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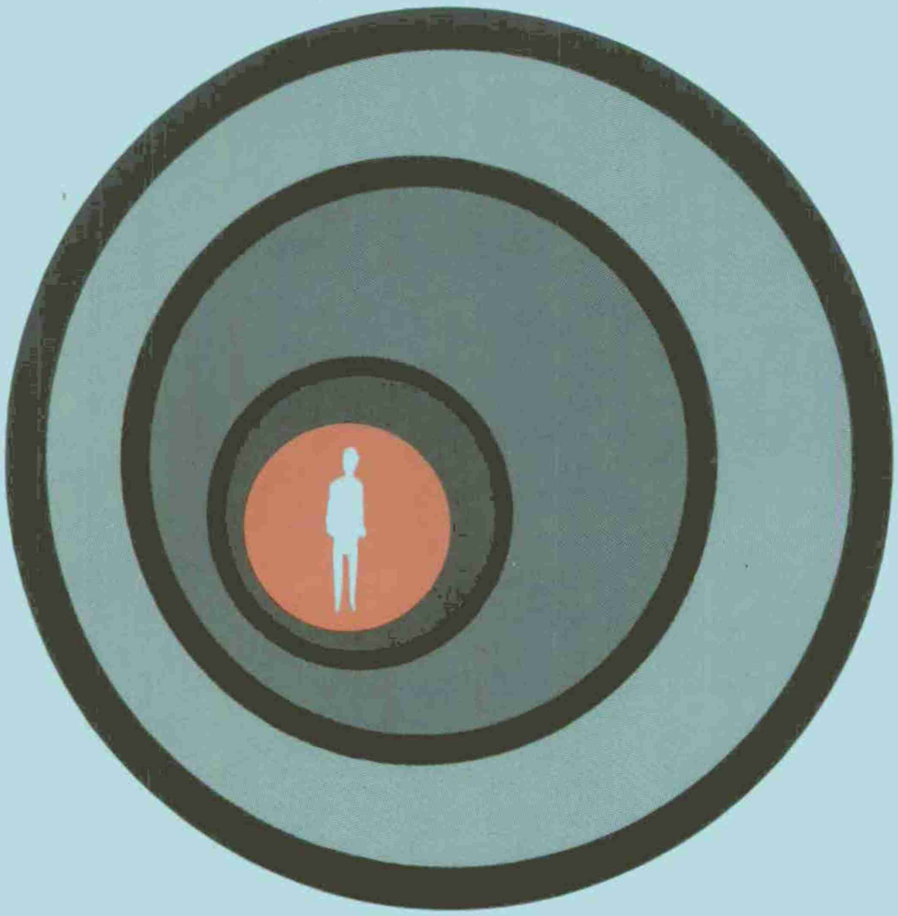
TAEG REPORT NO. 42.

TRAINING EFFECTIVENESS EVALUATION OF DEVICE 2F87F, P-3C OPERATIONAL FLIGHT TRAINER.

Chief of Naval Education and Training Support.



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JANUARY 1977

TRAINING ANALYSIS AND EVALUATION GROUP
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The purpose of this study was to determine the training effectiveness of the newly installed Device 2F87F Operational Flight Trainer (OFT) as a substitute for the earlier generation 2F69D OFT used in combination with the P-3 aircraft in training replacement patrol plane pilots. This study provided the opportunity to evaluate the potential of a sophisticated state-of-the-art flight simulator concurrent with its coming on-line in an operational setting.

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20. ABSTRACT (continued)

The performance of 27 recent Undergraduate Pilot Training (UPT) graduates trained in the new OFT was compared with the performance of UPT graduates trained under the pre-2F87F curriculum.

Utilizing the new 2F87F Device in the ongoing P-3 program resulted in:

- a reduction of in-flight training time required for the completion of the FAM/INST phase of replacement pilot training
- a reduction in number of practice landings in the aircraft from 52 to 36 (31 percent), and
- a reduction in average training time differences between fast and slow learners.

It was concluded that:

- the average number of flights required to qualify pilots could be reduced from six to four
- practice landings in the aircraft could be reduced by 16, and
- the narrow field of view visual system enhances the training capability of the new simulator and appears to meet the requirements for multiengine training.

Subsequent phases of study are expected to address the issues of:

- the effect of increased simulator training
- increasing the precision of measuring proficiency
- assessment of an integrated simulator/flight regime compared to a block training regime as used in this study
- an evaluation of the contribution of the motion system to student performance and possible physiological effects; i.e., motion sickness
- determination of meaningful substitution ratios through comparison of a simulator-trained group with an aircraft-only trained group, and
- assessment of the effect of loss of visual simulation on trainer substitution values.

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ACKNOWLEDGMENT

The foresight demonstrated and the efforts expended by the former Commanding Officer, CAPT D. J. Wolkensdorfer, and members of Patrol Squadron THIRTY, particularly LCDR George Brown, in seeking an evaluation of the training effectiveness of Device 2F87F, P-3C Operational Flight Trainer, immediately after its acceptance by the Navy, are exceptionally laudable. The opportunity to evaluate the potential of a sophisticated state-of-the-art flight simulator concurrent with its coming on-line in an operational setting does not often occur. Patrol Squadron THIRTY capitalized on this opportunity.

The constant support and cooperation of the present Commanding Officer, CAPT Frank L. Woodlief, the officers of the Pilot Training Division, and the flight instructors are expressly acknowledged. Without their concern, gathering the substantial amount of data required for analyses would have been impossible.

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INTRODUCTION

Advances in simulation technology together with substantial gains in the technology of training have shaped new and impressive utilization goals for the flight simulator. Evidence to date indicates that substantial economies accrue when a flight simulator is employed efficiently in conjunction with the aircraft in accomplishment of training objectives. These advances in design and in utilization place the "new breed" of simulators currently coming on-line quite realistically in contention as a major flight training medium in today's military environment.

This report examines the extent of substitution of simulator training for in-flight training. Specifically, the report presents the results of a study evaluating the effectiveness of the recently accepted Device 2F87F Operational Flight Trainer (OFT) in the fleet replacement pilot training in Patrol Squadron (VP) 30.

The work reported here is the first phase of a three-phase study program concerned with assessing the training effectiveness of Device 2F87F.

The first phase was specifically concerned with determining the effectiveness of Device 2F87F as a substitute for the currently used Device 2F69D OFT and the P-3 aircraft.

Phase II of the program will examine major variables that impact on the effective utilization of Device 2F87F in the current VP 30 program. The specific issues include the following:

1. Compare the effects of simulator plus flight training vs. flight-only training. Substitution ratios between simulator and the aircraft will be derived and VP 30 will be provided the requisite information for determining courses of action in those situations where the 2F87F OFT is not available for training.

2. Determine the optimum number of simulator flights required preparatory to in-flight training. Block training (i.e., all OFT training given to completion followed by training in the air) vs. integrated training (i.e., simulator and aircraft training interspersed) will be examined.

3. Examine the contributions of the six-degrees of freedom motion system to performance.

4. Determine the contribution of visual simulation to performance.

Both issues 3 and 4 are expected to provide guidance to squadron planners in the event either of the systems become inoperative for brief or extended periods of time.

Phase III of the program will establish a standardized performance assessment capability for Device 2F87F and will initiate an effort to implement an automated performance measurement system. This subsumes the development of performance standards for P-3 replacement pilot training and automatic scoring with a diagnostic capability.

BACKGROUND

The impetus for this program began in February 1972 when the Training Analysis and Evaluation Group (TAEG) was tasked to perform a training analysis of P-3 replacement pilot training and to examine the potential utilization of flight simulation as a surrogate for in-flight training at the P-3 replacement squadron level.[1,2,3]

The initial work assignment began with an analysis of pilot training practices and an assessment of training resources at the replacement squadron level. A goal was to determine if procurement of advanced capability flight simulators could reduce the number of training aircraft required while maintaining an equivalent quality of training. The results of these analyses were published in TAEG Reports No. 5[4] and No. 7.[5] This was followed by another study which demonstrated that in-flight training could be significantly reduced by the effective utilization of the existing synthetic training devices (i.e., 2F69D OFT and 2C23 Cockpit Familiarization Trainer (CFT)). The resulting training and cost benefits were published in TAEG Report No. 10 (Browning, Ryan, and Scott, 1973).[6]

[1] COMFAIRWINGSPAC msg 140240Z Jan 72

[2] CO VP 31 ltr ser 106 of 25 Jan 72

[3] CO VP 30 ltr ser 250 of 25 Feb 72

[4] Training Analysis of P-3 Replacement Pilot Training. TAEG Report No. 5. 1972. Training Analysis and Evaluation Group, Orlando, FL.

[5] Task Analysis of Pilot, Copilot, and Flight Engineer Positions for the P-3 Aircraft. TAEG Report No. 7. 1973. Training Analysis and Evaluation Group, Orlando, FL.

[6] Browning, R. F., Ryan, L. E., and Scott, P. G. Training Analysis of P-3 Replacement Pilot and Flight Engineer Training. TAEG Report No. 10. 1973. Training Analysis and Evaluation Group, Orlando, FL.

Consulting services and assistance in the development of the specifications for Device 2F87F were also provided by TAEG in the selection of viable visual simulation systems, the design for instructional control, the selection of a synthetic voice generation system, and in defining the performance measurement capability. In conjunction with this program of study, continuing consulting services were provided to the P-3 replacement squadrons, principally VP 30, concerning effective utilization of existing training assets. As a result of the previous studies and the continuing dialogue, VP 30, upon receipt of Device 2F87F, requested additional services from the TAEG in a letter to the Chief of Naval Education and Training (CNET).[7] In April 1976, TAEG was tasked by CNET to perform an assessment of the training potential of Device 2F87F in the ongoing P-3 training program and to provide inputs to the development of a curriculum that would capitalize on the unique capabilities of the simulator. The study design and data collection were begun in April 1976; simulator and aircraft flights for this phase of study were completed in August 1976.

PURPOSE OF THE STUDY

The goal of this study was to determine the training and cost effectiveness of the newly installed Device 2F87F OFT as a substitute for the earlier generation Device 2F69D OFT in combination with the P-3 aircraft in training replacement patrol plane pilots. The intent was to discover the potential of the device as a substitute environment for the learning of aircraft tasks and to maximize its future utility for that purpose. The intensive investigation of Device 2F87F capabilities is in consonance with the immediate goal of VP 30 to reduce the in-flight training time required to qualify pilots for assignment to operational P-3 patrol squadrons. Another objective of this study was to appraise the simulator training syllabus developed by VP 30 for the familiarization/ instrument (FAM/INST) phase of replacement pilot training. This new syllabus was based on the projected capabilities of Device 2F87F and on previous training analyses performed by TAEG.

PERSPECTIVE

The effort reported here has a number of features worthy of note. Perhaps the most significant aspect is the opportunity that emerged for assessing the contribution of a "brand new" on-line high fidelity simulator in producing P-3 aircraft-qualified aviators for the Fleet. The uniqueness of the opportunity enabled the tailoring of the study to adapt a specific OFT to a specific real world training situation. The goal was straightforward -- efficiently integrate the new Device 2F87F into the ongoing VP 30 training system without interrupting or delaying the pilot production

[7] CO VP 30 ltr 44:ds:10171 of 12 April 76

commitments. VP 30 has, as part of its mission, the responsibility for transitioning pilots to the P-3 four engine turboprop aircraft. The squadron trains approximately 200 pilots per year, distributed over 10 classes. About 80 percent of the trainees are newly designated first-tour naval aviators.

The foresight demonstrated by VP 30 in seeking this evaluation is highly commendable. Evaluating the potential of a state-of-the-art flight simulator concurrent with its acceptance by the Navy and in the operational setting is a rare opportunity. The joint TAEG-VP 30 program is exploiting this opportunity to obtain data using current students in the pipeline to the fullest, with the expectation of resolving some knotty issues that have plagued simulator utilization for decades.

The significance of the results of this study are enhanced since the work was accomplished in the operational setting. During the study, VP 30 conducted its business as usual. Effective experimental control and standardized data collection were maintained during the study in that a team member was always onsite at VP 30. Also, the team members rode in the simulator and flew on student training flights in the P-3 aircraft. This ensured that the experimental design was achieved; it also enabled TAEG to provide necessary guidance and support to the instructors conducting the student performance evaluations.

Certain accommodations had to be made in the design and conduct of the study due primarily to the recency of the device coming on-line and to constraints associated with gathering data during the normal operations of the squadron.

Initially, the desired experimental design had to be modified slightly to conform to squadron scheduling. Students are required to meet defined goals at given times in the program. For example, pilots must complete the FAM/INST phase at specified dates in order to integrate with a team for the follow-on tactics training. However, this did not compromise the study design (see section II of the report). It did, however, preclude an initial determination of the optimum number of simulator periods required prior to transferring to the aircraft. This objective will be accomplished in a subsequent study.

Concomitantly, beginning the study immediately after Device 2F87F acceptance limited the absolute number of training periods available, since maintenance training and maintenance periods competed for simulator time.

Finally, the lack of specialized simulator instructor training and experience in the utilization of the high fidelity Device 2F87F presented some difficulties, which were overcome. New instructor pilots are assigned with each succeeding class. However, instructor turnover is a fact of life and is part of a larger problem in replacement pilot training.

ORGANIZATION OF THE REPORT

In addition to this introduction, section II presents the training situation at VP 30 and the approach used for the conduct of onsite evaluation. Section III presents the analysis of data and a discussion of findings. Section IV compares the cost of training utilizing the experimental syllabus with the new device and the traditional syllabus with the P-3 aircraft. Finally, section V presents an appraisal of the experimental syllabus and conclusions resulting from the present phase of study with appropriate recommendations.

SECTION II

APPROACH

The study approach employed in evaluating the training effectiveness of Device 2F87F involved an assessment of the device under actual operating conditions. The work was accomplished onsite using the available resources of VP 30 and an instructional staff assigned to their normal training schedules.

Frequently transfer studies are performed in a laboratory environment and the results are extrapolated for application to a real world situation. While these studies are experimentally sound their results rarely have practical application in a field setting.

The in situ approach used in this study did present some unusual problems and confounding influences. However, the fact that the results have had immediate application at the training activity far outweighs any disadvantage that may have accrued from the approach.

DESIGN OF THE STUDY

The study was designed to compare the flight hours required for FAM/INST qualification in the traditional syllabus with the flight hours required for the experimental syllabus.

The experimental syllabus was developed by VP 30 based on the projected capabilities of Device 2F87F and on the previous TAEG task/training analyses.

STUDY PLAN. The plan jointly agreed upon by TAEG and VP 30 is shown in table 1. The plan was, to some extent, designed to accommodate constraints imposed by operational requirements. For example, 16 hours of device time each day were devoted to maintenance training and maintenance on the device. Furthermore, it was necessary that all students complete training by specified dates in order to integrate with tactical teams for Antisubmarine Warfare (ASW) training. These constraints imposed a limit of six simulator training periods available to each student in the study.

TABLE 1. STUDY PLAN

CONTROL (C) GROUP	EXPERIMENTAL (E) GROUP
4 CFT	4 CFT
6 CPT	6 CPT
3 OFT (Device 2F69D)	6 OFT (Device 2F87F)
6 P-3 Flights	4 P-3 Flights

TRAINING TASKS. The FAM/INST phase provides training for the 45 tasks shown on the Universal Grade Sheet (UGS), figure 1. The 20 circled tasks on the UGS are those tasks which in the traditional syllabus were graded on FLY 6, the FAM/INST check flight in the P-3 aircraft. Since the 20 check items were the principal tasks deemed by the squadron to require in-flight demonstration of proficiency and were common to both the old and new syllabi, they were used in this study as the basis for comparing the performance of the E and C groups.

SUBJECTS. Of the approximately 160 newly designated first-tour naval aviators trained by VP 30 each year, 27 were selected from classes 7608, 7609, and 7610 as experimental subjects. The remaining first-tour students from these classes were designated as a Concurrent Control (CC) group. To provide a larger number of control subjects, the data from the VP 30 training records of 58 first-tour pilots from fiscal year 1976 classes (7603, 7604, 7605, 7606) were included. These subjects were designated as an Historical Control (HC) group. All groups used in this study were matched on the basis of undergraduate basic and advanced flight grades.

All subjects had completed undergraduate multiengine training in the S-2, a small twin reciprocating engine aircaft. All possessed Standard Instrument Cards.

INSTRUCTORS. Instructors with different levels of experience were used in this study. Prior to the start of the experiment none had instructed on a high fidelity state-of-the-art flight simulator such as Device 2F87F.

Each experimental group instructor received a short course in the operation of the device and was briefed by the TAEG on the purpose of the evaluation, the conduct of both simulator and aircraft training sessions, the proficiency-based grading system, and the data recording requirements.

TRAINING DEVICES UTILIZED IN THE STUDY. Three classes of training devices were used in the study: the new digital operational flight trainer and an older analog operational flight trainer; a cockpit procedures trainer; and a cockpit familiarization trainer. Descriptions of the devices are provided below.

Operational Flight Trainer, Device 2F87F. The recently accepted Device 2F87F simulates the flight (pilot, copilot, and flight engineer) stations of the P-3C Orion, a four-engine turboprop aircraft used to support landbased ASW and other long range surveillance and data gathering missions. The high fidelity digital device is equipped with a six-degrees of freedom motion system and a visual capability which is a

TRAINEE:	TRAINING SESSION:
INSTRUCTOR	FLIGHT TIME:
DATE:	FIRST PILOT TIME:
	COPILOT TIME:

Flight was: Satisfactory Unsatisfactory Incomplete Remarks on Back

	P	AA	A	BA	U		P	AA	A	BA	U
01 PREFLIGHT						26 FIRE OF UKN ORIG. (CPT)					
02 USE OF CHECKLISTS (CPT)						27 SMOKE REMOVAL (CPT)					
03 ENGINE STARTS						28 REST. ELECT PWR (CPT)					
04 START MALFUNCTION (CPT)						29 BAILOUT DRILL (SIM)					
05 TAXI						30 EMERGENCY DESCENT (SIM)					
06 INSTRUMENT PROCEDURES						31 DITCHING DRILL (SIM)					
07 ANTI-ICE/DE-ICE (CPT)						32 HOLDING					
08 BRAKE FIRE						33 NON PREC APPR's NO.					
09 TAKEOFF						34 PREC APPR's NO.					
10 ABORT FOUR ENGINE NO.						35 CIRCLING APPROACH					
11 ABORT THREE ENGINE NO.						36 MISSED APP					
12 EFAR						37 LDG PTRN AIRWORK					
13 DEPARTURE						38 NORMAL/APP FLAP LDGS NO.					
14 NTS						39 CROSSWIND LDGS					
15 GOVERNOR INDEXING						40 WAVEOFF					
16 BASIC AIRWORK						41 THREE ENG LANDINGS NO.					
17 LOITER SHUTDOWN (CPT)						42 TWO ENG LANDINGS (NO P)					
18 PROP MALF (CPT)						43 NO FLAP LANDINGS NO.					
19 EMERG SHUTDOWN (CPT)						44 KNOWLEDGE OF PROCEDS					
20 ENGINE RESTART (CPT)						45 CO-PILOT RESP					
21 AIRCOND/PRESS OP (CPT)						46					
22 HYD SYS OP/MALF (CPT)						47					
23 FUEL SYS OP/MALF (CPT)						48					
24 NAV FLT INST MALF						49					
25 ELECT SYS OP/MALF (CPT)											

Figure 1. Universal Grade Sheet

narrow angle (50° horizontal by 38° vertical) television model board system. A broad range of environmental conditions varying from full daylight color to darkness with variable visibility, ceilings, and wind conditions can be simulated. The model board simulates an area of approximately 15 by 5 nautical miles on a scale of 2000 to 1 for the low altitude maneuvers associated with takeoff, landing, and instrument approaches. Low altitude on-top conditions are simulated electronically, and high altitude simulation is provided through the use of a high altitude model board.

Operational Flight Trainer, Device 2F69D. An older operational flight trainer configured to the earlier P-3A/B models was used in the training of the C group. This solid state analog device, which was the principal simulator used before delivery of the 2F87F, came into the inventory late in 1966 and provides crew or individual training for the pilot, copilot, and flight engineer. The 2F69D simulates the flight dynamics, systems, navigation, and communications functions of the P-3 aircraft and provides limited motion (three-degrees of freedom) and environmental cues. No visual simulation is provided. The device, with its analog simulation, requires considerable maintenance to insure high fidelity performance.

Cockpit Procedures Trainer (CPT), Device 2C45. The currently used CPT was developed from a modification of an obsolete P-3 OFT. The motion simulation, most of the flight dynamics, and unneeded systems were removed or disabled. The device in its present configuration provides training in powerplant management and systems procedures for both normal and emergency operations.

Cockpit Familiarization Trainer (CFT), Device 2C23A. The CFT provides a static simulation of the pilot, copilot, and flight engineer positions. It is used to facilitate the learning of the nomenclature, location, and function of the various controls, instruments, switches, and annunciator lights. The device is well suited to the learning of repetitive tasks such as normal and emergency procedures.

Both procedures and familiarization trainers have been previously demonstrated to be effective substitutes for operational flight trainers and aircraft in learning cockpit/layout and procedural tasks. They are less expensive to operate and require less maintenance support. Assignment of procedural training tasks to the CFT and CPT enables more effective usage of the OFT for training of tasks more suited to the capabilities of the simulator.

PROCEDURE

GROUND SCHOOL, CFT, AND CPT TRAINING. The experimental and control groups received identical ground school, CFT, and CPT training (i.e., the present syllabus).

EXPERIMENTAL GROUP SIMULATOR TRAINING. The experimental subjects received six simulator training sessions. In each 4-hour simulator session, one student occupied the left seat and one student occupied the right seat for the first 2 hours; the students then exchanged seats for the second 2 hours. In addition, a flight engineer student received training during these sessions.

Although training in the simulator was not limited to the 20 check tasks, emphasis was placed on training these 20 tasks to proficiency prior to the first flight in the P-3 aircraft. Proficiency was defined as performance estimated to be equivalent to that required to demonstrate competence on that task on the conventional FLY 6 check.

As students demonstrated proficiency in the various tasks, instructors were requested to concentrate on tasks not previously judged proficient. For those tasks previously judged proficient, training was continued on a refresher/reinforcement basis. Because of the limited simulator time, all students were not trained to proficiency on all tasks.

EXPERIMENTAL GROUP IN-FLIGHT TRAINING. On the first flight in the aircraft, FLY 1, each student was to be checked on all 20 check tasks. This flight check was the equivalent of the flight check given to the C group on their 6th flight. However, not all E group students received the 20 tasks; the number of tasks actually checked on FLY 1 varied from 9 to 19.[8] On FLY 2, training and/or flight checking was provided on those tasks not judged proficient on FLY 1; any time remaining was used for refresher training on tasks previously judged proficient. Flights 3 and 4 were conducted in the same manner.

CONTROL GROUP TRAINING. The CC and the HC groups both received the same training (i.e., ground, synthetic, and in-flight). In this syllabus, training in the P-3 included more than the 20 check tasks circled on the UGS, figure 1. This was necessary because some of the tasks such as emergency descent, ditching and others could not be adequately trained in the CFT, CPT, or Device 2F69D.

DATA GATHERING. The principal sources of data for analysis were the universal grade sheets (figure 1) and the landing data sheets (figure 2). Hard copy printouts of the approach and landings performed in the simulator were made for use in evaluation of the performance measurement capability of the device and for normative data needed in establishing performance standards. An example is shown in figure 3. The data was not used for comparative purposes in this study. However, some instructors found the printouts valuable as a debriefing source.

[8] Weather, mechanical difficulty, student readiness, or instructor oversight accounted for the reduced number of tasks checked.

NAME	#1	#2	#3	#4	#5	#6	#7	...N
FLIGHT #								
DATE								
FINAL								
ALT+/-								
A/S+/-								
LINEUP L/R								
AFTER FLAPS								
FLAP SELEC (EARLY/LATE)								
NOSE ATTITUDE (HI/LO)								
LINEUP (L/R)								
POWER+/-								
FLARE								
FLARE ALTITUDE (HI/LO)								
POWER+/-								

REMARKS ON REAR   CIRCLE ONE   FIRST TOUR   SECOND TOUR

Figure 2. Landing Data Sheet

01 INITIAL STATE

GEAR DOWN & HAGL <900 100 %M

S.E.T.	IAS ABS	SHP1 ABS	SHP2 ABS	SHP3 ABS	SHP4 ABS	WDIR ABS	WVEL ABS	TURB ABS
01:25 MAX	154.	980	963	979	980	20	22	9

02 TO TOUCHDOWN, LAND FLAPS, OR WAVEOFF

WOW ON $ SHP3 >2500 $ FLAP >20 E V(

S.E.T.	HDG ABS	SHP3 ABS	VV 0 +-1	IAS ABS	STIK ABS	PTCH ABS	CLD ABS	HAGL ABS
00:00	238.5	758	-1216	155.	-723.	D 1.5	102	852
00:03	226.5	764	-1300	156.	-555.	D 2.7	944	768
00:06	219.0	762	-1006	155.	-647.	U 1.1	862	704
00:09	207.1	755	-559	151.	-603.	U 1.8	757	672
00:12	197.9	747	-241	148.	-719.	U 1.8	660	660
00:15	187.2	742	-440	147.	-679.	D 0.1	546	632
00:18	178.3	740	-635	145.	-659.	U 1.4	446	592
00:21	162.0	902	-738	145.	-499.	U 0.4	333	548
00:24	147.1	842	-871	146.	-475.	U 0.1	241	496
00:27	128.6	775	-676	144.	-395.	U 1.9	149	448
00:30	112.8	768	-485	141.	-415.	U 1.5	896	424
00:33	97.3	765	-571	140.	-539.	U 3.3	476	384
00:36	92.0	1087	-316	138.	-511.	U 2.4	300	368
00:39	86.9	1040	-222	138.	-787.	U 1.8	192	360
00:42	88.4	728	-347	137.	-663.	U 2.2	160	336
00:45	86.2	479	-543	135.	-595.	D 0.0	120	308
00:48	86.9	475	-722	133.	-591.	U 1.2	72	264
00:51	83.7	475	-840	133.	-459.	D 0.2	36	208
00:54	83.2	473	-773	132.	-459.	U 0.3	18	164
00:57	84.5	473	-867	131.	-451.	D 0.3	12	108
01:00	83.0	474	-960	131.	-583.	U 1.9	4	48
01:03	84.3	222	-658	128.	68.5	U 2.4	-2	4
01:06	83.1	-6	-192	121.	996.	U 0.4	4	-
01:07	81.1	-7	-138	120.	1016	U 1.3	6	
MAX			-1300					

Figure 3. Approach and Landing Data

MEASUREMENT. During simulator and aircraft flights students were assigned grades on the basis of the conventional grading system used in Navy pilot training. In this system, referred to as the "U, BA, A, AA," the letter U denotes unsatisfactory performance and is equated to a numerical grade of 0; BA denotes below average and a grade of 2.5; A denotes average and a grade of 3.0; and AA denotes above average and a grade of 3.5. The numerical scores of all students were compiled and averages were obtained for individuals and for groups.

In addition to the grading of U through AA an additional grade of P was assigned when proficiency was demonstrated for each task. P was defined as performance estimated to be equivalent to that required to demonstrate competence in that task on the conventional FLY 6 check. The FLY 6 check was chosen because an A grade on a FLY 1 is not equivalent to a grade of 3.00 on every flight; the quality of performance expected for later flights is considerably higher than that expected for earlier flights. It was therefore possible for a student to receive a grade of A or AA for a given task on FLY 1, 2, or 3 and not be graded proficient. Use of the dual grading system (U, BA, A, AA and Proficiency) allowed trainees to be compared with their peers for record purposes while providing the study team with the necessary proficiency grades for analysis purposes. Control groups were graded on the conventional basis except for those from class 7610 who were graded on a dual basis for comparative purposes. After classes 7608 and 7609 had completed their training it became evident that data on proficiency in the aircraft for C group students would enable additional comparisons.

QUESTIONNAIRES. Questionnaires were administered to all instructors to obtain judgments of (1) training effectivenesss and (2) visual, motion and dynamic fidelity of Device 2F87F.

SECTION III

DATA ANALYSIS

This section presents an analysis and discussion of data collected during this study. The data is presented under two main topics: (1) Actual Flight Training Hours and (2) Proficiency-Based Flight Training Hours. The actual flight training hours data represent the total number of flight hours received by both the C and E groups. The proficiency-based flight training hours represent the number of hours required to attain proficiency in the 20 check tasks. Proficiency grades were collected for the entire E group and for the seven students used as controls from class 7610.

ACTUAL FLIGHT TRAINING HOURS

Table 2 summarizes the number of students, flight averages from undergraduate pilot training, average VP 30 flight hours per student, and the VP 30 check flight average grade.

The HC group hours were obtained from VP 30 training records, and the CC and E groups hours were obtained from the present study.

TABLE 2. FLIGHT HOURS AND FLIGHT GRADES OF CONTROL AND EXPERIMENTAL GROUPS

	HC	CC	E-1	E-2	E-3	Combined E Group
Number of Students	58	16	9	8	10	27
UPT Basic and Advanced Flight Average	55.8	55.8	57.5	49.7	54.9	54.2
Average VP 30 Flight Hours per Student	15.1	14.5	9.0	8.5	8.3	8.6
VP 30 Check Flight Average Grade	3.02	3.02	3.01	3.06	3.03	3.03

HC = Historical Control Group
CC = Concurrent Control Group
E = Experimental Group

The data of most interest from table 2 concerns the number of flight hours received by the HC, CC, and E groups to complete FAM/INST training. The combined E group average of 8.6 hours represents a savings of 40.6 percent (5.9 hours) over the CC and 43 percent (6.5 hours) over the HC group. The average check flight score of the combined E group (3.03), while slightly higher, did not differ significantly ($p > .05$) from that of the control groups (3.02).

The combined E group flight hours shown in table 2 show further reduction in flight hours over the findings reported in a previous TAEG study (TAEG Report No. 10) involving the P-3 aircraft and Device 2F69D. The E groups in that study required an average of 11.75 flight hours per student. It is tempting to conclude that the visual capabilities of Device 2F87F are responsible for the 3.15 flight hour savings from that achieved in the 2F69 study (11.75 - 8.6 = 3.15). Such a conclusion while realistic, cannot unequivocally be demonstrated with the data of this study. The flight dynamics, motion, other simulation features, and instructional control of Device 2F87F are superior to those of Device 2F69D. Thus the difference between the former and the present study is confounded by the superiority of the 2F87 as a surrogate for in-flight training.

PROFICIENCY BASED TRAINING HOURS

The next three tables provide data based on the proficiency grading system. Table 3 presents the cumulative proportion of check tasks on which E group trainees are judged proficient in the airplane. The experimental design used in this study called for all 20 check tasks to be performed on FLY 1. As mentioned earlier, the number actually checked ranged from 9 to 19. While no individual received all 20 check tasks on FLY 1, each task was presented to one or more students on FLY 1. Thus all check tasks were evaluated on a FLY 1. This presented the opportunity to evaluate the performance of each check task on FLY 1 as a function of whether that task had been trained to proficiency in Device 2F87F. Table 3 presents these data. A higher cumulative proportion (.76) of check tasks trained to proficiency in Device 2F87F was judged proficient on FLY 1 than those same tasks not trained to proficiency (.46). This means that training check tasks to proficiency in the device prior to in-flight training reduces the time for these tasks to be judged proficient.

By FLY 2, students had been checked on an average of 18.2 tasks. Thirteen students were never flight checked on Brake Fires and/or Four Engine Aborts. Two students required one refly; the other 25 students completed training in 4 flights.

TABLE 3. CUMULATIVE PROPORTION OF CHECK TASKS ON WHICH EXPERIMENTAL GROUP TRAINEES WERE JUDGED PROFICIENT IN THE AIRCRAFT

	FLY 1	FLY 2	FLY 3	FLY 4
Tasks trained to proficiency in Device 2F87F	.76	.87	.94	.99
Tasks practiced in Device 2F87F but not trained to proficiency	.46	.60	.75	.96
All check tasks	.73	.85	.92	.99

In interpreting the data from table 3 it must be realized that many tasks that had previously been judged proficient were given further training on FLY 2, 3, and 4. In fact, there were 365 instances where tasks were given further training after having been judged proficient. Some of these repetitions were necessary; e.g., Normal Landings and Instrument Procedures. However, some, such as Engine Failure After Refusal (EFAR), Aborts, and Loiter Shutdown, probably did not require the number of repetitions they received. The data in table 3, therefore, do not represent a pure "Train-to-Proficiency" concept.

Table 4 presents a comparison of the check task proficiency attainment by the experimental group and a control group of seven students from class 7610. The control groups from classes 7608 and 7609 were not graded on a proficiency basis; hence, data from these groups were not available for comparison. Data in this table are based on the assumption that a check task presented for the first time on FLY 1, 2, 3, or 4 and judged proficient on that flight, required only that one flight to be judged proficient. This approach does not take into account that relevant elements of a subsequent task may be learned prior to introduction of that task on a later flight.

The column labeled Average Flights to Proficiency represents the number of flights the students flew in the P-3 before being judged proficient on each task shown. It does not mean, for example, that 1.1 flights were required to become proficient in check task No. 11 (Departure). What it does mean is that, on the average, students in the E group were judged proficient on Departure in 1.1 flights. The C group was judged proficient in Departure in an average of 2.1 flights. During the 1.1 and 2.1 flights, most of the other check tasks were being trained and/or checked also.

TABLE 4. CHECK TASK PROFICIENCY ATTAINMENT

		EXPERIMENTAL GROUP CLASSES 7608, 09, 10 (N=27)		CONCURRENT GROUP CLASS 7610 (N=7)	
		Average Flights To Proficiency	Standard Deviation	Average Flights To Proficiency	Standard Deviation
Task No.	CHECK TASKS				
1	Preflight	1.4	.84	3.9	1.06
2	Use of Checklists	1.1	.27	2.6	.79
3	Engine Starts	1.0	.00	2.7	.49
4	Taxi	1.1	.42	3.4	.48
5	Instrucment Procedures	1.6	.89	3.4	2.2
6	Brake Fire	1.1	.24	1.3	.52
7	Takeoff	1.1	.32	3.6	.98
8	Abort Four Engine	1.1	.29	2.3	.49
9	Abort Three Engine	1.4	.75	1.7	.49
10	Engine Failure After Refusal	1.4	.69	2.6	.53
11	Departure	1.1	.20	2.1	1.52
12	Basic Airwork	1.6	1.01	2.9	1.68
13	Non-Precision Approach	1.3	.60	3.0	1.29
14	Precision Approach	1.4	.69	4.3	1.38
15	Landing Pattern Airwork	1.7	.92	5.0	.00
16	Normal/Approach Flap Landings	1.7	.94	5.3	.76
17	Waveoff	1.2	.40	3.0	1.29
18	Three Engine Landings	1.7	.91	2.1	.69
19	No Flap Landings	1.6	.74	2.0	.82
20	Knowledge of Procedures	1.4	.79	4.3	1.11

As shown in table 4, every check task was judged proficient for the E group in fewer flights than for the C group. Also, a comparison of the Standard Deviations (SD) of the E and C groups suggests that Device 2F87F reduces the average training time difference between "fast" and "slow" learners for the E group.

Although the E group data show that (1) Landings, (2) Landing Pattern Airwork, (3) Basic Airwork, and (4) Instrument Procedures require more flight training time than the remaining check tasks, a task-by-task comparison of the E and C groups shows the benefits of the 2F87F to be greatest for (a) Normal Landings, (b) Landing Pattern Airwork, (c) Precision Approaches, and (d) Knowledge of Procedures. This indicates that Device 2F87F is just as effective for training the more difficult tasks as it is for training knowledge and procedural tasks.

Table 5 shows the number of check tasks presented and the number of check tasks on which trainees were certified proficient. For example, on FLY 1, student number 10 was proficient in all 12 tasks presented. Student number 2 was not proficient on all tasks presented on FLY 1 but was proficient on all 20 tasks presented on FLY 2.

Although it is not certain that the 6 students (10, 13, 17, 20, 21, and 23) who were proficient on all tasks presented on FLY 1 would have been proficient in all 20 tasks, had they been presented, that possibility is plausible and is assumed to be true. The fact that these six students were proficient on all additional tasks presented on FLY 2, 3, and 4 supports this assumption. The data also support the generalization that once a student is judged proficient on a task, his subsequent performance on that task will also be judged proficient. In only 50 instances out of 1,200 gradings were students given a below average (BA) grade on a task that had previously been graded proficient. The subsequent lowering of a grade to below average after proficiency is achieved occurred less than 5 percent of the time. This finding is all the more substantial given the variability of human performance (both on the part of the student and the instructor).

It can be inferred from table 5 that six students (10, 13, 17, 20, 21, and 23) required only 2.11 flight hours each to become proficient in all check tasks (i.e., were proficient on all tasks on FLY 1). Similarly five students (2, 7, 15, 22, and 26) required 4.22 flight hours each. Three students (11, 16, and 19) required 6.33 flight hours each; 11 students (1, 3, 4, 5, 6, 8, 12, 14, 24, 25, and 27) required 8.44 flight hours each; and 2 students (9 and 18) required 10.55 flight hours each. The average number of flight hours required for all students to become proficient was 6.2.

While it can be inferred that proficiency in this study was attained in an average of 6.2 flight hours, it must be pointed out that the

TABLE 5. NUMBER OF CHECK TASKS PRESENTED AND NUMBER OF CHECK TASKS ON WHICH TRAINEES ARE CERTIFIED PROFICIENT

	FLY 1		FLY 2		FLY 3		FLY 4		FLY 5	
TRAINEE	NO. OF TASKS	PROFICIENT	NO. OF TASKS	PROFICIENT	NO. OF TASKS	PROFICIENT	NO. OF TASKS	PROFICIENT	NO. OF TASKS	PROFICIENT
1	15	14	18	17	19	17	20	20	--	--
2	19	15	20	20	20	20	20	20	--	--
3	17	12	17	13	17	16	18	18	--	--
4	12	5	20	8	20	11	20	20	--	--
5	17	12	18	17	18	17	19	18	--	--
6	17	14	18	14	18	18	19	19	--	--
7	18	14	19	19	20	20	20	20	--	--
8	17	8	19	10	20	15	20	20	--	--
9	13	8	16	8	19	8	20	17	20	20
10	12	12	18	18	19	19	19	19	--	--
11	12	3	19	12	19	19	19	19	--	--
12	13	5	19	11	19	18	19	19	--	--
13	18	18	20	20	20	20	20	20	--	--
14	16	9	18	12	18	16	19	19	--	--
15	15	14	16	16	18	18	18	18	--	--
16	14	11	18	16	18	18	18	18	--	--
17	16	16	20	20	20	20	20	20	--	--
18	17	11	20	18	20	18	20	19	20	20
19	14	11	19	18	19	19	20	20	--	--
20	15	15	20	20	20	20	20	20	--	--
21	16	16	17	17	19	19	20	20	--	--
22	12	10	20	20	20	20	20	20	--	--
23	12	12	18	18	18	18	18	18	--	--
24	14	4	19	16	19	16	20	20	--	--
25	15	6	19	17	20	19	20	19	--	--
26	11	6	14	14	16	16	18	18	--	--
27	9	6	13	7	15	12	19	19	--	--

NOTE: Each "FLY" represents 2.11 flight hours.
Only two students required five flights.

proficiency grading system used is not sufficiently precise to warrant further reductions in flight training until additional validity data are obtained.

LANDING PERFORMANCE OF EXPERIMENTAL AND CONCURRENT CONTROL GROUPS

Table 6 shows the average number of landings for the E and CC groups. The average number of landings performed to Device 2F87F is estimated because the computer printouts which provided this data were not always available. The estimate was made from those printouts available. The aircraft landings, however, are based on an actual count.

TABLE 6. AVERAGE NUMBER OF LANDINGS FOR THE EXPERIMENTAL AND CONCURRENT CONTROL GROUPS

	Device 2F87F Landings	Aircraft Landings
Experimental Group Average	28*	36
Concurrent Control Groups Average		52
Difference in Aircraft Landings Required		16

*Estimated from computer printouts

The average number of aircraft landings for the C group was 52; the average number of landings for the E group was 36. This represents a savings of 16 landings per trainee (31 percent reduction).

A comparison of the E group performance shown in table 4 with the actual number of landings shown in table 6 suggests savings greater than 31 percent. The average number of flights for the E group to reach landing proficiency was 1.7. Landing Data Sheets show that each student received approximately 10 landings per flight. The inference from this is that the average number of landings required to attain proficiency would be 17. A comparison of 52 landings for the C group with 17 landings for the E group suggests a possible savings of 35 landings per trainee or a 70 percent reduction.

The landing data sheets were also analyzed in terms of the number of errors made per landing. The data are presented in the following table.

TABLE 7. ERRORS PER LANDING

	E Group	C Group
FLY 1	2.33	2.76
FLY 2	2.11	2.48
FLY 3	1.97	2.15
FLY 4	1.58	1.90
FLY 5		1.71
FLY 6		1.68

Inspection of the data shows that the E group made fewer errors per landing on each flight than the C group, but the differences are not statistically significant ($p > .05$). It is of interest, however, that the errors per landing for the E group on FLY 4 were less than those of the C group on FLY 6.

QUESTIONNAIRES

In addition to the quantitative data, judgments were sought concerning the effectiveness of Device 2F87F. To accomplish this, two questionnaires were developed and administered to the instructor pilots. One questionnaire concerned the training adequacy of the device and the other concerned the simulation adequacy of the device. A 5-point rating scale was used: 0 = no value; 1 = little value except to introduce; 2 = good but requires further training in the aircraft; 3 = very good but requires validation in the aircraft; and 4 = totally adequate, requires no further training, only reinforcement or refresher. Table 8 summarizes the judgments of 11 instructors concerning the adequacy of the device for training FAM/INST tasks. The queries yielded an overall rating of 3.36 which falls between very good and totally adequate. On an individual task basis no task was given a mean rating of less than 2.00.

Table 9 summarizes the instructor judgments concerning the adequacy of the simulation capability of Device 2F87F. Simple yes no responses were elicited on the fidelity of key simulator capabilities. The consensus of the instructors is that the visual, the motion, and the dynamic fidelity are adequate except for ground effect and taxiing. Since the time the questionnaire was administered, the ground effect fidelity in Device 2F87 has been improved. Visual simulation of taxiing can be improved by replacing the present camera pickup unit with an improved version that is now available.

TABLE 8. SUMMARY OF INSTRUCTOR JUDGMENTS ON THE TRAINING ADEQUACY OF DEVICE 2F87F

ADEQUACY OF THE SIMULATOR TO TRAIN ITEMIZED TASKS

0 = No Value
1 = Little value except to introduce
2 = Good but requires further training in the aircraft
3 = Very good but requires validation in the aircraft
4 = Totally adequate, requires no further training, only reinforcement or refresher.

	0	1	2	3	4
01. PREFLIGHT (Cockpit only, does not include internal and external portions of aircraft not simulated)				2	9
02. USE OF CHECKLIST					11
03. ENGINE STARTS				5	6
04. START MALFUNCTION				3	8
05. TAXI		2	4	4	1
06. INSTRUMENT PROCEDURES				1	10
07. ANTI-ICE/DE-ICE				3	8
08. BRAKE FIRE			2	4	5
09. TAKEOFF			2	8	1
10. ABORT FOUR ENGINE			2	6	3
11. ABORT THREE ENGINE			3	7	1
12. EFAR			2	7	2
13. SID (Departure)				1	9
14. NTS				3	8
15. GOVERNOR INDEXING					10
16. BASIC AIRWORK				8	2

TABLE 8. SUMMARY OF INSTRUCTOR JUDGMENTS ON THE TRAINING ADEQUACY OF DEVICE 2F87F (continued)

	0	1	2	3	4
17. LOITER SHUTDOWN/RESTART				4	7
18. MECHANICAL FEATHER PROP MALFUNCTION				5	6
19. ENG SHUTDOWN PROP MALFUNCTION				2	9
20. ENGINE RESTART				5	6
21. AIR COND/PRESS OP			3	5	3
22. HYD SYS OP/MALF				5	6
23. FUEL SYS OP/MALF					11
24. NAV FLT INST MALF					11
25. ELECT SYS OP/MALF					11
26. FIRE OF UNKNOWN ORIGIN			1	2	8
27. SMOKE REMOVAL			1	5	5
28. RESTORING ELECT PWR			1		10
29. BAILOUT DRILL				7	4
30. EMERGENCY DESCENT		1		2	8
31. DITCHING DRILL			1	5	4
32. HOLDING			1	1	9
33. NON PRECISION APPROACHES (VOR, TACAN, ADF, LOCALIZER, BKCRSE, ASR)				3	8
34. PRECISION APPROACHES (ILS, GCA)				3	8
35. CIRCLING APPROACH		2	3	5	1
36. MISSED APPROACH				3	8
37. LDG PATRN AIRWORK			3	6	2
38. NORMAL LANDINGS		1	8	2	
39. CROSSWIND LANDINGS			7	4	
40. WAVEOFF			1	7	3

TABLE 8. SUMMARY OF INSTRUCTOR JUDGMENTS ON THE TRAINING ADEQUACY OF DEVICE 2F87F (continued)

	0	1	2	3	4
41. THREE ENG LANDINGS		1	6	4	
42. TWO ENG LANDINGS	1	1	5	3	1
43. NO FLAP LANDINGS		1	5	5	
44. KNOWLEDGE OF PROCEDURES			1	2	8
45. COPILOT RESPONSIBILITIES			1	1	9

TABLE 9. SUMMARY OF INSTRUCTOR JUDGMENTS ON THE SIMULATION ADEQUACY OF DEVICE 2F87F

	Yes	No
Do you consider that the visual system provides adequate visual cues for:		
1. Judgment of:		
Velocity	6	4
Altitude	7	3
Runway alignment	11	0
2. Training in asymmetrical thrust maneuvers such as loss of an outboard engine on takeoff:	9	2
3. Realistic simulation of restricted visibility and low ceiling for instrument approaches:	10	1
4. Taxiing the aircraft?	4	7
Do you consider that the motion system offers adequate simulation of the following?		
1. Yaw caused by asymmetrical thrust	10	1
2. Acceleration cues on takeoff	10	1
3. Deceleration cues on landing and reversing	9	2
4. Rough runway and rough air	9	2
5. Onset of a skid while airborne	6	5
6. Buffet prior to stall	7	3
7. Steering	8	3
Do you consider the dynamic fidelity of the simulation adequate to provide realistic simulation of the following?		
1. Ground effect	5	6
2. Directional control while steering	6	4
3. Directional control from thrust	10	0
4. Directional control while reversing	11	0

TABLE 9. SUMMARY OF INSTRUCTOR JUDGMENTS ON THE SIMULATION ADEQUACY OF DEVICE 2F87F (continued)

	Yes	No
5. Acceleration on takeoff	9	2
6. Deceleration on landing	7	3
7. Control loading (feel) in all flight regimes	8	3
Do you consider that the voice synthesizer and automated GCA provide realistic training that will transfer to the aircraft?	11	0

SUMMARY OF FINDINGS

The findings resulting from an analysis of the performance data collected during the study are summarized below:

- There were no significant differences in check flight grades for the E groups after 8.6 flight hours and the HC and CC groups after 15.1 and 14.5 hours respectively.
- Tasks trained to proficiency in Device 2F87F have a higher probability (.76) of being judged proficient on FLY 1 than those not trained to proficiency (.46).
- The E group attained proficiency in every check task in less flight time than the CC group from class 7610.
- Use of Device 2F87F reduced the average training time difference between fast and slow learners for the E group.
- Proficiency grades awarded during aircraft training were lowered to "Below Average" on subsequent trials less than 5 percent of the time.
- The E group received 16 fewer landings than the CC groups.
- Based on the proficiency grading system, the E group reached landing proficiency in 17 landings.

The results of the questionnaire responses are summarized below:

- The dynamic fidelity of Device 2F87F provides realistic simulation of directional control on ground, directional control from thrust, directional control from reversing, acceleration on takeoff, deceleration on landing, and control feel in all regimes. Instructors are divided on the realism of ground effect.
- The present visual system provides adequate cues for judgment of velocity, altitude (height), and runway alignment. The visual simulation also provides adequate cues for asymmetrical thrust maneuvers, restricted visibility, and reduced ceilings for instrument approach training.
- Visual simulation does not provide adequate cues for taxiing.

- The motion system provides adequate cues for the following: yaw caused by asymmetrical thrust, acceleration cues on take-off, deceleration cues on landing, reversing, rough air, rough landings, onset of a skid, buffet prior to stall, and ground steering.

- The voice synthesizer for automated GCA provides realistic training.

SECTION IV

ECONOMIC ANALYSIS

This section presents a comparison of the costs associated with the pre-2F87F syllabus and projected costs for training using the experimental syllabus and Device 2F87F. An estimated 10-year useful life for the device and 20 years for the aircraft were used for life-cycle costing. The comparison is based on the number of training hours required by the two training regimes and an annual throughput of two hundred pilots, the average number trained by VP 30 each year.

Table 10 shows a comparison of the student and media hours of the pre-2F87F and the experimental syllabi for the FAM/INST phase of replacement pilot training. The student hours were determined from the VP 30 syllabus sheets except for the P-3 hours which were obtained from completed grade sheets. The media hours are derived by dividing the number of student hours by the number of students being trained simultaneously. For example, in the CPT or OFT two students receive training concurrently; therefore, 1 media hour provides 2 hours of student training. In the aircraft where the instructor occupies one of the two pilot seats at all times, 1 media hour provides 1 student training hour. Therefore, aircraft media hours and student hours are identical.

TABLE 10. STUDENT AND MEDIA HOURS FOR FAM/INST PHASE OF REPLACEMENT PILOT TRAINING

MEDIA	STUDENT HOURS PER COURSE		MEDIA HOURS PER STUDENT	
	Pre-2F87F	Experimental	Pre-2F87F	Experimental
CPT	13	16	6.5	8
OFT (2F69D)	9	--	4.5	--
OFT (2F87F)	--	24	--	12
P-3	15	9	15.0	9

Table 11 provides a comparison of the annual media hours required to support the two systems (pre-2F87F and experimental). Student hours and media hours are shown for an annual throughput of 200 students.

TABLE 11. YEARLY STUDENT AND MEDIA HOURS

MEDIA	STUDENT HOURS PER YEAR		MEDIA HOURS PER YEAR	
	Pre-2F87F	Experimental	Pre-2F87F	Experimental
CPT	2600	3200	1300	1600
OFT (2F69D)	1800	--	900	--
OFT (2F87F)	--	4800	--	2400
P-3	3000	1800	3000	1800

The numbers of media required for the programs compared and the derivation of acquisition and operating costs follow:

CPT. The CPT (2C45) is available for training 12 hours per day, 5 days per week, 50 weeks per year or 3,000 hours per year. One CPT will meet the procedures training requirement for either the pre-2F87F or experimental syllabus. The stated acquisition cost is the present value of the device as stated in the Master Cross Reference List.[9] The annual operating cost for the CPT was derived as follows: $43 per hour for maintenance and support[10] plus $32 (two students at $16 per hour)[11] and instructor cost ($29 per hour),[12] all multiplied by the number of hours the device is utilized for each syllabus annually.

[9] Master Cross Reference List. Cognizance Symbol "20" Training Equipment, as of 18 August 1976. Naval Training Equipment Center (Code N-44), Orlando, FL.

[10] Personal Communication with Naval Training Equipment Center (Code N-321), Orlando, FL.

[11] Navy Military Billet Cost Data for Life Cycle Planning Purposes, NAVPERS 15163, September 1975. Chief of Naval Personnel, Washington, DC.

[12] Ibid.

2F69D. The 2F69D is available for training 12 hours per day, 5 days per week, for 50 weeks or 3,000 hours per year. One OFT is required to support the present syllabus. The estimated acquisition cost of the OFT is one-third the cost of the entire Weapon System Trainer as stated in the Master Cross Reference List.[13] The annual operating cost for the device was derived as follows: $73 per hour for maintenance and support,[14] $32 per hour (2 students),[15] $29 per hour for the instructor[16] for a total of $134 per hour. This cost ($134) multiplied by the annual requirement of 900 hours yields the operating cost.

2F87F. The 2F87F is available for training 16 hours per day, 5 days per week, 50 weeks per year for a total of 4,000 hours per year. One device will provide the training time needed to meet the requirements of the experimental syllabus. The stated acquisition cost of four units is $16.9M or approximately $4.225M per cab.[17] The annual operating cost of the device was derived as follows: $83 per hour for device maintenance and support,[18] $32 per hour for students,[19] and $29 per hour for the instructor[20] for a total of $144 per hour. This cost multiplied by an annual requirement of 2,400 hours yields the annual operating cost.

[13] Op. cit. Master Cross Reference List.

[14] Personal communication with Naval Training Equipment Center (Code N-321), Orlando, FL.

[15] Op. cit. Navy Military Manpower Billet Cost Data for Life Cycle Planning Purposes.

[16] Ibid.

[17] Op. cit. Master Cross Reference List.

[18] Personal communication with Naval Training Equipment Center (N-321), Orlando, FL.

[19] Op. cit. Navy Military Manpower Billet Data for Life-Cycle Planning Purposes.

[20] Ibid.

<u>P-3C</u>. The P-3C utilization averages 35.73 hours per month.[21] Based on the annual requirement for 3,000 flight hours in the pre-2F87F syllabus, 7 aircraft are required. The acquisition cost (flyaway cost) of each aircraft is $13.7M[22] or a total acquisition cost of $95.9M. The annual cost of operation for seven aircraft is $6.853M (7 times $979K per year).[23]

Based on an annual requirement for 1,800 flight hours in the experimental syllabus, 4.2 aircraft are required. Since these aircraft can also be used to support other VP 30 training; e.g., Tactics, the number was not rounded off to 5. The acquisition cost (flyaway cost) of each aircraft is $13.7M[24] or a total acquisition cost of $57.54M. The annual cost of operation is $4.112M (4.2 times $979K per year).[25]

Tables 12 and 13 depict the life-cycle costs for the pre-2F87F and the experimental syllabi in both discounted and nondiscounted dollars.

To make a rational economic decision which is theoretically sound and consistent with Department of Defense (DOD) Instruction 7041.3, discounted dollar costs must form the basis for the decision. The DOD currently has a 10 percent discount rate established by DOD Instruction 7041.3 to be used for all economic analyses of proposed defense investments.[26] Discounted dollars are time-phased and discounted at a rate of 10 percent per annum. The present costs shown in tables 12 and 13 represent such discounting.

[21] <u>Navy Program Factor Manual</u>, Volume I, OPNAV-90P-02 (Revised 1 July 1976).

[22] Personel communication with Naval Air Systems Command (PMA240), Washington, DC.

[23] Op. cit. <u>Navy Program Factors Manual</u>.

[24] Personal communication with Naval Air Systems Command (PMA240), Washington, DC.

[25] Op. cit. <u>Navy Program Factors Manual</u>.

[26] <u>DOD Economics Handbook</u>, Second Edition, (undated) Defense Economic Analysis Council, OASD(C) SP&I, Washington, DC.

By summarizing the annual discounted values for each alternative, the present cost (life cycle) of the alternative is determined. Under ceteris paribus conditions, it is most economical to choose the alternative which has the lowest present cost. For alternative one, the pre-2F87F syllabus, the present costs were found to be $125.099 million and for alternative two, the experimental 2F87F syllabus, present costs were $81.314 million. The discounted dollar comparison of the two systems for a 10-year period reveals that in present-day dollars the experimental system will require $44 million less investment to achieve the same training benefit received from the pre-2F87 program. Therefore, the experimental syllabus is the most economically efficient alternative.

TABLE 12. LIFE CYCLE COSTS FOR A 10-YEAR PRE-2F87F VP 30 FAM/INST SYLLABUS (THOUSANDS OF DOLLARS)

	CPT(2C45)	OFT(2F69D)	P-3C	NON-DISCOUNTED	DISCOUNTED
Number of Media Required	1	1	7	-	-
Present Value	1,390	1,396	95,900	98,686	98,686
Annual Operation Cost					
Year 1	135	121	6,853	7,109	6,782
2	135	121	6,853	7,109	6,164
3	135	121	6,853	7,109	5,602
4	135	121	6,853	7,109	5,097
5	135	121	6,853	7,109	4,635
6	135	121	6,853	7,109	4,209
7	135	121	6,853	7,109	3,825
8	135	121	6,853	7,109	3,476
9	135	121	6,853	7,109	3,164
10	135	121	6,853	7,109	2,879
NON-DISCOUNTED COST				169,776	
REMAINING P-3C VALUE AT YEAR 10				47,950	
TOTAL NON-DISCOUNTED COST (LIFE CYCLE) OF PRE-2F87F SYLLABUS				121,826	
DISCOUNTED COST				144,519	
DISCOUNTED P-3C VALUE AT YEAR 10				19,420	
PRESENT COST (LIFE CYCLE) OF PRE-2F87F SYLLABUS				125,099	

TABLE 13. LIFE CYCLE COSTS FOR A 10-YEAR 2F87F EXPERIMENTAL FAM/INST SYLLABUS (THOUSANDS OF DOLLARS)

	CPT(2C45)	OFT(2F87F)	P-3C	NON-DISCOUNTED	DISCOUNTED
Number of Media Required	1	1	4.2	-	-
Present Value	1,390	4,225	57,540	63,155	63,155
Annual Operation Cost					
Year 1	166	346	4,112	4,624	4,411
2	166	346	4,112	4,624	4,009
3	166	346	4,112	4,624	3,644
4	166	346	4,112	4,624	3,315
5	166	346	4,112	4,624	3,015
6	166	346	4,112	4,624	2,737
7	166	346	4,112	4,624	2,488
8	166	346	4,112	4,624	2,261
9	166	346	4,112	4,624	2,058
10	166	346	4,112	4,624	1,873
NON-DISCOUNTED COST			109,395		
REMAINING P-3C VALUE AT YEAR 10			28,770		
TOTAL NON-DISCOUNTED COST (LIFE CYCLE) OF 2F87F EXPERIMENTAL SYLLABUS			80,625		
DISCOUNTED COST			92,966		
DISCOUNTED P-3C VALUE AT YEAR 10			11,652		
PRESENT COST (LIFE CYCLE) OF 2F87F EXPERIMENTAL SYLLABUS			81,314		

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

This section presents specific conclusions and recommendations based on student performance data and on instructor responses to questionnaires.

SPECIFIC CONCLUSIONS AND RECOMMENDATIONS

The results of student performance in this study support the following.

CONCLUSION	RECOMMENDATION
The combination of six simulator and four aircraft flights will maintain current standards and achieve a $40 million savings over a 10-year period.	Continue the combination of six simulator and four aircraft flights until additional data are collected and assessed. Track experimental subjects after leaving VP-30 to determine their subsequent performance and the number of flight hours and months required for designation as Patrol Plane Commander.
Flight time can be reduced by training each task to proficiency in Device 2F87F prior to that task being checked or trained in the aircraft.	Train all tasks to proficiency in the simulator prior to their training in the aircraft. This concept should be adhered to whether simulator training is conducted in a block or interspersed with flight training. It is also recommended that a group be trained to more rigid proficiency standards in Device 2F87F to determine the subsequent effect on performance in the aircraft.
It is possible that overall training time in both the simulator and the aircraft can be reduced by conducting training based on proficiency attainment.	Conduct further experiments to validate the train-to-proficiency concept; i.e., training terminated after proficiency attained.
Six simulator periods may be inadequate for some students or the instructional strategy used by some instructors may be inadequate.	Standardize the instructional strategy and conduct additional study to determine the optimum number of simulator periods.

Landing practice in the simulator transfers to the aircraft.	Continue simulator experiments to determine the optimum number of landing trials required for proficiency.
Software and hardware changes are required to permit more effective utilization of the performance measurement capability of the device.	Perform an engineering evaluation to determine the hardware/software modifications required to output data for automatic scoring and debriefing feedback to students.

The following is based on instructor responses to the questionnaires.

CONCLUSION	RECOMMENDATION
Dynamic fidelity realistically simulates the aircraft.	Implement a rigorous program to insure that the quality of simulation is maintained.
The narrow angle visual system appears to meet the requirements of multiengine training. Instructor acceptance of simulators increased with the addition of a visual capability. The precise contribution of the visual system cannot be determined without a study of students trained without the use of the visual system.	Conduct a study in which the performance of students who have been trained with the visual "on" are compared to performance of students who are trained with the visual "off."
The quality of the ground visual scene does not provide adequate cues for training the taxi task. (The taxi visual presentation on the Braniff Airlines 727 simulator, a Redifon Duoview system, appeared to be significantly superior to that of Device 2F87F.)	Perform an engineering evaluation of the on-ground visual simulation to determine the requirements for improvement.
The acceptance of the motion simulation by instructors indicates the face validity of this system.	Conduct a study in which the performance of students who have been trained with the motion "on" is compared to performance of students who are trained with the motion "off."

The voice synthesizer provides standardized training in GCA procedures, terminology, and approaches. The voice synthesizer can be expanded to provide additional automated training.

Determine other areas of training that could utilize the voice synthesizer.

POST NOTE

In addition to the conclusions and recommendations articulated above, various perceptions and insights were obtained during the conduct of the study and from the outcomes of the performances. A discussion of these follows.

DEVICE UTILIZATION. Two capabilities of Device 2F87F are not currently being utilized.

The night visual capability was a stated requirement in the original request submitted by the training squadrons. It was procured at considerable expense and does provide realistic night simulation of both Visual Flight Rules (VFR) and Instrument Flight Rules (IFR) conditions. The current VP 30 FAM/INST syllabus does not include any night training; the first student exposure to night operation of the P-3 is on the Day/Night bounce flight at the conclusion of the succeeding tactics ground school phase. We strongly urge that the night visual capability be utilized either in the FAM/INST syllabus or as a prelude to the Day/Night bounce flight in the Tactics phase.

The performance measurement capability of Device 2F87F is not utilized except for hardcopy printouts of landings. The prime reason for nonutilization of this training feature is the lack of data output in a format suitable for the instructor to make diagnostic assessment of student performance. Further, no provision is made to store student performance data to build a normative data base for automatic scoring. These limitations are imposed by constraints in software and in hardware. It is essential that the design deficiencies be identified with appropriate solutions in order to realize the full potential of automatic performance measurement and scoring, diagnostic evaluation, and automated instruction. The realization of full performance measurement capability will require development of performance standards, scenarios, and data translation.

INSTRUCTOR TRAINING. VP 30 has a comprehensive Instructor Under Training (IUT) syllabus to prepare new instructors for duty as an aircraft flight instructor. A program comparable to the IUT syllabus to prepare new personnel as simulator instructors should be developed. Device 2F87F has made possible more realistic training of various maneuvers and emergency situations. The improved instructional control has expanded the range of training and provides the capability to concentrate more training events in each hour of instruction. To use this capability effectively requires instruction beyond the simple operation of the device. Instructors should be provided training in instructional strategy and in the theory of instruction in order to enhance and standardize the training program.

TRAINING OF HIGH-RISK MANEUVERS AND EMERGENCIES. In the past, considerable emphasis has been placed on training emergencies and high-risk maneuvers in the P-3 aircraft. Observation of the Air Force's heavy multiengine programs and airline training indicates that most high-risk maneuvers and emergency training have been assigned to the simulator. Device 2F87F offers an opportunity to explore the feasibility of training the high-risk maneuvers in the simulator, thereby reducing the safety risks associated with this training in the aircraft.

Analysis of P-3 aircraft mishap data from the Naval Safety Center indicates that likely candidates for simulator training are TWO ENGINE LANDINGS and NO-FLAP LANDINGS. Based on data over a 4-year period there are few actual occurrences, but there is heavy emphasis on training these maneuvers. For example, in the case of NO-FLAP LANDINGS only 12 actual cases occurred in the 4-year period while extensive air training time is devoted to practicing this maneuver. All high-risk maneuvers should be analyzed to determine the frequency, the number of mishaps durining practice, and the feasibility of training in the simulator. Initially these maneuvers could be trained in the simulator and checked and/or validated in the aircraft. If the maneuvers can be performed satisfactorily in the aircraft after simulator training, they should be considered for simulator-only training.

TRAIN-TO-PROFICIENCY CONCEPT. The ultimate reduction in aircraft training time may be achieved only through proficiency-based training. While the concept of "proficiency" training is easily articulated, the implementation of this approach is not. At VP 30 the entire curriculum would have to be restructured. This would be no small undertaking since many different training tracks (e.g., TACCO, flight engineer, SENSO, etc.) would have to be coordinated. The present programs are structured so that students are scheduled for phase completion at times appropriate to forming teams for further training. Although conversion to a train-to-proficiency concept presents a number of formidable problems, it has merit and therefore warrants consideration.

INSTRUCTOR CURRENCY. As student flight hours are reduced, it is obvious that instructors will be deprived of flight time. To maintain currency, additional flight time for instructors should be scheduled. This, of course, will offset some of the savings in student flight training time. One option is to provide a refresher program in the simulator.

EXPERIMENTAL SIMULATOR SYLLABUS. The experimental syllabus used in this study was developed by the squadron instructors based on the traditional FAM/INST syllabus and predicted device capabilities. The academic, CFT, and CPT training remained constant. Since the traditional syllabus was based on previous task and training analysis studies (TAEG Reports No. 7 and 10), the syllabus was in consonance with accepted modern training methodology.

There were, however, some modifications made to the syllabus at the completion of the simulator training for the first E group. These modifications were made to eliminate training for procedural tasks that could be more cost-effectively trained in a part-task trainer. These modifications made more time available which was used for training those tasks requiring the full simulator capabilities of Device 2F87F. Experimental groups two and three had the advantage of this additional time.

UNANSWERED ISSUES

Although this study provided valuable information about the use of Device 2F87F for training, a number of issues concerning the amount of substitution that may be obtained under different conditions remain unanswered. The specific issues are outlined below. As indicated in section I of this report, they will be addressed in later phases of this study program.

- Determine the effect of increasing the number of simulator periods

- Assess the effect of an integrated simulator/flight syllabus compared to the block syllabus used in this study

- Continue to investigate the train-to-proficiency concept and seek to increase the precision in measurement of proficiency. Determine the feasibility of implementing a train-to-proficiency concept for the familiarization/instrument phase of pilot training at VP 30.

- Evaluate the effect of loss of motion simulation on student performance and possible physiological discomfort. Several instances of physiological discomfort have been reported with visual on and motion off. Similar phenomena, described as a form of vertigo, were reported for earlier devices with visual simulation and no motion simulation.[27]

[27] Miller, J. W. and Goodson, J. E. A Note Concerning Motion Sickness in the 2-FH-2 Hover Trainer. 1958. U.S. Naval School of Aviation Medicine, U.S. Naval Aviation Medical Center, Pensacola, FL.

- Determine meaningful substitution ratios through comparison of a simulator trained group with an aircraft-only trained group

- Assess the effect of loss of visual simulation on trainer sbustitution values.

Viable approaches to examining these issues have already been identified in coordination with VP 30, and the squadron has agreed that this work should be undertaken.

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