10.4	0	0	X	5.2
CFI	X	0	X	.06	X	X	.01	.14	ND	X	0.5
PAR	X	15.6	X	-6	X	X	9.5	-14	ND	X	1.3
HRVI	X	.12	X	.03	X	X	.14	ND	ND	X	.30
			AVERAGE DURATION			146.7 Sec.					
					PROFILE THREE						
% Hi Qual	X	56.6	1.2	50.6	0.3	16.7	54.8	0	21.8	22.7	23.11
CFI	X	0	0	.07	.01	.01	.09	.01	.13	.01	.04
PAR	X	56.6		47.1	-1	15.9	50.7	-0.1	11.6	21.9	22.4
HRVI	X	.03	.24	.21	.02	.03	.07	ND	.07	ND	.08
			AVERAGE DURATION			164.2 Sec.					

% Hi Qual = Percent Highly Qualified

CFI = Control Frequency Index

PAR = Performance Activity Ratio

HRVI = Heart Rate Variability Index

X = Not Accomplished

N.D. = No Data Tape

TABLE 7. ELEMENT 3. (Airspeed Control)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual	87.7	93.1	89.3	79.4	X	99.1	81.3	98.9	X	93.0	90.2
CFI	.27	.34	.29	.57	X	.18	.20	.56	X	.04	.30
PAR	84.4	90.8	86.2	67.7	X	98.9	77.6	98.3	X	92.7	87.2
HRVI	.14	.24	.15	.12	X	.06	.17	ND	X	ND	.15
			AVERAGE DURATION			152.2 Sec.					
					PROFILE TWO						
% Hi Qual	X	98.5	X	92.7	X	X	82.2	67.0	94.7	X	88.2
CFI	X	.42	X	.35	X	X	.35	.45	ND	X	.40
PAR	X	97.9	X	90.1	X	X	76.0	52.1	ND	X	79.2
HRVI	X	.12	X	.03	X	X	.14	ND	ND	X	.10
			AVERAGE DURATION			146.7 Sec.					
					PROFILE THREE						
% Hi Qual	X	83.9	88.8	90.8	98.3	92.8	67.1	83.5	70.6	X	72.18
CFI	X	.51	.30	.51	.38	.16	.42	.46	.45	X	.39
PAR	X	75.7	85.4	86.1	97.7	91.6	53.2	75.9	57.4	X	77.8
HRVI	X	.03	.24	.21	.02	.03	.07	ND	.07	X	.10
			AVERAGE DURATION			164.2 Sec.					

% Hi Qual = Percent Highly Qualified

CFI = Control Frequency Index

PAR = Performance Activity Ratio

HRVI = Heart Rate Variability Index

X = Not Accomplished

N.D. = No Data Tape

Element 4 Description:

- The pilot was tasked to intercept the 085° Radial outbound from the 6 DME arc at 1300' indicated altitude and 100 KTAS. Data collection was started when the CDI showed the aircraft within 5° (Hi Qual) of the 085° Radial and was terminated on the 085° Radial at 8 DME.

Element 4 Findings (Ref: Tables 8,9 and 10):

- This element required the pilot to determine intercept angle and roll-in/roll-out rates while maintaining airspeed and altitude. The element duration was short requiring rapid physical and mental adjustments. Subject pilots appeared to have performed well except for altitude control. CFIs and PARs for both airspeed and CDI parameters reflect a good deal of concentrated effort to achieve Hi Qual. The altimeter did not seem to hold as much importance in the pilot's cross check as the other instruments. Cyclic movement dominated other control inputs.

TABLE 8. ELEMENT 4. (SERVO ALT)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual	0	0	5.7	3.1	X	0	16.6	0	X	0	3.2
CFI	.01	.09	.02	.57	X	.18	0	.01	X	.06	.11
PAR	-1	-9	3.8	-52.1	X	-18	16.6	-1	X	-6	-8.3
HRVI	.22	.31	.17	.16	X	.12	.22	ND	X	ND	.20
				AVERAGE DURATION		90.5 Sec.					
					PROFILE TWO						
% Hi Qual	X	0	X	0	X	X	0	0	0	X	0
CFI	X	0	X	.02	X	X	.02	.02	ND	X	.02
PAR	X		X	-2	X	X	-2	-2	ND	X	-2.0
HRVI	X	.23	X	.08	X	X	ND	ND	.13	X	.16
				AVERAGE DURATION		115.5 Sec.					
					PROFILE THREE						
% Hi Qual	X	0	0	39.5	0	0	0	0	23.7	X	7.9
CFI	X	0	0	.06	.27	.03	0	.09	.01	X	.06
PAR	X	0	0	35.9	-27	-3	0	-9	22.9	X	2.5
HRVI	X	.03	.21	.14	.03	.03	.09	ND	.10	X	.08
				AVERAGE DURATION		109.9 Sec.					

% Hi Qual = Percent Highly Qualified

CFI = Control Frequency Index

PAR = Performance Activity Ratio

HRVI = Heart Rate Variability Index

X = Not Accomplished

N.D. = No Data Tape

TABLE 9. ELEMENT 4. (Airspeed Control)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual	96.4	100	75.4	92.9	X	99.1	84.3	99.2	X	70.8	89.7
CFI	.08	.09	.24	.57	X	.18	.02	.30	X	.30	.22
PAR	96.1	99.9	69.5	88.9	X	98.9	84.0	99.0	X	62.0	87.3
HRVI	.22	.31	.17	.16	X	.12	.22	ND	X	ND	.17
			AVERAGE DURATION			90.5 Sec.					
					PROFILE TWO						
% Hi Qual	X	97.8	X	94.2	X	X	95.4	7.1	89.1	X	76.7
CFI	X	.42	X	.41	X	X	.16	.42	ND	X	0.35
PAR	X	96.7	X	91.8	X	X	94.7	-31.9	ND	X	1.28
HRVI	X	.23	X	.08	X	X	.22	ND	ND	X	0.18
			AVERAGE DURATION			115.5 Sec.					
					PROFILE THREE						
% Hi Qual	X	100	100	77.2	97.7	67.4	93.9	100	93.9	X	91.3
CFI	X	.35	.23	.56	.44	.11	.50	.36	.50	X	0.38
PAR	X	99.9	99.9	64.4	96.7	63.8	90.8	99.9	90.8	X	77.0
HRVI	X	.03	.21	.14	.03	.03	.09	ND	.10	X	0.09
			AVERAGE DURATION			109.9 Sec.					

% Hi Qual =	Percent Highly Qualified
CFI =	Control Frequency Index
PAR =	Performance Activity Ratio
HRVI =	Heart Rate Variability Index
X =	Not Accomplished
N.D. =	No Data Tape

TABLE 10. ELEMENT 4 (CDI)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual	44.9	69.5	32.0	56.9	X	61.9	66.4	54.7	X	57.3	55.5
CFI	.29	.67	.15	.54	X	.56	.50	.47	X	.37	0.44
PAR	28.9	49.1	21.8	33.6	X	40.6	49.4	33.4	X	41.5	37.3
HRVI	.22	.31	.17	.16	X	.12	.22	ND	X	ND	0.20
			AVERAGE DURATION			90.5 Sec.					
					PROFILE TWO						
% Hi Qual	X	60.7	X	42.3	X	X	60.3	57.6	63.6	X	56.9
CFI	X	.46	X	.47	X	X	.61	.62	ND	X	0.54
PAR	X	42.6	X	15.2	X	X	36.1	31.1	ND	X	31.3
HRVI	X	.23	X	.08	X	X	.22	ND	ND	X	0.18
			AVERAGE DURATION			115.5 Sec.					
					PROFILE THREE						
% Hi Qual	X	60.3	46.6	57.3	26.9	67.4	59.2	46.7	43.4	X	51.0
CFI	X	.43	.21	.62	.50	.11	.52	.50	.72	X	0.45
PAR	X	43.2	35.4	30.8	-9.7	63.8	38.0	20.1	2.6	X	28.0
HRVI	X	.03	.21	.14	.03	.03	.09	ND	.10	X	0.09
			AVERAGE DURATION			109.9 Sec.					

% Hi Qual = Percent Highly Qualified

CFI = Control Frequency Index

PAR = Performance Activity Ratio

HRVI = Heart Rate Variability Index

X = Not Accomplished

N.D. = No Data Tape

Element 5 Description:

- The subject's task on Profiles Two and Three was to intercept and arc South on the Randolph Tacan 9 DME arc at 1300' indicated altitude and 100 KTAS. Data collection began when the aircraft's heading was Hi Qual. Heading reference was provided by the heading marker on the Horizontal Situation Indicator (HSI). Position of the heading marker was determined by the pilot and reflected his calculation of a proper rollout heading to complete the intercept. Data collection for this element ended when the CDI showed the aircraft within 5° of the 115° Radial.

Element 5 Findings (Ref: Tables 11 and 12):

- As this task was fairly simple in motive, expectations were for a high degree of quality performance from the subject pilots. Altitude control data is contrary to this expectation. CFIs indicate that the pilots tended to relax and generally made only cyclic control inputs. Airspeed control was good. Data indicates both a mental and physical concentration in this area on both profiles.

TABLE 11. ELEMENT 5. (SERVO ALT)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual											
CFI	////////TASK NOT APPLICABLE ON THIS PROFILE////////////////////////////										
PAR											
HRVI											
			AVERAGE DURATION ____								
					PROFILE TWO						
% Hi Qual	X	0	X	0	X	X	0	0	0	X	0
CFI	X	0	X	.07	X	X	0	.05	ND	X	0.03
PAR	X		X	-7	X	X	0	-5	ND	X	-3.0
HRVI	X	.19	X	.09	X	X	.17	ND	.17	X	0.16
			AVERAGE DURATION			170 Sec.					
					PROFILE THREE						
% Hi Qual	X	51.3	47.9	65.9	0	41.5	0	7.6	0	X	26.8
CFI	X	.11	0	.03	.05	.01	0	.14	0	X	0.04
PAR	X	45.9		64.9	-5	40.9		-5.4	0	X	20.2
HRVI	X	.01	.24	.13	.02	.08	.18	ND	.29	X	0.14
			AVERAGE DURATION			141.1 Sec.					

% Hi Qual = Percent Highly Qualified

CFI = Control Frequency Index

PAR = Performance Activity Ratio

HRVI = Heart Rate Variability Index

X = Not Accomplished

N.D. = No Data Tape

TABLE 12. ELEMENT 5. (Airspeed Control)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual											
CFI	////////	////////	///TASK NOT APPLICABLE ON THIS PROFILE//						////////	////////	/////
PAR											
HRVI											
			AVERAGE DURATION ____								
					PROFILE TWO						
% Hi Qual	X	100	X	95.1	X	X	99.1	90.7	82.2	X	93.4
CFI	X	.17	X	.50	X	X	.47	.58	ND	X	0.43
PAR	X	99.9	X	92.6	X	X	98.7	85.3	ND	X	94.1
HRVI	X	.19	X	.09	X	X	0.17	ND	.17	X	0.16
			AVERAGE DURATION		170 Sec.						
					PROFILE THREE						
% Hi Qual	X	90.5	68.7	88.3	94.3	90.3	95.5	96.4	91.9	X	89.5
CFI	X	.51	.29	.28	.36	.16	.38	.38	.42	X	0.35
PAR	X	85.7	59.6	85.0	92.2	93.8	93.8	95.0	88.5	X	86.1
HRVI	X	.01	.24	.13	.02	.18	.18	ND	.29	X	0.41
			AVERAGE DURATION		141.1 Sec.						

% Hi Qual = Percent Highly Qualified
CFI = Control Frequency Index
PAR = Performance Activity Ratio
HRVI = Heart Rate Variability Index
X = Not Accomplished
N.D. = No Data Tape

Element 6 Description:

- Data collection began when the CDI reflected Hi Qual performance after intercepting the Randolph Tacan 115° Radial outbound. The task included maintaining 1300' and 100 KTAS. The segment was terminated when the aircraft reached 18 DME. At this point data recording was terminated until approximately 39 minutes elapsed time from takeoff.

Element 6 Findings (Ref: Tables 13,14, and 15):

- Concentration on cyclic inputs again appeared to dominate pilot activity. This element was fairly long and gave the subject an opportunity to establish a stable flight condition. Collective inputs were at a minimum and as a result altitude control suffered. Flying totally hooded in Profile Three appeared to increase and concentrate instrument cross check and had a positive effect on altitude control.

TABLE 13. ELEMENT 6. (SERVO ALT)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual											
CFI	//////	//////	///TASK	NOT APPLICABLE	ON THIS	PROFILE	///	//////	//////	/////	
PAR											
HRVI											
			AVERAGE DURATION								
					PROFILE TWO						
% Hi Qual	X	23.1	X	0	X	X	0	0	0	X	4.6
CFI	X	.03	X	.07	X	X	0	.13	ND	X	0.06
PAR	X	21.8	X	-7	X	X	0	-13	ND	X	0.45
HRVI	X	.26	X	.04	X	X	.22	ND	.14	X	0.17
			AVERAGE DURATION		379.1 Sec.						
					PROFILE THREE						
% Hi Qual	X	22.4	100	20.2	14.5	2.7	12.5	0	6.9	X	22.4
CFI	X	.29	.01	.10	.08	.02	0	.16	.03	X	0.09
PAR	X	-.10	99.9	12.2	7.7	.7		-16	4.1	X	13.6
HRVI	X	.50	.22	.16	.02	.07	.15	ND	.13	X	0.18
			AVERAGE DURATION		426 Sec.						

% Hi Qual = Percent Highly Qualified

CFI = Control Frequency Index

PAR = Performance Activity Ratio

HRVI = Heart Rate Variability Index

X = Not Accomplished

N.D. = No Data Tape

TABLE 14. ELEMENT 6. (Airspeed Control)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual											
CFI	//////////	//////////	//////////	TASK NOT APPLICABLE ON THIS PROFILE						//////////	//////////
PAR											
HRVI											
			AVERAGE DURATION ____								
					PROFILE TWO						
% Hi Qual	X	91.1	X	97.3	X	X	91.9	93.6	93.5	X	93.5
CFI	X	.37	X	.58	X	X	.28	.44	ND	X	0.42
PAR	X	87.8	X	95.7	X	X	89.6	90.8	ND	X	91.0
HRVI	X	.26	X	.04	X	X	.22	ND	.14	X	0.17
			AVERAGE DURATION		379.1 Sec.						
					PROFILE THREE						
% Hi Qual	X	94.7	97.4	95.5	94.1	93.8	88.9	90.7	93.7	X	93.6
CFI	X	.29	.12	.49	.27	.17	.40	.36	.42	X	0.32
PAR	X	93.2	97.1	93.3	92.5	92.7	84.5	87.4	91.1	X	91.5
HRVI	X	.50	.22	.16	.02	.07	.15	ND	.13	X	0.18
			AVERAGE DURATION		426 Sec.						

% Hi Qual = Percent Highly Qualified

CFI = Control Frequency Index

PAR = Performance Activity Ratio

HRVI = Heart Rate Variability Index

X = Not Accomplished

N.D. = No Data Tape

TABLE 15. ELEMENT 6. (CDI)

SUBJECT NO.	1	2	3	4	5	6	7	8	9	10	MEAN
					PROFILE ONE						
% Hi Qual											
CFI	////////////TASK NOT APPLICABLE ON THIS PROFILE////////////										
PAR											
HRVI											
			AVERAGE DURATION								
					PROFILE TWO						
% Hi Qual	X	61.2	X	53.6	X	X	43.8	60.4	60.2	X	55.8
CFI	X	.27	X	.51	X	X	.65	.58	ND	X	0.50
PAR	X	50.7	X	29.9	X	X	7.3	30.4	ND	X	29.6
HRVI	X	.26	X	.04	X	X	.22	ND	.14	X	0.17
			AVERAGE DURATION		379.1 Sec.						
					PROFILE THREE						
% Hi Qual	X	44.5	60.1	65.5	61.0	63.5	58.1	48.7	60.7	X	57.8
CFI	X	.47	.19	.41	.50	.08	.33	.53	.30	X	0.35
PAR	X	18.4	52.5	51.4	41.5	60.5	44.3	21.5	48.9	X	42.4
HRVI	X	.50	.22	.16	.02	.07	.15	ND	.13	X	0.18
			AVERAGE DURATION		426 Sec.						

% Hi Qual = Percent Highly Qualified
CFI = Control Frequency Index
PAR = Performance Activity Ratio
HRVI = Heart Rate Variability Index
X = NotAccomplished
N.D. = No Data Tape

Elements 7 through 23:

- During the data reduction and analysis phase, discovery of inflight recorder errors and computer programming discrepancies precluded the recalling of data from these elements in intelligible form. Attempts to reconstruct the data have been thwarted by the planned disestablishment of the Instrument Flight Center (IFC) and the departure of those persons directly involved with the programming and recorder operation.

Cessation of helicopter flight activities at the IFC coupled with the loss of both subject and project pilots preclude reaccomplishment of these elements. The result is the inability to include the objective data analysis for elements 7 through 23 in this report.

B. SUBJECTIVE DATA FINDINGS

Each subject was provided with questionnaires to be completed at specific times during the data collection process. These times were just prior to the first flight (Preflight Questionnaire), at the completion of each data flight, and a comprehensive Post Flight Questionnaire at the termination of the final data flight. The collected questionnaire responses are contained in attachments "C" through "I".

Pilot responses validated the test plan assumptions of degree of difficulty. Profile Three posed the greatest challenge to the subjects. Though the flying experience base of the subject pilots was quite high, normal helicopter operations do not usually pose as much workload to the pilot. For the most part, the pilots faced up to the challenge of Profile Three with generally better results than on the other profiles where he flew "unhooded."

C. PSYCHOPHYSIOLOGICAL/AND BIOCHEMICAL DATA FINDINGS

Incomplete data from elements 7 through 23 makes it difficult to formulate a valid assessment in this area. However, increases in mean heartrate correlated with increases in workload have been noted in some past studies involving flying tasks. Since workload is difficult to define empirically and some mental processing tasks evidence decreases of heartrate, the heartrate variability measure has been developed and used by some investigators to study the sometimes conflicting effects of workload on heartrate. Tasks that require a centralized type of mental processing may be expected to stabilize heartrate, therefore decreasing variability. Tasks requiring more peripheral visual scanning and mental processing of multi-cue information may be expected to show greater levels of variability. The limited data available from this study tends to support the expectations. In the element by element analysis of HRVI, however, the expectations may have been influenced by the subtle differences between processing information for manuevering the air-

craft and the the constant need to monitor instruments concerning engine performance, and to perform safety and communications tasks.

URINALYSIS

Analysis of urine samples for all biochemical and statistical measures has not been completed at the time of this report. Preliminary analysis of the available biochemical indicators, however, appears to show no trends by which to differentiate substantially the three profiles of flight. Complete analysis will be provided by the School of Aerospace Medicine (USAFSAM) at a later date.

SLEEP AND FATIGUE

The effects of sleep and fatigue are intrinsically intertwined with heart-rate and urinalysis measures. Correllation of these areas will be provided by USAFSAM.

SECTION IV

CONCLUSIONS

As a result of the incomplete data base in all parameters, no definite conclusions can be made concerning short duration helicopter pilot workload and stress analysis. With the limited data that is available, however, some observations of consequence may be made.

One would expect that the easier the task, the more likely a higher percentage of Hi Qual performance would be reached. Conversely, the more difficult the task, more effort is demanded. Quality of performance would be expected to be contingent on the effort expended and the alertness of the pilot.

The data indicates that when faced with a relatively simple task, the pilots tended to accept a greater range of performance standards for self-satisfaction. When these parameters were exceeded, control inputs were quite severe and heartrate variability increased dramatically. This would indicate that the pilots were caught off guard and overreacted to the situation. As a result, performance was generally poorer than would be expected given the reduced complexity of the task.

When faced with a difficult task that demanded more concentration, the pilots would tighten up their own performance standards and increase their concentration to achieve a Hi Qual level of performance. Control inputs were many, but not severe in application. Heartrate showed a steady pace indicating a "relaxed" or "controlled" condition. This indicates that the pilots were prepared for the individual tasks and were, in essence, able to accomplish a difficult task while expending a minimum amount of energy. Unfortunately, these observations are based on only the data available from the first 15 minutes of the flight profiles. Substantiating data from the rest of the flight is not available for those reasons previously stated. One would expect that time, fatigue, and stress would have had a definite impact on performance and the HRVI. Project pilot notes taken during the flights indicate that the above observations have substantial merit.

However, these notes are subjective in nature and can not be reinforced by objective data.

SECTION V

RECOMMENDATIONS

Although the study is incomplete, a further study is unwarranted at this time. Until a more precise means of biochemical data sampling and processing can be devised, further studies in the realm of short duration helicopter pilot workload should be held in abeyance. The data that was collected and analyzed in this study did not produce any particularly significant findings. It is doubtful that further study at this time would greatly alter the results.

SLEEP SURVEY

DATE

NAME *(Last, First, MI)*

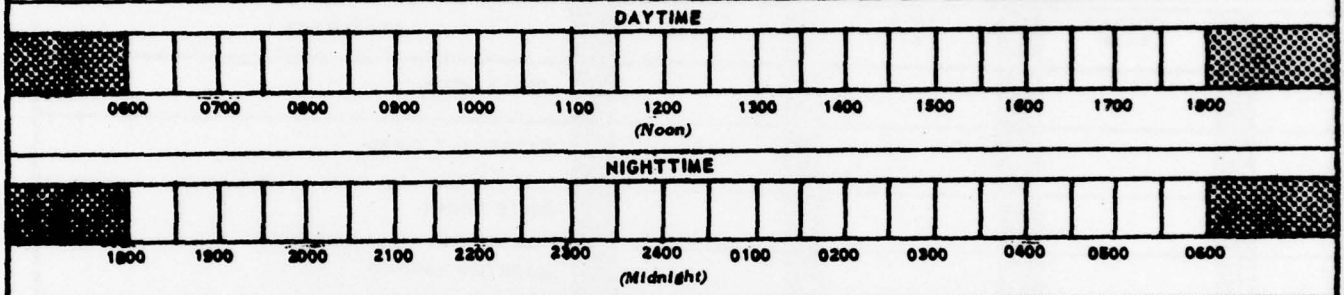
GRADE

AGE

SEX

PRIMARY DUTY

1. On the chart below, mark an X for each half hour to indicate how much you slept in the past 24 hours.



2. HOW MUCH TROUBLE DID YOU HAVE GOING TO SLEEP LAST NIGHT?

☐ NONE ☐ SLIGHT ☐ MODERATE ☐ CONSIDERABLE

3. HOW RESTED DO YOU FEEL?

☐ WELL RESTED ☐ MODERATELY RESTED ☐ SLIGHTLY RESTED ☐ NOT AT ALL

4. DO YOU FEEL LIKE YOU COULD HAVE USED SOME MORE SLEEP?

☐ YES ☐ NO

REMARKS

SUBJECTIVE FATIGUE CHECKLIST

DATE

SECURITY NUMBER	NAME (Last, First, MI)	CODE ON CASE NR.

RANK	TEST IDENTIFICATION

INSTRUCTIONS: Make one, and only one (✓) for each of the ten items. Think carefully about how you feel right now.

ITEM NR.	BETTER THAN	SAME AS	WORSE THAN	STATEMENT
1.				VERY LIVELY
2.				EXTREMELY TIRED
3.				QUITE FRESH
4.				SLIGHTLY POOPED
5.				EXTREMELY PEPPY
6.				SOMEWHAT FRESH
7.				PETERED OUT
				VERY REFRESHED
9.				FAIRLY WELL POOPED
10.				READY TO DROP

REMARKS

HELICOPTER WORKLOAD STUDY

PREFLIGHT QUESTIONNAIRE

Subject Number 1 thru 10 Date 11 May 77 thru 12 Aug 77

Operational mission normally flown: VIP, Army Support, Training, Range Support

Aircraft/helicopter current in: U-21, T-42, H-1H, TH-1F, UH-1N BH-47, BH-205, BH-206

Please indicate your flight experience (approx).

	AVERAGE	MIN	MAX
Total Flying time as pilot	3670	1700	9000
Total helicopter time	2022	70	6200
Total instructor pilot time	1001	-0-	4000
Total actual instrument time	163	40	350
Total simulated instrument time	295	50	700

Atch C

POSTFLIGHT QUESTIONNAIRE (EACH FLIGHT) - MISSION # 1

1. Was this mission similar in pilot workload to any missions you typically fly?

Six out of eight responses indicated that Mission #1 more closely resembled their typical operations. The two negative responses came from pilots whose primary mission is to instruct and majority of their flying time is "Hands Off."

2. Have you ever flown a helicopter mission with this degree of stress or greater?

All of the subject pilots indicated they have flown missions that were more difficult and posed a greater degree of stress on them (ie: combat, SARs, flights in I.M.C., etc.).

3. How would you rate the difficulty of this mission?

a. Very Simple. - One response

b. Relatively Easy - Six responses

c. Mildly Difficult - One response

d. Moderately Difficult.

e. Very Difficult.

f. Impossible.

4. Compared to your usual flying do you feel you had a:

a. Good day.

b. Normal Day. - Seven responses

c. Bad Day. - One response

Atch D

POSTFLIGHT QUESTIONNAIRE (EACH FLIGHT) - MISSION # 2

1. Was this mission similar in pilot workload to any missions you typically fly?

Five of eight subject pilots felt the workload involved in this flight was similar to the workload involved in some of the operational tasks that they are involved in. Two pilots felt the workload was greater than what they were normally used to.

2. Have you ever flown a helicopter mission with this degree of stress or greater?

All responded that they have flown missions that posed greater amounts of stress.

3. How would you rate the difficulty of this mission?

a. Very Simple.

b. Relatively Easy. - One response

c. Mildly Difficult. - Four responses

d. Moderately Difficult - Three responses

e. Very Difficult.

f. Impossible.

4. Compared to your usual flying do you feel you had a:

a. Good Day. - Two responses

b. Normal Day. - Four responses

c. Bad Day. - Two responses

Atch E

POSTFLIGHT QUESTIONNAIRE (MISSION #2)

1. Did you feel more comfortable before or after the curtains and hood were installed?

Three quarters of the pilots that flew mission felt more comfortable being able to have outside references. The two pilots that felt more comfortable after the hood and curtains were installed felt that the absence of outside distraction enabled them to pay closer attention to their instruments.

2. Was your aircraft control better or worse after the curtains and hood were installed?

Six pilots claimed their aircraft control deteriorated significantly from their own standard after installation of the hood and curtains. One pilot felt he was doing much better, while another felt his control was not affected.

3. Did the presence of the curtains and hood affect your performance in any way? (If yes, explain.)

Six of the eight pilots felt they had to work harder at their instrument cross check. Light filtering through the curtains and causing glare spots on the instruments fostered a tendency to stare at one instrument. Two pilots did not alter their scan and did not feel the hood and curtains had any appreciable effect on their normal performance activities.

Atch F

POSTFLIGHT QUESTIONNAIRE (EACH FLIGHT)- MISSION #3

1. Was this mission similar in pilot workload to any missions you typically fly?

Seven of ten pilots indicated that the stress posed by this profile was much greater than the stress normally encountered in their typical missions. Comments accompanying the three positive remarks indicated that it was a toss-up.

2. Have you ever flown a helicopter mission with this degree of stress or greater?

Seven pilots had flown missions of greater stress. All of these missions were related to combat and initial training. Three pilots felt that they had never experienced stress of this magnitude.

3. How would you rate the difficulty of this mission?

a. Very Simple.

b. Relatively Easy.

c. Mildly Difficulty. - Three responses

d. Moderately Difficulty. - Three responses

e. Very Difficult. - Four responses

f. Impossible.

4. Compared to your usual flying, do you feel you had a:

a. Good Day.

b. Normal Day.- Five responses

c. Bad Day. - Five responses

Atch G

POSTFLIGHT QUESTIONNAIRE (MISSION # 3)

1. Did the presence of the curtains and hood affect your performance in any way? (If yes, explain.)

An inherent problem with the installation of the curtains allowed transient light to occasionally cause glare spots on the instrument panel. Although this was commented on by nearly all the pilots, only three felt that it had an effect on their performance. Two pilots responded that the weight of the hood caused neck fatigue which degraded their performance.

Atch H

POSTFLIGHT QUESTIONNAIRE (AFTER COMPLETING ALL MISSIONS)

1. Which mission (1, 2, or 3) was most difficult?

Eighty percent of the subject pilots felt that mission three posed the most difficult challenge to their piloting abilities. Twenty percent felt that mission two was the most difficult.

2. Which mission (1, 2, or 3) most closely resembles the difficulty of your typical mission?

Seventy percent of the subject pilots felt that mission two fairly represented the degree of difficulty normally encountered in their normal scope of operations. Thirty percent felt that mission one more closely resembled their type of mission normally flown.

3. Which mission (1, 2, or 3) was the easiest?

One hundred percent of the subject pilots felt that mission one was the easiest of the three.

Atch I