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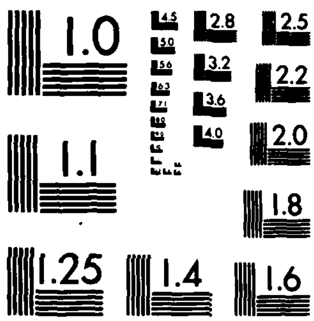
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TECHNICAL REPORT: NAVTRAEQUIPCEN IH-352

COST EFFECTIVENESS OF SIMULATION FOR LOW LEVEL FLIGHT TRAINING

Advanced Simulation Concepts Laboratory
Naval Training Equipment Center
Orlando, Flordia 32813

FINAL REPORT MAY 1983

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NAVTRAEQUIPCEN is conducting research and development aimed at advancing the state-of-the-art for flight simulators. This R&D is in the areas of data base sub-systems, image generation and delivery sub-systems, and display sub-systems. Flight simulatiors can be used to provide benefits in two ways: (a) reduce flying hours, with equal effectiveness in flight performance and (b) increase effectiveness of flight performance without increasing cost. In

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) order for the services to make reasonable training trade-off decisions, difficult quantification of decreased costs or increased benefits must be attempted. This quantification is even more difficult when developments in the R&D area are considered. This report represents an attempt to quantify the cost effectiveness of simulation for low-level flight training, taking into account developments that are occuring in the R&D area.

This report present the results of an analysis of the cost effectiveness of visual simulation of low level, high speed flight when such simulation is used as an aid to attaining and maintaining proficiency in low level navigation and air-to-surface weapons delivery. It is based upon the assumption that recent advances in the technology supporting the use of computer generated imagery will provide the capability to produce visual scenes with sufficient cues and realism to effectively train pilots in low level visual operations.

In this effort, estimates of research and development, fabrication, and life-cycle simulator costs were provided by the Naval Training Equipment Center (NTEC). Aircraft operating and accident costs were obtained from Navy records.

However, an extensive review of the literature and discussions with Navy, Air Force, and NASA researchers revealed that there have been no definitive studies which could be used as a basis for estimating TERs for a low level simulator. Therefore, a questionaire was developed and administered to experienced naval aviators. By this method, judgments were obtained on the percent of training that could be accomplished in a simulator and on the amount of simulator time that would be required to replace a 10 percent cut in flying time. This data was used in an equation to provide estimates of TERs.

When a weapons system is augmented with simulators, there are some systems costs that cannot be eliminated or reduced. Because the United States must be prepared to conduct military operations, the cost of maintaining weapons system in a state of readiness cannot be reduced by the use of simulators. These costs include the expenses associated with maintaining bases, runways, and personnel. When simulators or other training devices are used to replace actual flying time in a phase (such as low level training), the savings that may be realized include operations. Only these savings were included in this analysis.

The results of these analyses demonstrate that development of low level visual simulators would provide cost effective training.

COST EFFECTIVENESS OF SIMULATION FOR LOW LEVEL FLIGHT TRAINING

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PREFACE

This report documents a procedure for obtaining subjective data on the training effectiveness of a simulator concept in a form that is suitable for use in projective cost analyses. In the absence of data on actual training effectiveness ratios obtained from objective measures with existing simulators, estimates by subject matter experts provide an alternative to using a canonical "0.50," or upper or lower bounds which may fail to differentiate among alternatives. It should be noted that this approach first provided information which was used to select the most promising alternative from a field of six candidate aircraft systems. This would not have been possible with the canonical or upper/lower bounds approach. Such a simplistic approach would not be in accord with actual data which demonstrates that TERs vary from 0 to nearly 3.

This report is restricted to an analysis of the probable cost effectiveness of a particular simulator design that is intended for use in training for visual low level flight operations. While it is noted that the pilots who provided the data stated that a reduction in total flying time was not, in their opinion, a satisfactory alternative, the decision on how to use the flight hours saved through simulation is not a part of this study.

There are several assumptions which had they been made differently may have changed the conclusions that were reached. The reader should be aware of these assumptions. First, the costs of aircraft operation were limited to data provided by the Navy. Base maintenance supply, depot maintenance, and replenishment spares were not specifically included for the A-7. Such an approach may be justified in part by the requirement to maintain combat aircraft even if there were no flight training hours. If these costs were included, the amortization period for a simulator would be reduced. This would improve the already favorable analysis in favor of procuring a simulator.

The decision to include accident costs was introduced to account for what is perceived to be a very real cost of low level flight training. The question as to whether to use initial fly away costs or current replacement costs was not consciously addressed. Available data were used. The resulting difference is minor and quantitative rather than qualitative. The position of the author is that, sooner or later, lost aircraft and crews must be replaced; and this replacement is a cost that must be considered.

The authors acknowledge the interest and support of Ms. D. M. Baldwin and Mr. E. Maldonato of NTEC who were instrumental in initiating and supporting this effort. Equally important were the consideration and comments made by the naval aviators. Their thoughtful judgments provided the material upon which this analysis is based.

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INTRODUCTION

1.1 EXECUTIVE SUMMARY

This report presents the results of an analysis of the cost effectiveness of visual simulation of low level, high speed flight when such simulation is used as an aid to attaining and maintaining proficiency in low level navigation and air-to-surface weapons delivery. It is based upon the assumption that recent advances in the technology supporting the use of computer generated imagery will provide the capability to produce visual scenes with sufficient cues and realism to effectively train pilots in low level visual operations (Graf and Baldwin, 1982). After a review of training requirements and mission characteristics of seven navy jet aircraft with low level and/or air-to-ground capability, it was concluded that maximum benefits could be achieved by providing a low level visual simulation system for the A-7. Factors which contributed to selection of the A-7 include its primary mission of low level attack, the high cost of accidents associated with low level and air-to-surface operations, the number of operational squadrons, and estimates of the transfer of training effectiveness obtained from experienced naval aviators at both east and west coast installations. For some weapons systems, such as the A-6 and S-3, the low operational costs and lack of visual low level missions reduced the cost benefit ratio and the utility of a visual low level simulator. For other systems, such as the F/A-18 and the AV-8A, limited operational experience and limited number of squadrons combined to preclude effective analyses. It well may be that a low level visual simulator, developed and fabricated for the A-7, could be used for these aircraft as operational experience reveals a need. While the A-4 was considered as a candidate for a low level visual simulator, its low costs and age provided valid reasons for rejecting it in favor of the A-7. Nevertheless, the rather high accident rates during air-to-surface weapons delivery training should not be disregarded in future decisions for procurement of a follow-on system.

Cost information serves as the data base for computation of Transfer Effectiveness Ratios (TERs). In this effort, estimates of research and development, fabrication, and life-cycle simulator costs were provided by the

Naval Training Equipment Center (NTEC). Aircraft operating and accident costs were obtained from Navy records. However, an extensive review of the literature and discussions with Navy, Air Force, and NASA researchers revealed that there have been no definitive studies which could be used as a basis for estimating TERs for a low level simulator. Therefore, a questionnaire was developed and administered to experienced naval aviators. By this method, judgments were obtained on the percent of training that could be accomplished in a simulator and on the amount of simulator time that would be required to replace a 10 percent cut in flying time. This data was used in an equation developed by Bickley (1980) to provide estimates of TERs.

When a weapons system is augmented with simulators, there are some systems costs that cannot be eliminated or reduced. Because the United States must be prepared to conduct military operations, the cost of maintaining weapons systems in a state of readiness cannot be reduced by the use of simulators. These costs include the expenses associated with maintaining bases, runways, and personnel. When simulators or other training devices are used to replace actual flying time in a phase (such as low level training), the savings that may be realized include reduced fuel costs and reduced losses from accidents associated with low level operations. Only these savings were included in this analysis. There are additional savings that may be realized in simulating air-to-surface operations. Since analysis of weapons delivery activities was not originally a part of this effort, no data was obtained on the cost of weaponry used in training and in maintaining proficiency. Had these costs been included in the calculations, the cost benefit ratios would be more favorable and the amortization period for the low level visual simulators would be shorter.

Analyses of the data for A-7 low level training revealed that 52.6 minutes of simulator operation would be required to replace 30 minutes of low level visual navigation in the aircraft, and that to get 30 minutes of low level training in the aircraft an additional 30 minutes of ingress/egress flying is required. In effect, an hour of flight time may be replaced with 52.6 minutes of simulator practice in low level visual navigation, as long as no more than 10 percent of low level navigation flight time is replaced. Four simulators would be needed for this training (two on each coast). Their cost of $75 million would be amortized in 6.37 years. Based on existing simulator utilization data, each of the simulators would be available for other training approximately 1080 hours per year.

If the 4 simulators were used to provide training in air-to-surface weapons delivery, replacing 10 percent of the hours currently spent on the weapons range, a nominal 2-hour range sortie with 30 minutes on the range would be replaced by 85 minutes of simulator time, all of which would be spent in weapons delivery practice. The simulator could provide moving tactical targets and immediate feedback on errors and accuracy. Even when the savings achieved by the use of an inexhaustible supply of simulated weapons are not counted, simulator costs would be amortized in 5.9 years. Yearly, 1600 hours of training time would be available on each simulator for other purposes.

Because using four low level visual simulators for navigation or range time results in extra hours of simulator availability, it was hypothesized that they could be used for both navigation and weapons delivery training. By replacing 5 percent of navigation and 10 percent of range time with simulator time, the simulators would be fully utilized. The combined yearly cost benefits would be nearly $19 million and the cost of the devices could be amortized in 4 years. It should be emphasized that this analysis does not contain any recommendations to reduce total flying time. All of the pilots who were interviewed were adamant on this point: flying hours have already been cut to a point where combat proficiency may be adversely affected. A study which is based upon the value judgments of naval aviators cannot be expected to arrive at conclusions unsupported by these subject matter experts. The recommendation resulting from this analysis is to reallocate flying hours from low level navigation and air-to-surface attack; and to use the flying hours saved in this phase to improve training and proficiency in other phases such as instrument flying or air combat maneuvering where the vestibular cues and g-forces that occur in flight are vital in achieving proficiency and cannot be duplicated in a simulator.

The results of these analyses demonstrate that development of low level visual simulators would provide cost effective training. The benefits of simulation as calculated in this report are conservative. They do not account for savings in the cost of weapons. They do not include adjustments for increases in the cost of fuel which are almost certain as world reserves are depleted. They are based upon an assumption of equal pilot proficiency as a result of the simulation. Because an effective low level visual simulator will permit aviators to practice flying lower than they are allowed to during actual peacetime training flights, these simulators should produce superior aviators for wartime missions.

While visiting the Air Force Human Resources Laboratory at Williams AFB, an experiment was observed which used an F-111 visual system with a T-38 cockpit. The purpose of this experiment was to determine the visual cues necessary to permit low level flight training in a simulator. Two recommendations result from this visit. The first is that the development of a modular simulation system be evaluated. By developing the visual system as a separate module, it could be used with a variety of cockpits. Development costs would be lower and the useful life of the visual module could be extended by using it with newer aircraft. Once a visual module has been developed, it could be evaluated for use with other weapons systems. The second recommendation is to establish values for minimum visual cues so that software development costs may be set at reasonable values.

A final recommendation for development of a visual low level simulator is to conduct a training requirements analysis for the A-7 weapons system. This requires the gathering of data on existing A-7 simulators, as well as information on training courses and proficiency requirements, weapons costs, scoring requirements, tactics, and accident reports. An analysis of this data should be directed at development of hardware and software specifications that will ensure that the final product answers the specific needs of simulation for low level flight training.

1.2 OVERVIEW

The yearly cost benefits accruing from the use of a simulator may be calculated as the reduction in actual low level flying costs, less the operating costs of the simulator. When these cost benefits are positive, they may be used to amortize the research and development and procurement costs of the simulator. Because of the useful life of a simulator is usually limited to 10 years, it is not unreasonable to require that initial costs for a new simulator be amortized within 10 years.

To calculate the reduction in low level flying costs, the number of flying hours reallocated to other phases of training must be multiplied by the cost per hour. The number of flying hours reallocated is quite arbitrary down to some absolute minimum; however, the number of hours reallocated will have an effect on the efficiency of simulator training. As more flying hours are reallocated, the number of simulator hours required tends to increase exponentially (Bickley, 1980). While it is possible to calculate costs per hour based upon all costs of ownership of the aircraft weapons system, such calculations are unrealistic because even if all flying were replaced by simulation, we would still have to underwrite costs of ownership of the complete weapons system and personnel to operate it in case of war. Therefore, for the purposes of this study, the cost per hour for operating aircraft consists mostly of the cost of fuel expended. While the costs of munitions used for training should be included in operating costs, this study was not originally intended to address the use of a low level visual simulator for weapons delivery training and no such weapons cost data was obtained. That consideration of such costs would have a beneficial effect on training costs may be seen from a comparison of the cost of firing a practice missile (in thousands of dollars) with the recurring simulation costs amounting to a fraction of the missile cost. It was postulated that accident costs occur as the result of exposure to hazardous conditions (such as low level flying), and therefore they will be reduced when low level flying hours are reduced. Accident cost savings were included in the reduced flying costs. Accident costs reduction was computed as a percent of total low level accident costs, with the percent being the percent reduction in actual low level flying.

It must be noted that, while this analysis postulates a reduction of some magnitude in low level flying hours, there is no intent to reduce the total number of flying hours. It is assumed that hours saved in an improved low level training program will be reallocated to another phase of training.

Operating costs for a hypothetical low level visual simulator were provided by NTEC. To determine the number of simulator hours required it is necessary to divide the number of flying hours replaced by the Transfer Effectiveness Ratio (TER). The TER is a variable, dependent upon the nature of the task being trained, the quality of the simulation and the number of flying hours replaced. A true TER is determined after a simulator has been built, using between-subject measures of trainees who use and trainees who do not use the simulator. There is no data on TERs for low level visual training. The Air Force has a C-130 low level visual simulator at Little Rock AFB, but no data on actual TERs has been generated. An F-111 low level visual simulator was found to be inadequate after the system was developed and efforts are underway at Williams AFB to improve on the display. The new B-52 WST at Castle AFB has been found to provide inadequate visual cues for low level navigation except in areas of dense features such as air base complexes. Since there is no data on low level visual TERs in the literature, and no information expected from existing visual simulators, a decision was made to gather estimates of TERs from subject matter experts.

In order to obtain the necessary TER judgments from naval aviators, a questionnaire was developed. It was administered to experienced aviators who flew the A-7, A-6, A-4, AV-8, S-3, and F/A-18. Judgments made by these subject matter experts were analyzed and transformed into equivalent TERs and the relation between flight hours and simulator hours. As the experimenters became familiar with missions, training requirements, costs, accident statistics, and the magnitude of the various programs, all but the A-7 data was removed from consideration. The rationale for this action was that a visual low level simulator needs to be developed only once, and that its development should be accomplished for the most cost effective program. Once the visual low level simulation system is developed, it may certainly be used for other weapons systems.

Early in the study it became apparent that there are actually two tasks involved in low level navigation that could be taught in a part task trainer. The first involves piloting and aircraft control in order to operate safely and effectively at low altitude. This task involves psychomotor skills, spatial orientation, and rate judgments. A trainer for this task must have realistic dynamic flight control responses, an extremely wide field of view, texture streaming, and both depth and speed cues. It need not represent any particular location, but should provide practice over desert, mountains, water, fields, and hilly terrain. The second low level task that is amenable to simulation is realistic navigation. A trainer for this task need not provide any realistic aircraft flight controls. Terrain clearance could be selected and maintained while heading could be controlled by a rate joystick. This device should be capable of duplicating geographic, cultural, and natural features of actual locations. It would be used to train aircrews on recognition of surface features, course adjustments, off course corrections, and precise airspeed control. While the first (aircraft control) trainer would have a primary utility in initial training and replacement training, the second device would be more useful to operational pilots who are fully combat ready. The data and questionnaires in this study are based upon the aircraft control simulator. Observations on the utility of a simple navigation simulator with real world data are included.

Although the scope of this study did not initially include evaluation of a simulator for air-to-ground weapons delivery, it became obvious that the capability to generate a wide field of view with realistic visual imagery, complete with depth cues, was sufficient to permit ground attack maneuvering, target identification, and target attack. In particular, the ability to create moving military targets, as well as conventional range targets, provides a training capability that is not present in the aircraft itself. Where feasible, the cost effectiveness statistics have been computed for a simulator with low level visual imagery that is used to provide training in ground attack as well as navigation.

In gathering data from Naval and Marine aviators, a simulator was described which included a realistic cockpit and a detailed visual scene. Photographs and a video tape of proposed image quality (as described in Graf and Baldwin, 1982) were shown to over one half of the crewmembers who completed the questionnaires. Because there was no actual simulation available, the crewmembers were asked to envision a very high quality training device. Reference was made to night carrier landing trainers (NCLTs) and existing VITAL simulators in providing a concept of what a low level visual trainer might be like. In responding to the questionnaires, the crewmembers concept could be described as "like a daytime NCLT."

Crewmembers were not told exactly how such a device could be built. Helmet-mounted approaches were suggested and wraparound dome projections were discussed. The pilots were assured that the proposed simulator would provide depth cues in sufficient detail to enable visual terrain avoidance. Recent developments in computer generated imagery (CGI) and computer generated synthesized imagery (CGSI) were discussed as possible means to produce imagery of sufficient quality to permit useful training.

There are two distinct cost benefits that may accrue through the use of effective simulation. First, there is the savings in aircraft operating costs, especially in petroleum, oil, and lubricants (POL). Because of the lower costs of simulator operation, there is a positive benefit for substituting simulator hours (in a quantity adjusted for the effectiveness of training) for aircraft hours. The cost difference may be used to "amortize" the initial capital investment in development and procurement (Orlansky and String, 1977). It should be noted that the current uses of the cost benefit calculations are predicated upon the thesis that total flying hours will be reduced to make up for the costs of simulation. There is, however, a reluctance among aircrews to reduce total flying hours. Current allocations are already so low that aircrew combat readiness is threatened.

The second benefit comes from decreased accidents during low level operations. There are two reasons for fewer accidents. The first is due to reduced exposure: even if the accident rate was not reduced, there would be a reduction in accidents due to less exposure to the hazards of low level flight. Low level flight is hazardous, due to the lack of time to correct for errors or malfunctions and the hazards are increased during the maneuvering for ground attack. The second reason for decreased accidents involves use of the simulator to train inexperienced pilots until their proficiency increases to a point where they can perform the required tasks safely. This report presents a cost benefit analysis which includes adjustments for the costs of accidents. Costs are computed using FY82 dollars except where otherwise indicated.

Because official data on transfer effectiveness are not available, visits were made to Naval and Marine Corps Air Stations on both the east and west coasts to obtain subjective estimates of key parameters. At these stations, simulator facilities were visited in order to gain appreciation of the perspective of the crewmembers serving as subject matter experts. In addition, researchers visited Air Force and NASA facilities to determine the status of other attempts to train crewmembers in low level navigation using simulation. The results of these visits are reviewed in Section 2 of this report, as well as a review of current and proposed image generation techniques.

Navy and Air Force accident statistics for various military aircraft are also presented in Section 2. Cost determinants for the A-7 are presented in Section 3. These include aircraft costs, simulator costs, calculation of Transfer Effectiveness Ratios and accident costs. The algorithms used in calculating the cost effectiveness of a low level simulator, and the results of using these algorithms with A-7 data are also presented in Section 3. Recommendations and observations are presented in Section 4. Data from the questionnaires and key field conference points of contact are contained in the appendices.

1.3 REVIEW OF METHODOLOGY

Orlansky and String have written a number of articles on military system cost effectiveness. It is this work which provides the basis for the determination of the cost effectiveness of low level flight. However, significant differences do exist between these methods and those used in this report. Before discussing these differences, it is important to present a brief overview of some of the recent work published by Orlansky and String.

In "The Cost Effectiveness of Flight Simulators for Military Training," Orlansky and String (1977) detail their methodology for life cycle cost analyses. Several points are made. Orlansky relates that studies have determined that simulators are most effective when used for training precise, by-the-book procedures. This realm encompasses emergency procedures and the like. High speed low altitude flight also is a regime requiring extremely precise manipulation and cognitive task repertories.

A second point associated with training any task is the instructional system itself. If an antiquated or inadequate training program is supplied with a high fidelity, state-of-the-art flight simulator, it would probably be safe to assume the course would still be antiquated and inadequate, albeit technologically superior to the course without the simulator. This is merely to say that cost effective simulators depend on effective training and instructional methods, designed rationally and completely.

Orlansky points out that the majority of simulator R&D is currently aimed at the undergraduate pilot programs. However, he asserts that flight costs in those programs are only 10 percent of the total; the real payoff comes when transition and support training are considered. These two areas comprise a full 90 percent of flight cost. A reduction in flight time (and hence costs) in these phases could create substantial savings while still maintaining proficiency.

Orlansky consistently maintains these assumptions and points throughout his other recent cost effectiveness analyses; these include evaluations of computer assisted and computer managed instruction, as well as maintenance trainer cost effectiveness.

In Orlansky and String's evaluation of flight simulators (1977), they provide a list of the costs which are included in a life cycle cost analysis (LCCA). For the simulator, these include procurement costs, discount rates, the amortization rate, student load and simulator availability, and finally the personnel necessary to man the simulator. These data permit the utilization cost per hour to be calculated. They do not mention maintenance costs or parts. It appears that several reasons exist for this omission; primarily, there is a lack of such data due to different maintenance operations (some simulators are maintained by military personnel, others by contractors). The differences in internal accounting between the maintenance units precludes valid and standardized data collection.

The real differences between the Orlansky cost algorithms and those used in this report lie in the determination of aircraft costs. Orlansky uses only POL, maintenance, spare parts, and base support costs in his algorithms. In this report, the algorithms are expanded to include aircraft replacement/repair costs, personnel related costs (including medical expenses, payments to dependents, crew replacement costs), and property damage resulting from aircraft accidents.

The rationale behind such an algorithm expansion can be supported because a simulator for low level flight is very situation-specific. The total number of aircraft losses per year is quite small in comparison to the total flight time of the armed forces. However, in the various tactical and strategic scenarios currently envisioned, low level flight plays a pivotal role. If a reduction in mishaps and an increase in proficiency can be realized, the expenditure of funds for such a simulator could be justified. Orlansky's algorithms are not used for situation-specific simulators; their objectives range from cockpit familiarization to weapons systems use, take-offs and landings to emergency procedures.

The algorithms used by Orlansky and String have been neither discarded nor downplayed; they in fact provide the basis for the expansion of the algorithms used herein.

SECTION 2
SUPPORT MATERIAL REVIEW

2.1 DATA SOURCES OVERVIEW

Even a cursory examination of the simulators currently in use at various operational and training centers yields a long list of system components, visual systems, and fidelity levels. It should be noted that few if any operational simulators are equipped with visual systems adequate for low level flight. However, some approaches, such as the Computer Generated Synthesized Imagery (CGSI) technique currently being investigated under the auspices of NTEC (Graf and Baldwin, 1982), could prove to be a breakthrough in fidelity levels when perfected.

Intuitively, the most effective method of simulating low level flight, and therefore training low level flight, is to provide the student with all of the kinesthetic, visual, aural, and cognitive inputs normally received during flight. This is not possible for one simple reason: the simulator is not actually flying. Duplication of the myriad physiological and psychological cues would require an exact duplication of the actual aircraft flight path and external environment. Thus, the starting point (of training low level flight in a simulator) is already less than optimum.

This state of affairs defines the next limiting factor in simulator usage, i.e., because they are less than optimum, they can only augment flight hours. Simulators can never totally replace actual training flights because they are not training flights.

With these and other parameters in mind, simulator designers have arrived at a variety of purported solutions to the tradeoffs between technological feasibility, effectiveness as a training device, and cost. Most of the flight simulators currently in use are combinations of the following systems:

Motion: The necessity of motion to provide kinesthetic cues to the student is currently disputed. Thus, some simulators are floor-mounted with no movement capability at all, while others are constructed on exotic six-degree-of-freedom (roll, pitch, yaw, longitudinal, lateral, and vertical translation) motion bases. These two extremes represent the delimiters of the cost spectrum, with six-degree-of-freedom motion base simulators sometimes costing as much as the actual aircraft.

Internal Environment: As with the motion component, interior fidelity spans a wide range. At the lower end of the continuum stands the photographic mockup of the cockpit, while at the opposite end one finds fully functional controls, displays and indicators. Most flight simulators tend toward the latter end of the scale. This type of simulator has the highest fidelity but is more costly because the instruments must be provided with simulated or stimulated inputs, usually from a computer.

External Environment: This component falls into two loose divisions: auditory and visual simulation. Auditory is by far the simplest, while visual simulation is the major field of concern.

Auditory simulation consists of both natural and man-made audio inputs. Natural inputs can be considered to be environmental sounds such as wind rush, thunder, and other naturally occurring audio phenomena. Man-made audio inputs include engine noise, radio and intercom transmissions, weapons delivery and the like.

Visual simulation is the most difficult but easily the most important facet of the external environment. Humans rely on visual inputs for the majority of their position and orientation information. Visual cues such as parallax, convergence, atmospheric haze, foreground blurring, interposition, and apparent size all enable the pilot to fly his aircraft in terrain following and avoidance regimes without crashing. These cues can be presented to some extent with CGI (to a fixed observer) but such imagery is far from perfect. Current visual systems simulate the range from pure instrument flight (i.e., no visual imagery) to fairly viable imagery using either CGI, hybrid systems, or modelboards.

The current battlelines seem to be drawn between those advocating very high fidelity (six-degree-of-freedom motion bases, state-of-the-art visuals, and realistic environments) and those who recommend the minimum fidelity necessary for training and nothing more. The determination of actual simulator fidelity lies beyond the scope of this report, but a general review of currently operational simulators visited follows for reader comparison.

2.1.1 C-130 Mission Simulator

This simulator is located in the training facility of the Military Airlift Command (MAC) at Little Rock AFB in Little Rock, Arkansas. It is equipped to provide full mission simulations for C-130 crews in the area surrounding Little Rock AFB. The high quality General Electric visual system can provide realistic imagery down to 300 feet AGL for low level navigation, parachute extraction, and assault landings.

The visual system is enhanced by several features. Primarily, the displayed terrain is representive of the actual topography of the 30,000 square miles around Little Rock. The area is accurately portrayed with digitized landmass data from the Defense Mapping Agency (DMA). Because the visual scene and aircraft instruments are correlated, the crew gains a realistic impression of actual flight.

A second feature is the texture generator. This unit adds texture (i.e., shading, streaking, etc.) to the CGI. Because texture streaming is such an important visual cue to distance and speed, this greatly enhances the simulator's low level flight simulation capability.

Finally, a special effects generator allows the display of surface-to-air missiles (SAMs), antiaircraft artillery (AAA) and flares. The inclusion of threat environments and other aspects of the aircraft mission provides a total training environment.

When fully operational, the C-130 Mission Simulator will be capable of crew training 20 hours per day, 7 days per week, providing a maximum utilization of 600 hours per month. In its current state, the WST is utilized 240 hours a month for take-off and landing only. However, after 3 January 1983, the visual imaging system (VIS) contract maintenance will allow for maximum utilization. About August 1983, the WST is expected to be fully integrated into the low level curriculum after the completion of Flight Operational Testing and Evaluation (FOT&E).

The non-visual portion of the WST, maintained by the Air Force, is utilized 350 hours per month. This is expected to increase to 400 hours per month after FOT&E completion.

The average operating cost of this simulator is $600 per hour. It is currently being used for enroute navigation, low level threat maneuvers, and all-weather (IFR/VFR) operations. Externally, flat to moderately rough terrain is simulated as well as turbulence, visibility, and weather conditions.

2.1.2 Oceana NAS

The A-6 Wing at Oceana NAS provided the following data, based on one training squadron and six operational squadrons (there should be seven operational squadrons by the spring of 1984). Fifty students are trained each year in order to maintain the operational squadrons at a strength of 15 crews. The training includes 16 visual low level sorties at 2.2 hours per sortie. Of this, 82 percent involves actual low level flight (1.8 hours per sortie). Using these figures, it may be estimated that student low level time is 1440 hours per year. Although OPNAV permits flight as low as 200 feet AGL, Wing policy restricts low level navigation to 500 feet AGL. Since training flights are flown at 360 knots, one might seriously question whether any of the "low level" training is realistic enough to permit adequate transfer of skills to the combat arena where greater airspeeds and lower altitudes are required for survival.

It was pointed out that a simulator maintenance contract expired earlier this year and the availability rate had slipped from 90 percent to 60 percent. As a result, available sorties were being allocated to the training squadron.

It was noted that there are so few instructor/instructor flights and other overhead flights that these may be omitted from calculations. Cost data was not available at Oceana. Therefore, simulator and aircraft cost data were obtained from the Pentagon.

2.1.3 Whidbey Island NAS

The A-6 Wing at Whidbey Island, Washington provided cost data for A-6E aircraft operations and for device 2F114. These data are shown in Figures 1 and 2. For use in the cost benefit formulas, only the $1250 Fuel/Oil/Miscellaneous costs are applicable. Note that for the 2F114 to be cost effective, it must generate a Transfer Effectiveness Ratio of 0.32 when the cost per hour of use for device 2F114 is $396.

$$(396/1250 = 0.32)$$

At Whidbey Island, simulator in-commission rate is approximately 99 percent. The aircrew members like simulators and take full advantage of simulator training capability. The WST syllabus has been carefully developed to ensure maximum benefit to aircrews. Four navigation sorties are scheduled in the simulator for each crew and two NATOPS qualification sorties are used for pilots and for bomb navigators.

The A-6 is an all weather medium attack aircraft. It is equipped for night low level attack and can operate in instrument meteorological conditions (IMC). Daytime visual navigation sorties are not a part of its primary mission. Such training has been described as nice to have but not required. The A-6 has an excellent safety record for low level operation. Crewmembers could not recall a low level navigation accident in recent years.

Organizational maintenance (1974)	\$362/FLT hr × 110%	\$ 760
Intermediate maintenance (1974)	\$308/FLT hr × 110%	647
Depot maintenance (1974)	\$675/FLT hr × 110%	1418
Fuel/oil/misc		1250
Flight crew (training) pilot/B/N		25
Approximate average total of direct costs/flt hr		\$4100

NOTE: Maintenance cost data is no longer recorded. Extensive research would be required to calculate today's costs. An inflation factor of 110% was applied to 1974 maintenance date to approximate 1982 maintenance costs.

Figure 1. Average A-6E Direct Flight Hour Costs for FY82

Organizational, intermediate and depot maintenance and operator costs. Device personnel cost × 0.28 for benefits.	$792,028
Material support costs. Personnel cost x 0.28 for benefits.	24,813
Indirect on-site management costs. Personnel cost × 0.28 for benefits.	39,525
Material costs	64,181
Electrical costs	12,000
Approximate total cost of Device 2F114 supporting operations	$932,601
Approximate average Device 2F114 support utilization.	$= \frac{\text{Total support cost}}{\text{Total utilization}}$

Total Device 2F114 utilitzation for FY82 2354 hours

Cost per trainer hour

$$\text{Cost/trainer hour} = \frac{\$932,601}{2354} = \$396/\text{hour}$$

Device 2F114 was utilized 700 hours for low level training scenarios

Figure 2. Average Device 2F114 (A-6E, WST) Training Hour Costs for FY82

2.1.4 T-38 Simulator, Randolph AFB

At Randolph Air Force Base in San Antonio, Texas, student pilots receive supplemental training in a T-38 simulator with a motion base. The visual system is a combination of CGI and a terrain modelboard in that when maximum altitude is exceeded (i.e., when the simulator is flown above the sides of the modelboard) the student enters a cloud deck. While in the clouds, the visual system transitions from the modelboard to CGI. When he exits the clouds, the pilot sees a blue sky with a brighter, more prominent horizon. All of the above-cloud imagery is CGI.

The system is not very suitable for low level flight because of the small scale (of the modelboard) necessary to provide a reasonable flight area. The modelboard at Randolph is 8 × 11 scale miles square; even this small area requies a board 30 × 50 feet. For an aircraft traveling at 400 knots, the modelboard is extremely limited as a lengthwise traverse could be performed in less than two minutes.

Personnel at Randolph state that low level flight is not trained on the simulator; one of the more important visual cues (texture) is not available to the pilot, because the scale is too small.

Personnel at Randolph feel that there is a need for low level flight in every flying command of the Air Force. They believe a suitable simulator would fill a niche that is empty at this time.

2.1.5 NASA Ames

Personnel at NASA Ames are interested in full mission simulation capability for two reasons. First, it provides a method of certifying command pilots without the expenditure of large quantities of fuel for aircraft operation. Appendix H of the FAA training regulations permits total transition training in a simulator. In Phase 2, simulators are being used for transition and upgrade of pilots who are already qualified either in similar aircraft or as a copilot. Phase 3 (not yet incorporated) will involve the initial training of commercial pilots. The second use of full mission simulation capability is as a laboratory tool to study high level information processing, crew coordination and workload.

Transfer effectiveness ratios have not been evaluated, but simulation has been shown to reduce training time in the aircraft. Some maneuvers (such as flare and touchdown) are more difficult than others to simulate. The use of simulators in commercial aviation has shown more promise, due in part to more simple maneuvers than those required for military operations.

The low level mission is not a part of the civil/commercial charter, however, visual take-off and landing operations are high interest items. It would be valuable for NTEC to establish a close liaison with NASA, and the FAA in order to get maximum benefit from their experience with simulations. Low level navigation problems are not unlike those encountered during landing approach.

2.1.6 Castle AFB

The primary item of interest at Castle AFB was the B-52 WST. There is, as yet, *no empirical data on transfer* effectiveness ratios. However, it has been noted that "initially," one hour in the simulator is roughly equivalent to three hours in flight. This may be unique to the B-52 with complex procedures and coordination among six crewmembers. It is also related to the relatively long sortie time which involves literally hours of uneventful cruising between mission subtasks.

Currently, crews in training receive six simulator flights. These are alternated between actual aircraft sorties. Five years ago, crews were scheduled for 17 aircraft sorties during initial B-52 upgrade. All usually involved low level training and air refueling. The present syllabus calls for 15 sorties; checkout is on the fifteenth. There are fewer low level segments and fewer refueling segments. The flying time has been reduced from approximately 135 to 120 hours. There is a belief that the current graduate of the program is more proficient than his contemporary five years ago. A major reason is better crew coordination which is attributed to simulator training.

There is an intangible benefit that is expected to accrue from use of the simulator. The crews will be able to practice in a wartime environment with simulated hostile actions, battle damage, and emergencies. In addition, they will be able to practice wartime procedures. During training, aircrew actions are based upon safety considerations. In wartime, mission accomplishment becomes the overriding factor.

An attempt was made to determine how good the visual simulation had to be in order to transfer to aicraft operations. A senior pilot who has been involved in the WST procurement for a number of years pointed out that over low level routes and remote areas, the visual scene did not provide sufficient cues to avoid terrain impact. There are so few cues in these areas (40 edges per nm^2) that the simulation is essentially worthless for more than horizon information (no trees, no buildings, no texture, reduced cues with reduced altitude). After an approach to an airport, we asked the pilot to make a low level, high speed pass (similar to a bomb run) across the airport. On this low level segment, there was no problem in maintaining adequate terrain clearance, or in adjusting it up and down from 50 to 200 feet using only the rich field of visual cues. The usefulness of a visual scene for simulated low level operations is highly dependent upon the amount of detail in the scene. The runway and its immediate environs had 2000 edges. A 1 by 3 nautical mile rectangle around the runway had 5000 to 8000 edges. There were 20,000 to 26,000 edges within a 25 nm radius of the runway.

2.1.7 Lemoore NAS

Both the A-7 and F/A-18 facilities were visited at Lemoore NAS. The A-7 simulators have a planned availability of 80 hours a week. Their utilization, based upon 1982 data, is from 73 to 82 sorties per month. Since from 16 to 20 sorties are scheduled each week, the utilization effectiveness rate appears to be quite good for the 2F11, 2F84B, and 2F103.

The cost of A-7 simulation is from $20,000 to $26,000 per month. This cost should be compared with A-7 operating costs estimated at $750 per hour (land based) to $850 per hour (carrier based) for POL. FY82 data indicate a cost of $983 per hour for 5808 flying hours.

Because the F/A-18 is just becoming operational, historical data on costs, accident rates, and operations are scarce. POL costs of $737,530 for 678.6 hours indicate an estimated hourly cost of $1087 for flying the aircraft. A review of the F/A-18 syllabus dated October 14, 1982 reveals four aircraft sorties which specify low altitude flight (Flight Syllabus FNAV 171, FNAV 172, FLAT 174, and FLAT 175). Other sorties involve ground attack and may include low level ingress/egress: FEWT 176; FGAC 181 through 189; FGAN 191 through 193; FGAC 281 - 288. Only 5 of these 21 sorties are preceded by practice in a weapons tactics trainer. There appears to be plenty of opportunity to augment F/A-18 low level operations training with low level simulation. Estimates of the potential cost effectiveness of this simulation should be based upon the A-7 experience due to mission similarity. Adjustments should be made for two-engine operation, increased system sophistication, and reliability changes.

The F/A-18 simulator currently costs about $9000 per month to operate, but it is not fully manned. The A-7 simulator costs may be more appropriate for projecting future costs.

2.1.8 Miramar NAS

At Miramar, it was discovered that the need for a low level simulator for F-14 Tactical Airborne Reconnaissance Pod System (TARPS) crews has been recognized for over a year.

Three concepts for low level simulation were discussed at Miramar:

1. An entire simulator, complete with cockpit and wraparound scene.
2. Visual components only, combined with an existing simulator cockpit.
3. An "Atari" type desk top CRT to be used on carriers for fully qualified aircrews to review (or preview) actual mission routes.

COMFITAEWPAC (Commander Fighter Airborne Early Warning Wing, Pacific Fleet) has documented the need for a low level simulator in a letter which specifies the parameters of the device. These parameters include a 70-mm projection of actual out-the-window imagery onto a 160-degree screen. This device would provide realistic simulation of low level flight capability for both initial training and to maintain proficiency on flying altitudes below 200 feet when using visual references. Acquisition of this device will be an essential support to flight time of the F-14 TARPS.

2.1.9 North Island NAS

The only training squadron for S-3A aircraft is at North Island NAS. Based on the costs for three 2F92A simulators now in use, FASO defines cost estimates of $5200 per simulator per quarter. A simulator produces from 137 to 200 hours of training per month when operational (411 to 600 hours per quarter). This implies that hourly costs will range from $8.67 to $12.65. Because maintenance is being done by the Navy, this does not include manpower costs. Parts, provided through standard supply channels, are not included. It was estimated that the S-3A costs $500 an hour to fly.

The S-3A curriculum outline specifies that each student will receive 18 hours of training in the 2F92A simulator. This does not include low level visual navigation. Most of the S-3A missions are accomplished over water. There are no suitable low level training routes over land.

The Fleet Project Teams (FPT) Priority List Item Description number 81-8 describes an OFT Visual System Update. As of 5 February 1982, it was assigned Group II, Priority 2. The visual system envisioned would include total daylight capability, complete wraparound of the S-3A windows, sea texture, smoke, air-to-surface weapons delivery against moving targets, and air refueling. The primary justification for this update involves fuel savings.

2.1.10 Williams AFB

It costs $3.6 million per year to maintain the two cockpits and the Advanced Simulator for Pilot Training (ASPT) system at the Air Force Human Resource Laboratory (AFHRL). This provides five 12-hour days per week for 50 weeks, or 3000 hours of projected availability for each cockpit. The baseline cost is $1200 per hour ($600 per hour for each cockpit). Other associated costs such as sensor and digital components, power, and research team salaries produced additional costs that resulted in hourly costs at $900 per hour per cockpit in FY81. An estimate of $1150 per hour per cockpit was provided as fairly accurate in current dollars.

A program is underway to improve ASPT image quality. Project Engineers estimate that an optimum research simulator should have imagery at 40 footlamberts (5 minimum) with 2 arc minutes resolution (3 minimum) and a contrast ratio of 20 to 1. Current display system performance parameters are presented in Table 1. Improvements that are possible using a variety of selected projectors are presented in Table 2. Additional research is underway to resolve the high bandwidth and high information rate problems associated with the side fields that are required for low level simulation.

An Air Force SIMSPO conference was held at Williams AFB two weeks prior to this visit. One of the conclusions from this conference is that there appears to be very little information available on the Transfer Effectiveness Ratio (TER) for simulator training, and therefore no studies in progress. From the AFHRL viewpoint, it is too costly to gather actual data on TERs.

AFHRL personnel have performed a study on "A-10 Low Altitude Simulator Training." It involved A-10 upgrade classes for fighter lead-in training which included two or three low level sorties. Data were gathered on basic attack maneuvers (pre weapons delivery) and two low level sorties. Feedback from the subjects indicated that the relatively short (100 nm) simulator sorties were useful, but the data have not been analyzed. Due to the materials used, there is some question on possible classification. It was felt that the biggest problems were that the performance measures were relatively insensitive and, due to the training situation, there was insufficient experimental control. Although interesting, the information that was available did not contribute to the establishment of appropriate transfer effectiveness ratios for use in cost benefit calculations.

Another interesting piece of information came from a study conducted by other AFHRL personnel. In this study, some pilots preparing to participate in a Red Flag exercise (simulated combat missions in ground attack aircraft) were

TABLE 1. PERFORMANCE OF SELECTED CURRENT DISPLAY SYSTEMS
(from AFHRL briefing)

SIMULATOR	ANGULAR COVERAGE	ANGULAR RESOLUTION	IMAGE BRIGHTNESS	IMAGE CONTRAST RATIO	COLLIMATION
ASPT	300° HOR 150° VERT	7 ARC MIN	2-3 FL	20:1	PANCAKE WINDOW
NTEC VTOL SIM	100° HOR 70° VERT	15-20 ARC MIN	1.0 FL	12:1	DOME
F-111 SIM	80° HOR 45° VERT	4 ARC MIN	8-9 FL	40:1	BEAMSPLITTER COLLIMATION MIRROR
UNITED 727 PHASE THREE SIM	75° HOR 30° VERT	4 ARC MIN	5 FL	20:1	COLLIMATION MIRROR

TABLE 2. COMPARATIVE PERFORMANCE OF SELECTED PROJECTORS (from AFHRL briefing)

						THROUGH HIOS	
	RESOLUTION (TV LINES/PH) AT 10% MTF)	OUTPUT LUMINANCE (LUMENS)	CONTRAST RATIO	VIDEO BANDWIDTH (MHz)	RESOLUTION (ARC MIN AT 10% MTF)	BRIGHTNESS GAIN = 2 (FL)	CONRAST RATIO
PRODUCTION GE PROJ (PH5155)	650	1000	75:1	15-20	8.3	1.2	20:1
GE DUAL COLOR LY (HRA)	430 BG 540 HR	620 BG 540 HR	75:1	15-20	10 BG 1.2 HR	0.5	20:1
SODERN US ARMY UNIT SYS-14	650	1500 (POLARIZED)	80:1	18	8.3	3.7	20:1
SODERN UPGRADED INTERIM	900 BG 200 HR	2500 (POLARIZED)	80:1	18	6 BG 4.5 HR	6.1	20:1
ASPT CRT	750	4000	80:1		7.0	2-3	20:1

given the opportunity to practice the low level navigation, ingress, and ground attack in a low level simulator. The "survival rate" for these pilots was 85 percent, compared to 75 percent for pilots who did not have the opportunity to practice in a simulator. While these statistics indicate a measurable gain in mission effectiveness, they cannot be converted into transfer effectiveness ratios. They do indicate a positive benefit that can be realized from low level simulators.

After the Air Force accepted the FB-111 visual system, the DIG system for visual scene display was found to be inadequate. AFHRL has been asked to enhance the existing system so that it can be used for training. AFHRL is presently conducting a study to determine the levels of detail and scene complexity that are required to provide sufficient visual cues to operate at low level across terrain with ridges, slopes, and spurs. Initial evaluations have provided evidence that the "richness" of the visual scene is much less than what would be encountered in the real world. Sizing, familiarity, and density of objects in the visual field may be more important than realistic appearance. The results of this study may not be available until late 1983. One of the authors (with military flight experience) flew a portion of the low level route; he felt that the visual cueing was adequate to simulate low level flight if the pilot had already experienced it. The imagery source is the FB-111 system, producing a display which is viewed from a T-38 cockpit.

AFHRL is familiar with systems being developed by Boeing, Grumman, and Vought. There are likely to be other systems under development by major airframe and major simulator producers. It appears that research will lead directly to precise specifications and recommendations on non-edge based computer generated imagery, field of view, and dimensions of criticality. A major problem seems to be that of integrating the visual scene with other sensor imagery.

Researchers at AFHRL have conducted a training oriented study involving zones and canyons. The study evaluated the effect of a reduction in cues over time, compared with a no cue situation. In this situation, it was concluded that the cues did not help. Results found that there was a "terrific gain score" down to

25 to 50 feet. Referenced in the AFHRL report was a paper by Buckland (1980) which presented both pilot preference and objective data on the utility of texture patterns, vertical cues, and shadows. A second paper by Edwards, Buckland, Pohlman, and Stevens (1981) described a random ground pattern and inverted cones representing trees. The CGI environment at low level was judged to be effective, even though evaluation of prompting cues provided contradictory results.

2.1.11 Cannon AFB

The F-111 simulator at Cannon AFB has the same data base as Pease AFB. It is an edge based system on which 8000 instantaneous edges can be displayed using 256 scan lines. Three levels of detail are used, with the area around a runway having the highest level. Pilots have noted that there is no depth perception available; they cannot estimate their altitude. They have not noticed any improvement with increased level of detail. As was the case at Castle AFB, this may be because they typically do not fly low level in the vicinity of their home field. A second problem that has been identified is the lack of adequate peripheral displays. Additional difficulties have been noted in attempts to integrate the analog radar data base and the digital visual data base.

The training squadron commander noted that the simulator provides adequate training for instrument practice and night terrain following. It can be used to teach procedures. Visual capability was viewed as having little value even if current problems are corrected, except for building scenarios which are based on hostile territory. The F-111 mission involves single aircraft operations from 100 to 300 feet and tactical formation up to 500 feet. Because of the F-111 avionic capability and mission, it was suggested that the visual scene simulator might be more appropriate for the A-10.

2.1.12 Cherry Point MCAS

At Cherry Point, there is one squadron of A-4 aircraft but no simulator. There are five squadrons of A-6 and AV-8A aircraft. Only the A-6 has a simulator with a visual scene.

The 2F131 A-6 simulator with VITAL 4 visual system was visited. This system has been in operation since March 1982. Its actual availability has been 87 percent of the 1692.8 hours that were projected. It has been scheduled 94 percent of the hours actually available and utilized during 94 percent of the hours scheduled. The average monthly utilization has been approximately 105 hours. Based on five 12-hour days per week (50 weeks per year after holidays), there are about 3000 hours a year. This is used to provide 2321 trainer hours or 4642 man-hours of training for two crewmembers.

The labor costs for 7-1/2 people for 7-1/2 months have been $139,226. Based upon 1259.6 hours of utilization, the labor cost per hour has been $110.53. This simulator is operated by civil service personnel. Operation (power) costs were not given. The training squadron uses about 60 percent of the simulator. The remaining 40 percent is divided among the operational squadrons. This provides each crew with about one hour per month in the simulator.

POL costs for A-6 aircraft operations are approximately $1320 per hour. The AV-8A POL costs are approximately $1000 per hour.

2.1.13 Cecil Field NAS

At Cecil Field, there is an A-7 wing and an S-3 unit. Both have simulators.

The 2F111 A-7 simulator was visited. It has no visual system but is equipped with a FLIR simulation capability. The motion base for this simulator is being decommissioned. The 2F111 is used primarily for the training squadron. Fleet pilots use it only two or three times a year (Instrument check, FLIR, EW). Fleet pilots do use the NCLT frequently.

The 2F111 utilization and cost data for last fiscal year indicated operations costs of $12,822 for 1140 hours of utilization or $11.25 an hour. This figure does not appear to include the military salaries for the operators. The targeted hours for this unit were 1500 per year. It was scheduled to be used 1452 hours (96.8 percent). It was utilized during 1140 hours (78.5 percent). It was down 312 hours

(21.5 percent), due mainly to problems with the building air conditioner and computer. POL costs for the A7 are estimated at $850 per hour.

There is no S-3 training squadron at Cecil Field. On the east coast, the only low level mission is over water. Visual simulation is not needed for this mission. The maximum altitude is 2000 feet while typical altitudes are from 100 to 200 feet above sea level. A night air-to-air refueling simulator would be of great value. Current simulator capabilities include night Instrument Meteorological Conditions (IMC) and night landings.

2.2 SAFETY STATISTICS

2.2.1 Navy/Marine Safety Statistics

Navy and Marine statistical data on 338 mishaps occurring from January 1977 through October 1982 were furnished by the Naval Safety Center. These data are used to support Navy/Marine safety statistics presented in this study. Data from this report are shown in Table 3, Low Level Flight Mishaps, and Table 4, Range Flight Mishaps. (Any aircraft designation preceded by the letter T is a trainer.)

Table 3 is a summary of the low level flight mishaps which occurred during the period 1977 to 1982 for Navy and Marine Corps aircraft. The aircraft cost and personal injury costs are quoted as a dollar value relative to the year in which the mishap occurred. However, the total cost of mishaps for the year is quoted in fiscal year 1982 dollars. Where a non-fatal injury occurs, the price of the necessary medical treatment is included as the personal injury cost.

Table 4 presents range mishaps for the same time period as the low level mishaps in Table 3. Range mishaps occur on missions which take place on gunnery ranges. They generally involve air-to-ground weapons delivery. Total costs are equated for all years in 1982 dollars; the aircraft costs and personal injury costs are dollar costs relative to the year incurred.

TABLE 3. LOW LEVEL FLIGHT MISHAPS: 1977-1982 (NAVY/MARINE)

Aircraft	Year	Fatalities	A/C Cost ($1000)	Personal Injury Cost ($100)	Cost in FY82$ ($1000)
A-4	1979	1	2140	260	2470
	1980	1	2140	260	2470
	1982	0	2140	0	2140
TOTAL		2	6420	520	7080
TA-4	1978	0	945	0	1171
	1980	2	1171	378	1651
	1980	1	1171	260	1431
		3	3287	638	4253
TOTAL					
AV-8	1977	1	3104	200	3434
	1977	1	3104	200	3434
	1978	0	3104	0	3104
	1978	0	3104	0	3104
	1979	1	3104	200	3434
TOTAL		3	15520	600	16510
A-7	1977	0	5	0	5.3
	1977	0	564	0	600
	1978	1	2699	200	3204
	1979	0	2699	0	2874
	1981	1	2874	260	3204
	1982	0	2874	0	2874
	1982	1	2874	330	3204
	1982	1	2874	330	3204
TOTAL		4	17463	1120	19169.3
TOTAL FOR ALL LOW LEVEL MISHAPS		12	42690	2878	47012.3

TABLE 4. RANGE FLIGHT MISHAPS: 1977-1982 (NAVY/MARINE)

Aircraft	Year	Fatalities	A/C Cost ($1000)	Personal Injury Cost ($100)	Cost in FY82$ ($1000)
A-4	1978	1	1043	200	1373
	1978	1	2140	200	2470
	1978	1	2140	200	2470
	1978	0	2140	0	2140
	1980	1	2140	260	2470
	1980	1	2140	260	2470
	1981	1	776	260	1106
	1982	0	2140	3.115	2143.115
TOTAL		6	14659	1383	16642.115
TA-4	1979	0	1171	0	1171
	1980	0	1171	2.585	1174.281
TOTAL		0	2342	2.585	2345.281
A-7	1077	1	2521	200	3204
	1977	0	2521	0	2874
	1977	1	2521	200	3204
	1978	1	2699	200	3204
	1978	0	2699	11.06	18.249
	1979	1	2699	260	3204
	1980	1	2874	260	3204
	1980	1	2873	260	3204
	1980	0	2874	0.335	0.425
	1980	1	2874	260	3204
	1980	0	2874	2.015	2876.558
	1980	1	2874	260	3204
	1981	1	2874	260	3204
TOTAL		9	35778	2173.41	34605.232

TABLE 4. RANGE FLIGHT MISHAPS: 1977-1982 (NAVY/MARINE) (cont'd)

Aircraft	Year	Fatalities	A/C Cost ($1000)	Personal Injury Cost ($100)	Cost in FY82$ ($1000)
TA-7	1979	0	2189	0	2189
	1979	2	2189	520	2849
TOTAL		2	4378	1040	5038
F-4	1977	0	2510	0.53	2687.875
	1977	0	2510	0.67	2688.106
	1978	0	199.676	0	212.202
	1981	0	2678	0	2687
TOTAL		0	7897.676	1.2	8274.183
A-7	1977	1	3104	200	3434
	1977	0	3104	0.410	3104.52
	1978	1	3104	200	3434
	1981	1	3104	260	3434
TOTAL		3	12416	660	13406.52
TOTAL FOR ALL RANGE FLIGHT MISHAPS		20	77470	3867	80312.331

Between December 1980 and November 1982, the Navy Military Personnel Command reported 90 aircraft related fatilities of which 34 were military pilots.

2.2.2 Air Force Safety Statistics

Air Force statistical data on mishaps occurring from 1976 through October 1982 were furnished by Headquarters, Air Force Inspection and Safety Center.

Table 5 presents comparable mishap data for three Air Force aircraft: the A-7, F-111, and F/RF-4. Rate is the number of mishaps occurring per 100,000 flight hours. The Air Force defines a Class A mishap as one in which an aircraft is destroyed, a fatality occurs, or damages equal or exceed $500,000.

2.3 CURRENT IMAGE SYSTEMS AND TECHNIQUES

The Transfer Effectiveness Ratio of a low level flight simulator is dependent, in part, on the visual system's ability to produce sophisticated, real-world imagery. The participant in a simulation exercise should feel, think, and react as if what he is seeing is real, when in fact it is not. Sufficient cues must be provided for each particular task. Current technology provides various means for generating such cueing and imagery, but the most flexible systems are computer-based. The three most promising of these techniques are Computer Generated Imagery (CGI), Computer Synthesized Imagery (CSI), and Computer Generated Synthesized Imagery (CGSI). CGI and CSI are currently in use, while CGSI (a hybrid of the other techniques) is in the developmental stages.

Computer generated imagery uses data stored in a data file to create objects for display. Each significant point must be specified; line segments are then drawn between points as required.

In CGI, objects are composed of regular and irregular polygons. The problem develops when the number of edges (i.e., the total number of polygon sides) becomes so great that the processor is unable to recreate the scene at a real time (60 Hz) rate. For state-of-the-art CGI systems, this is around 8000 edges. This available edge processing capability is rapidly exhausted when

TABLE 5. AIR FORCE AIRCRAFT MISHAPS: 1976-1982

Aircraft	Year	Flight Hours	Aircraft Destroyed	Rate	Class A Mishaps	Rate	Low Level Mishaps	Rate
A-7	1976	99284	7	7.05	7	7.05	0	0.00
	1977	108681	7	6.44	7	6.44	0	0.00
	1978	100882	10	9.91	9	8.92	0	0.00
	1979	94210	7	7.57	8	8.66	2	2.16
	1980	91478	3	3.28	3	3.28	2	2.19
	1981	80848	4	4.95	4	4.95	1	1.24
	1982	74018	2	2.70	2	2.70	1	1.35
F-111	1976	62750	5	7.97	8	12.75	1	1.59
	1977	73628	7	9.51	7	9.51	2	2.72
	1978	63737	2	3.15	3	4.72	0	0.00
	1979	75989	10	13.16	13	17.11	3	3.95
	1980	73431	4	5.45	4	5.45	0	0.00
	1981	77648	1	1.29	3	3.86	0	0.00
	1982	69321	7	10.10	8	11.54	4	5.77
F/RF-4	1976	404363	19	4.70	24	5.94	3	0.74
	1977	419752	17	4.05	20	4.76	7	1.67
	1978	397648	18	4.53	17	4.28	3	0.75
	1979	390145	19	4.87	19	4.87	5	1.28
	1980	353461	18	5.09	19	5.38	3	0.85
	1981	351397	21	5.98	20	5.69	6	1.71
	1982	297835	10	3.36	11	3.69	4	1.34

displaying a detailed scene. Thus, scene modelers use edges sparingly in areas of high object density. This high object density is bought at the expense of fidelity; the majority of CGI is cartoonish in quality.

Realism is also lacking in CGI because the representation of curved surfaces is prohibitive in terms of the number of necessary edges. A circle, or for that matter any curved surface, can be approximated by a large number of points connected by very short line segments. It is easy to see why such representations rapidly escalate the edge total.

CGI is not without advantages. Because the image is created, it is possible to duplicate the visual representation of complex topography. The connection of different points to create this complex visual representation implies a grid or coordinate system; this is in fact the case. Once the surface is created, objects can be placed "on" the surface using the same coordinate/grid system. Because the computer is able to manipulate complex variables CGI can also maintain correct lighting and perspective while still moving the eyepoint. In short, CGI can depict highly complex relationships, but lacks the fidelity necessary for many applications.

Computer Synthesized Imagery (CSI) uses actual analog imagery for the displayed features. There are no elevation profiles modeled for the scene; they already exist in the photograph. Because no individual objects are modeled, the scene is usually static. Any object which moves through the scene must travel a prescribed course. Object interposition (an important monocular visual cue) must be determined manually for each frame of movement. Since no object is modeled individually and all are analog representations, there is little if any control over perspective and lighting factors.

The primary advantage of CSI is its high level of fidelity. Because objects are actual analog representations, any of the imagery from sensors now in use (including FLIR, Radar, LLLTV, and various other systems) can be represented. This neatly sidesteps the difficult programming task of modeling the radiative characteristics of a target over the currently utilized range of the electromagnetic spectrum. All that is necessary is a photograph of an image from the respective system.

Examination of some of the capabilities of CGI and CSI reveals that their strengths are complementary. A fusion of the two yields a system superior to either alone. This is what computer generated synthesized imagery (as reported by Graf and Baldwin, 1982) does. CGSI uses each of the parent techniques for their respective strong points. This produces a high fidelity visual scene with flexibility, which is unachievable by either system alone. Object detail is supplied by CSI and surface topography, perspective, and lighting are provided by CGI.

The actual CGSI scene is created by a series of overlays, beginning with the farthest object from the eyepoint. The object is placed on the CGI terrain. All of the least significant features (trees, bushes, and rocks) are represented two-dimensionally; high significance items (targets, buildings, etc.) are represented three-dimensionally.

Targets are stored as separate images from a variety of viewing positions. The processor assesses the viewer's eyepoint and presents the image of the target which most closely approximates the current eyepoint. The selected view of the object is transformed and warped to fit into the perspective and scale of the scene. The resulting scene is of extremely high fidelity, with moving targets, object occlusion and weapons effects.

The majority of other systems are too inflexible to be considered as candidates for low level flight simulation. As such, they do not merit discussion. The only one with viability at all is the terrain modelboard and it lacks detail, flexibility and gaming area.

SECTION 3
COST FACTORS AND ANALYSIS

As was explained in Section 1.2, the major difficulty in determining the cost benefits of low level visual simulators is in the establishment of an estimated Transfer Effectiveness Ratio (TER). In this section, the rationale for obtaining a valid estimate is discussed and the results of calculations are presented.

3.1 TRANSFER EFFECTIVENESS RATIOS (TERs)

The term "transfer of training" is typically used to describe the extent to which previously acquired skills or training facilitate subsequent learning of a similar task. With respect to pilot training, determining the degree of transfer from the simulator to the actual flight situation has many apparent advantages. Overall, simulator time is very inexpensive when compared to flight time. With a substantially high transfer rate, the cost of attaining a given flight criterion (by simulator or by some combination of flight and simulator time) will be less than the cost of flight training in the aircraft alone. Consequently, when developing a cost effective flight training syllabus, it is useful to determine the transfer effectiveness of various mixes of simulator and flight time.

Roscoe (1971) is usually credited for the development of the transfer effectiveness ratio. The TER provides a quantitative measure of the degree of transfer from the simulator to the aircraft by comparing the flight hours saved to the time spent in the simulator. It is well founded empirically that the effectiveness of transfer is a negative decelerated function of the amount of practice. In terms of aircraft simulators, this implies that as the number of practice hours increases, the benefit gained from each hour decreases at a proportional rate. Orlansky and String (1977) define the TER as:

$$TER = \frac{Y_o - Y_x}{X}$$

where

Y_o = time required by a control group to reach a performance criterion.

Y_x = time required for an experimental group receiving X training hours on a prior task.

X = increased practice time necessary to achieve the savings represented by $Y_o - Y_x$.

In terms of flight training, the TER can be stated more simply as:

$$\text{TER} = \frac{\text{Original Flight Hours - New Flight hours}}{\text{New Simulator Hours}}$$

As an additional measure of the effectiveness of training, Roscoe (1971) developed the concept of Percent Transfer. Basically, Percent Transfer indicates the amount of time saved in in-flight training due to the simulator and/or other training innovations.

Percent Transfer is defined by Orlansky and String (1977) as:

$$\frac{Y_c - Y_x}{Y_c} \times 100$$

where

Y_c = time required by a control group to attain a performance criterion or objective.

Y_x = time required by a group which has had prior practice on another task to reach a performance criterion.

In terms of flight training, Percent Transfer can be defined by the following formula:

$$\text{Percent Transfer} = \frac{\text{Original Flight Hours - New Flight Hours}}{\text{Original Flight Hours}} \times 100$$

The Percent Transfer describes the amount of actual flight training which can be replaced by simulator training.

3.1.1 TERs as a Function of Flight Hours Replaced

As mentioned earlier, transfer of training is a negatively decelerated function of the amount of practice on a previous task. Since appropriate mixes of training and real life experience are necessary to develop a cost effective training program, the utility of a general function relating the variable x, simulator hours, to y, actual flight time, becomes obvious. A relationship between simulator and aircraft hours is given by the following graph.

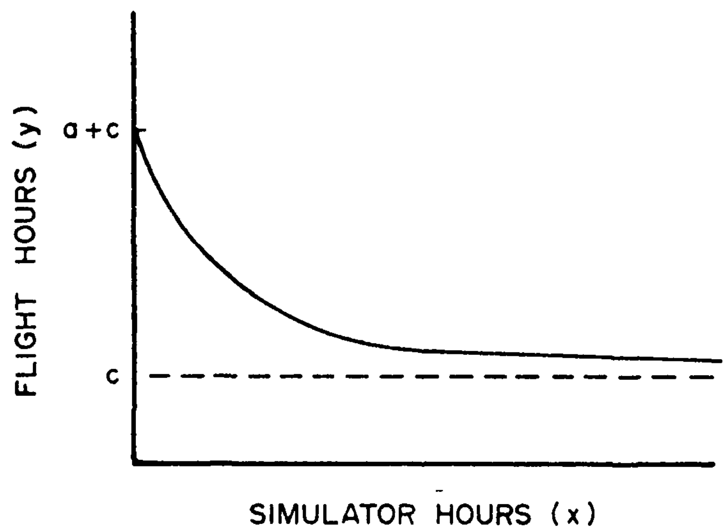

Figure 3. Relationship Between Simulator Training and Aircraft Flight Training

Bickley (1980) has shown that the above function will have the general form

$$y = ae^{-bx} + c$$

where

a = maximum replaceable flight time.

c = minimum required flight time.

x = simulator hours.

y = aircraft hours.

b = characteristic constant which determines TER.

e = 2.718.

The quantity y is at a maximum when no simulator hours are available ($x = 0$, $y = a + c$) and at a minimum when unlimited simulator hours are available ($y = c$). A decrease in the value of y because of increases in x (more simulator time) represents the savings in flight time which results from training on the simulator.

The development of this equation was based upon the assumptions that in order to maintain a constant level of proficiency, as simulator training increases required flight training decreases to a minimum value; and that for any set of values of required flight and simulator time, the rate of decrease in flight time is proportional to the difference between present flight time and minimum flight time. This second assumption can be interpreted that as the simulator is used to provide a larger portion of its total training capability, a greater number of hours of simulator time will be needed. This condition is typical of most training systems: initial learning rates are high and tend to taper off as maximum capability is approached. The observation that TERs decrease with the amount of training provided was also made by Roscoe (1971). The mathematical derivation of the equation

$$Y = ae^{-bx} + c$$

and the rationale behind it is presented in Bickley (1980). A major question is whether this theoretical, logical, mathematical development is supported by empirical data.

In 1973, before Bickley formulated his equation, Povenmire and Roscoe conducted an evaluation of a generic aircraft simulator by varying the amount of simulator training and measuring the flight time required to reach a given level of proficiency (passed FAA flight check). Based upon average flight times of 44.49, 39.90, 38.27, and 37.30 for the groups who received 0, 3, 7, and 11 hours of simulator time, Roscoe was able to present a graph showing the TERs decreasing with increases in simulator time. Bickley used the same data to compute required flight hours as a function of simulator hours:

$$Y = 6.7e^{-0.397x} + 37.6$$

Holman (1978) found that, for training in the CH-47 helicopter the average TER of 0.82 was actually a composite of TERs for individual maneuvers which ranged from 0.0 to 2.8. Realizing that variable TERs implied different curves for the various maneuvers, Bickley conducted a nonlinear regression analysis of data collected on 35 subjects performing 31 maneuvers. In all cases, the model was found to fit the data. This is especially reassuring since the evaluation showed that for some maneuvers, practice in the simulator transferred poorly to the aircraft. In Bickley's words, "It may be concluded that there is no cogent reason for rejecting as a viable heuristic the model under consideration."

3.1.2 Transfer Effectiveness Ratios for Low Level Flight

In order to determine the potential training values of low level flight simulation, 13 experienced A-7 pilots were asked to complete 2 questionnaires (see Appendix A). A complete tally of the responses to each question is presented by aircraft in Appendix B. It was hypothesized that pilots in training would benefit more from each hour of simulator training than the operational pilots (that is, the operational squadron has a lower transfer effectiveness ratio for a specified mix of simulator and flight time than the training squadrons). Therefore, the results were tabulated separately for training squadrons and operational squadrons.

Using the questionnaire data, a general function relating simulator hours and flight hours was computed for six aircraft. A detailed explanation of the computations necessary for developing the learning curve (representing the relationship between flight hours and simulator hours) are presented for the A-7. The computations for the other aircraft are not presented due to insufficient data, lack of visual low level mission, and/or lack of enough aircraft to warrant simulator development at this time.

Percent Transfer

Each subject matter expert was asked to estimate the percent to which 18 different tasks could be practiced to proficiency in the simulator. The Percent Transfers for these tasks are presented as the response to Question 6 of Questionnaire B (see Appendix B). The following Percent Transfers were calculated for the A-7 and are particularly applicable to low level flight (see Table 6). Crew coordination was eliminated for the A-7 because the aircraft has only one crewmember.

Low Level Flight Time

For the training pilots, low level flight hours were determined for a four-month period (typical length of a training program). The median amount of time spent flying low level during a 4-month training period for A-7 pilots was determined to be 29.88 hours (0.83 hours per mission × 9 missions per month × 4 months = 29.38 flight hours). The 0.83 hours per sortie and 9 sorties per month were median responses given to Question 2 of Questionnaire A and Question 10A of Questionnaire B, respectively.

TABLE 6. PERCENT TRANSFER ON LOW LEVEL FLIGHT MANEUVERS FOR THE A-7

Maneuver	Operational Squadron	Training Squadron
Correlation of Map and Visual Scene	40	50
Aircraft Flight Control	50	50
Armament	77.5	60
Target Identification	45	50
Attack Target	50	50
Other Navigational Tasks	55	80.5

For the operational pilots, the low level flight hours were determined on a monthly basis. The low level flight time for the A-7 operational pilots was 4 hours per month ($1.0 \times 4.0 = 4$), where 1.0 was the median response given to Question 1 of Questionnaire A, and 4.0 was the median response to Question 10A of Questionnaire B.

Simulator Hours (x)

The simulator hours required to replace a 10 percent reduction in low level flight time were given as the response to Question 5A of Questionnaire B (If your flying time was cut by 10 percent, how many simulator hours would it take to replace it?). The simulator hours were determined for a four-month period for the training squadron and on a monthly basis for the operational squadron. For the A-7, the median simulator hours required to replace a 10 percent decrease in flight hours were 3 hours per month for operational pilots and 5.25 hours per 4 months for the training pilots.

New Low Level Flight Hours (y)

To correspond to the increase in simulator hours, the new flight hours were 90 percent of the original flight hours. For the A-7, new flight time was 26.892

flight hours for the training pilots ($0.9 \times 29.88 = 26.892$) and 3.6 flight hours for the operational pilots ($0.9 \times 4.0 = 3.6$).

Maximum Replaceable Flight Time (a)

Maximum replaceable flight time was determined by using the product of the lowest percent transfer (on a low level maneuver) and low level flight time for the operational and training squadrons. For the A-7, the lowest Percent Transfer was 40 percent (correlation of map and visual scene) for the operational squadron and 50 percent (correlation of map and visual scene) for the training squadron. The value of (a) was 1.6 flight hours ($0.40 \times 4 = 1.6$) for the operational squadron and 14.94 flight hours ($0.50 \times 29.88 = 14.94$) for the training squadron.

Irreplaceable Flight Hours (c)

Irreplaceable low level flight hours were calculated by subtracting the replaceable flight hours (a) from the total flight hours. For the A-7, the irreplaceable flight time was 2.4 flight hours for the operational pilots ($4 - 1.6 = 2.4$) and 14.94 flight hours for the training pilots ($29.88 - 14.94 = 14.94$).

Characteristic Constant Which Determines TER (b)

Substituting the above variables (a, c, x, and y) into the general function relating simulator hours to aircraft hours ($y = ae^{-bx} + c$), the value of (b) can be calculated algebraically:

$$b = x^{-1} \ln ((y-c)\ a^{-1})$$

For the A-7 operational pilots:

$$b = (3)^{-1} \ln ((3.6-2.4)(1.6^{-1}))$$
$$= .096$$

which gives

$$y = 1.6e^{-.096x} + 2.4$$

For the A-7 training pilots:

$$b = x^{-1} \ln ((y-c)\ a^{-1})$$

$$b = (5.25)^{-1} \ln ((26.892 - 14.94)(14.04)^{-1})$$

which gives

$$y = 14.94\ e^{-.043x} + 14.94$$

Graphic representations of the functions for the A-7 are given in Figures 4 and 5. Note that the y-axis scaling varies considerably between graphs.

3.1.3 Transfer Effectiveness Ratios for Range Flight

During the course of this research, it became apparent that the mishap rate during range flight was substantially higher than the mishap rate for low level flight in general. In addition, Percent Transfers which apply specifically to range flight (target identification and attack target) tended to be higher than the other Percent Transfers considered. These factors suggested that it would be meaningful to determine both transfer effectiveness ratios and cost benefits for range flight as well as for low level flight.

It was estimated that range flight would require approximately 30 minutes of a total typical mission which involves range work. Since the number of sorties per month were already determined for training squadrons and operational squadrons, calculating the total range flight hours was straightforward. For the A-7 training squadron, the total amount of range time for the 4-month training period was 18 flight hours (9 sorties per month × 0.5 hours range time × 4 months per course = 18 hours per course). For the A-7 operational pilots, the total range

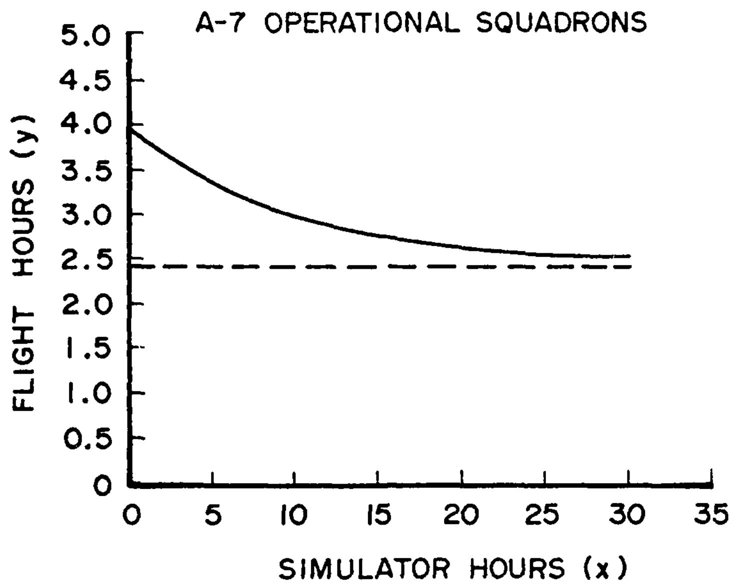

Figure 4. Plot for $Y = 1.6e^{-.096x} + 2.4$

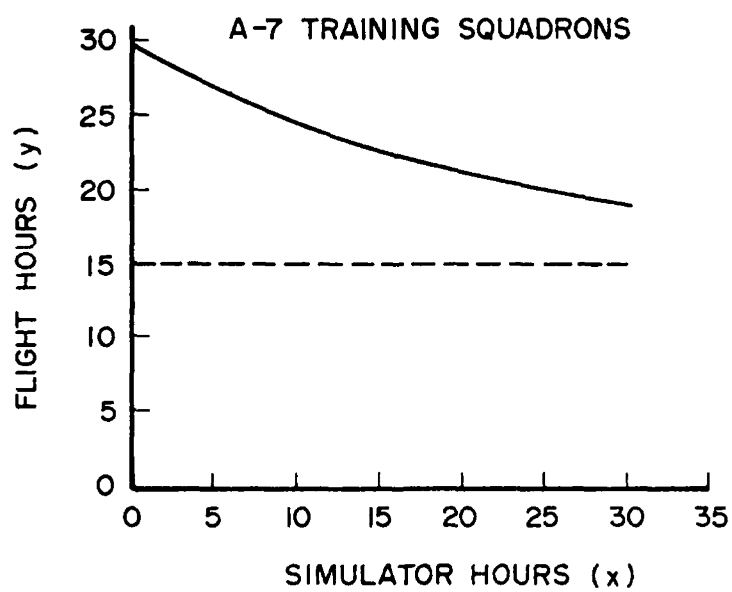

Figure 5. Plot for $Y = 14.94e^{-.043x} + 14.94$

flight time was 2 flight hours per month (4 sorties per month × 0.5 hours range time = 2 hours per month).

The lowest Percent Transfers were 50 percent (target identification, attack target) for the training squadron and 45 percent (target identification) for the operational squadron. The irreplaceable flight time (c) is given by the product of range flight hours and the lowest Percent Transfer. For the A-7, the irreplaceable flight time was 9 flight hours for the training pilots (0.5 hours × 18 sorties = 9 hours per course) and 0.9 flight hours for the operational squadrons (0.45 × 2 = 0.9 hours). Maximum replaceable range flight time (a) is given by the difference between total range flight time and irreplaceable range flight time. For the A-7, the maximum replaceable range flight time was 1.1 hours for the operational squadron (2 - 0.9 = 1.1) and 9 hours for the training squadron (18 - 9 = 9). The characteristic constants which determine TER (b) were identical to those used for the low level flight TERs. This gives the following equations for the A-7.

Operational Squadrons

$$y = 0.9e^{-.096x} + 1.1$$

Training Squadrons

$$y = 9e^{-.043x} + 9$$

From these equations, it was possible to calculate a estimate of the TER for any desired mix of aircraft and simulator hours. TERs were calculated with a 10 percent reduction in actual aircraft hours.

The functions relating simulator hours and aircraft hours for the A-7 are represented graphically in Figures 6 and 7.

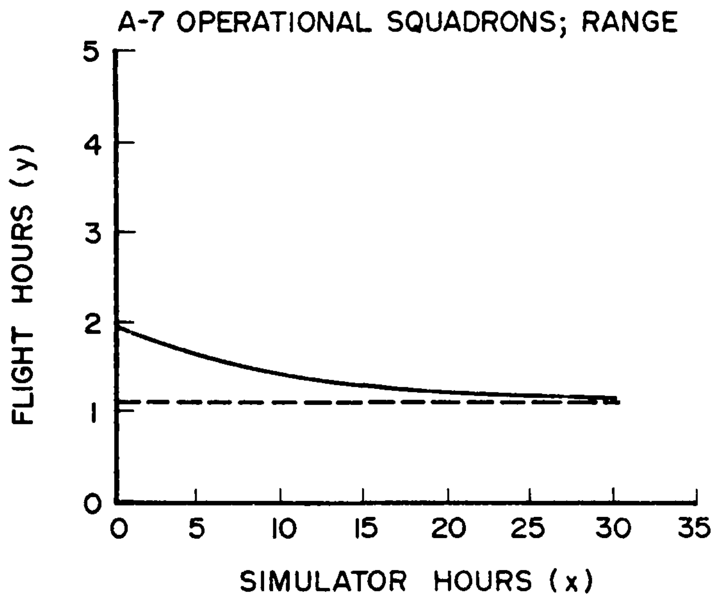

Figure 6. Plot for $Y = 0.9e^{-.096x} + 1.1$

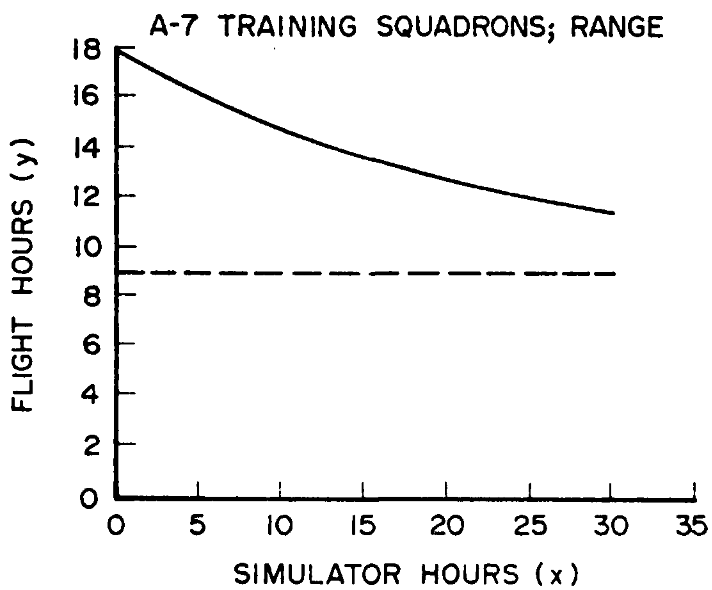

Figure 7. Plot for $Y = 9e^{-.043x} + 9$

TABLE 7. TERs CALCULATED FOR A 10 PERCENT REDUCTION IN ACTUAL FLIGHT TIME

Aircraft	Low Level TER	Range TER
A-7 Operational	0.13	0.08
A-7 Training	0.57	0.35

For an aircraft to practice weapons delivery, it must proceed to and from an approved range. While on the range, it can deliver only a limited amount of practice ordnance. Range time is usually limited to 30 minutes. The other 90 minutes for a typical mission are allocated to take-off, ingress, egress, and landing. These are routine actions, and in general do not require a lot of practice. In order for a pilot to get 30 minutes weapons delivery practice in an aircraft, he must spend 4 times that amount of time in flight. This is often non-necessary training and constitutes overlearning of normal tasks. In a simulator, nonessential flight tasks need not be practiced. For a simulator, an unlimited amount of ordnance is available.

For range sorties, the efficiency factor corrects for the fact that only one fourth of an aircraft sortie (30 minutes out of a 2-hour mission time) is devoted to range practice. In a simulator, four 30-minute range periods could be completed in 2 hours. Similarly, in an aircraft, only one half of a 2-hour sortie can be spent practicing low level navigation. A 2-hour simulator period could be used to complete two 1-hour low level segments.

It is recognized that it is possible to plan aircraft missions to incorporate both low level and range practice. It should not be assumed that all pilots need low level and range practice in a 2 to 1 ratio. Further, because of limitations for flight paths of aircraft carrying ordnance, a low level route leading to a range may be non-productive and would soon become overlearned. Options for different target areas for tactical moving targets and for simulated air defense weapons serve to increase the quality of simulation training for weapons delivery.

To compensate for this difference, the TERs are multiplied by an efficiency factor which accounts for the more efficient use of the pilot's time. For weapons delivery (or range) sorties, the efficiency factor is 4. For low level navigation sorties, the efficiency factor is 2.

When training TERs are multiplited by the efficiency factors, they are defined as "effective TERs" and reflect the capability of simulators to present training more efficiently than aircraft due to reset and freeze features and the freedom to practice only what is required. When 10 percent of low level navigation time is replaced with simulator time, the effective TER is 1.14; for 5 percent it is 1.224. When 10 percent of range training in weapons delivery is replaced with simulator time, the effective TER is 1.40.

3.2 ACCIDENT COSTS

3.2.1 Survivor Benefits

Benefits paid to survivors constitute a major expenditure which results from a fatal accident. Cost of survivor benefits was determined for 34 pilots killed in low level flight accidents from 1980 to 1982. Total benefits to survivors were determined by the formula below:

$$B = G + X + SC + CC$$

where

B = survivor benefits.

G = death gratuity.

X = burial expenses.

SC = Dependency and Indemnity Compensation (DIC) paid in total to spouse.

CC = DIC paid in total to children.

The death gratuity (G) is a sum paid to the next of kin of the deceased, which is equal to 6 months pay of the deceased, but not less than $800 nor more than \$3000. None of the pilots in our sample received 6 months pay of less than \$3000, so G was a constant of \$3000 in our formula.

Burial expenses (X) not exceeding \$1100 are paid for service connected deaths. In our formula, \$1100 is a constant.

Dependency and Indemnity Compensation (DIC) is a monthly payment made to the spouse and children, if any, of the deceased. It is paid to the spouse until death or remarriage, and to the children until age 18, or 23 if they attend a Veterans Administration (VA) approved college or university. Since it would be impossible to determine date of death or remarriage in the case of the spouse, or whether or not the children will attend a VA-approved school, a cut-off age of 50 was used to determine total DIC for the spouse, and a cut-off age of 18 was decided on for the children. Furthermore, since the birthdates of the spouses were unavailable, age was computed in each case to be one year younger than that of the deceased mate. In addition, since the exact year of death was unknown, 1980 was used as the year-of-death for all pilots in the sample. DIC was determined for spouses using the following formula:

$$SC = \left\{ \left[50 - (Y - D + 1) \right] \times 12 \right\} \times MS$$

where

SC = DIC paid to spouse
Y = pilot year of death (1980)
D = pilot birthdate
MS = amount of compensation to spouse per month according to deceased's rank

Similarly, total DIC for children is computed according to the following formula:

$$CC = \left[18 - (Y - T_n) \times 12 \right] \times MC + \ldots$$

where

T_n = birthdate of child.

MC = amount paid for number of children receiving compensation per month.

Using the above methods, the median survivor benefits paid for 34 pilots killed in low level accidents from 1980 to 1982 was $163,826 per pilot. This was used as the best estimate for benefits paid to survivors.

3.2.2 Personal Injury Costs

The Department of Defense estimates the injury costs incurred as the result of a fatality of a flying officer as $330,000 (OP NAV INST 3750.6M). Consequently, $330,000 was used as the best estimate for personal injury costs resulting from a fatal accident.

3.2.3 Yearly Accident Costs

Yearly accident costs were calculated for each aircraft by the following formula:

Yearly Accident Costs = Number of Accidents x (Aircraft Cost + Personal Injury Costs + Survivor Benefits)

Yearly accident costs ranged from $1,580,295.6 per year for the A-4 low level flight to $8,756,347,6 per year for the A-7 range flight. Yearly accident costs for range and low level flight are presented in Tables 8 and 9.

3.3 PROJECTED LOW LEVEL FLIGHT SIMULATOR COST

Various types of flight simulators have been available for training almost from the invention of the airplane, but use by the military services has always been limited. The reasons are obvious: simulators did not simulate airplanes very well and pilots preferred flying airplanes rather than in devices anchored to the ground. This situation has changed significantly because simulators have been

TABLE 8. ACCIDENT COSTS (RANGE)

Aircraft	Yearly Range Accidents	Aircraft Cost	Personal Injury Cost	Survivor Benefits	Yearly Accident Cost
A-7	2.6	$2,874,000	$330,000.00	$163,826	$8,756,347.6
A-6	0	$1,397,000	$330,000.00	$163,826	0
AV-8	0.8	$9,000,000	$330,000.00	$163,826	$7,595,060.8
S-3A	0	—	—	—	—
F/A-18	0	$31,084,000	$330,000.00	$163,826	0
A-4	1.6	$2,140,000	$330,000.00	$163,826	$4,214,121.6

TABLE 9. LOW LEVEL ACCIDENT COSTS

Aircraft	Yearly Accidents	Aircraft Cost	Personal Injury Cost	Survivor Benefits	Yearly Accident Cost
A-7	1.6	$2,874,000	$330,000	$163,826	$5,388,521.6
A-6	0	$1,397,000	$330,000	$163,826	0
AV-8	1	$9,000,000	$330,000	$163,826	$9,493,816.
S-3A	0	—	—	—	—
F/A-18	0	$31,084,000	$330,000	$163,826	0
A-4	0.6	$2,140,000	$330,000	$63,826	$1,580,295.6

improved, they are more acceptable to pilots, and the need to conserve fuel becomes increasingly important as supply diminishes and cost increases.

Increasing the use of simulators is not meant to reduce actual aircraft flight hours, but to allow for reallocation of flight hours to emphasize other tasks. For example, more hours will be available for practicing range flight maneuvers. Simulators permit training in areas which cannot be trained in aircraft; critical flying skills and hazardous mission maneuvers can be repeatedly practiced in a safe and forgiving environment.

Simulator operational cost information was obtained from personal interviews with squadron leaders at various military air stations. Table 10 lists these reported operational costs for the F-111 WST, F-114, F-131, ASPT, F-4 WST, and C-130 WST per utilization hour. Table 11 lists simulator procurement cost for the F-103, F-84B, F-111, and C-130 WST.

Breglia (1982) referenced Orlansky and String (1977) to provide estimated life cycle cost of a hypothetical training device employing the Helmet Mounted Laser Projector Eye Coupled Display Technology. Life Cycle Cost estimates for the projected low level simulator are given in Table 12 in 1982 dollars. No discounts are assumed. Costs are limited to simulator costs only and do not contain elements such as academic training, flight training, instructor pay and allowances, student TAD/TDY, student pay and allowances, training support, and training program development associated with total training costs. From Table 12, the procurement cost of four simulators can be determined to be $75 million (15,500 x 4 + 13,000). A total life cycle of ten years, 50 weeks per year, and a utilization of 80 hours a week are assumed. The hourly operational costs for the proposed simulator were estimated to be $262.50 per hour. This was calculated by dividing the operation cost ($10.5 million) by the estimated simulator usage over a ten-year period. As can be seen from the comparative data in Table 10, the $262.50 per hour estimate estimate is in agreement with current experience.

TABLE 10. OPERATIONAL COST 1982 (from Squadrons)

Simulator	Cost per Hour
F-111 WST	$425.00
F-114	$198.00
F-131	$110.53
ASPT	$1150.00
F-4 WST	$100.00
C-130 WST	$600.00

TABLE 11. SIMULATOR PROCUREMENT COST (FY82$)

Simulator	Procurement Cost (millions)
F-103	$3.50
F-84B	$5.0651
F-111	$5.19537
C-130 WST	$25.9

TABLE 12. PROJECTED LOW LEVEL SIMULATOR COST

1. Acquisition Costs ($K)	
Directed Research, Development, Test and Evaluation (RDT&E) (This includes exploratory development and advanced technology demonstration of high risk display components.)	$13,000
Production Costs (First Article)	
Cockpit/Instruments	$1,000
Flight Computer	500
Instructor/Operator Station	500
Motion Cueing	500
Display	5,000
Head/Eye Sensors	1,000
Computer Image Generator	4,500
Integration Assembly	1,000
Facilities (MILCON)	1,000
Production Total	$15,000
Government Procurement Costs	$500
Total Acquisition	$28,500
2. Operations Costs ($K for 10 years)	
Operation Manpower (40 MY)	$3,000
Maintenance Manpower (40 MY)	2,000
Maintenance Material	250
Utilities	250
Total Operations	$5,500
3. Personnel Support Costs ($K for 10 years)	$500
4. Recurring Investment Costs	
Spares	$2,000
Modifications	2,000
Support Equipment	500
Total Recurring	$4,500
5. Total LCC	$39,000

3.4 AIRCRAFT/SIMULATOR COST COMPARISON

This section presents the mishap rates and cost benefits that were calculated for the A-7.

3.4.1 Mishap Rates

Mishap rates were determined by the following formula:

$$\text{Mishap Rate} = \frac{\text{Number of Accidents}}{\text{Flight Hours}} \times 100{,}000$$

The mishap rates per 100,000 flight hours for each aircraft are presented for low level and range flight as Table 13 which were obtained from Tables 3 and 4. Overall, the mishap rates for range flight tended to be higher than those calculated for low level.

TABLE 13. MISHAP RATES

Aircraft	Range Mishap Rate	Low Level Mishap Rate
A-7	8.2	2.542
A-6	0	0
AV-8	13.892	17.3216
S-3A	—	—
F/A-18	0	0
A-4	15.7267	2.92113

3.4.2 Cost Benefits

Cost benefits were determined using the following algorithm:

$$\text{Cost Benefits} = \text{Reduced Flying Cost} - \text{Increased Simulator Costs}$$

Reduced flying costs result from a decrease in flight hours spent at low level as well as a reduction in accidents. In order to determine cost benefits, it was necessary to assume that a reduction in low level flight hours would cause a proportional decrease in accidents. Reduced flying costs were determined by the following formula:

$$\text{Reduced Flying Costs} = \text{Low Level Flight Hour Reduction} \times \text{Hourly Flight Cost} + \text{Accident Savings}$$

When determining low level flight hours reduced, it is important to remember that a decrease in time spent at low level or on a range results in a proportionally larger overall flight hour reduction. When low level flight time is reduced, other tasks within the sortie such as landing and take-off practiced during every flight are also eliminated. Consequently, the flight hours reduced will be calculated by the formula

$$\text{Low level flight hours reduced} = \frac{\text{Sortie length} \times \text{hours at low level}}{\text{Low level hours per sortie}}$$

The Increased Simulator Costs result from an increase in simulator hours required to maintain proficiency. With a projected simulator operational cost of $262.5 per hour, the increased costs can be determined by the following algorithm:

$$\text{Increased Simulator Costs} = \frac{\text{Low Level Hours Replaced}}{\text{Training TER}} \times \$262.5$$

Three situations were evaluated. They involved use of simulators to replace 10 percent of low level navigation flight, use of simulators to replace 10 percent of air-to-surface weapons delivery time, and use of simulators to replace 5 percent of low level navigation and 10 percent of weapons delivery time.

From a review of accident statistics, it was noted that pilots with less than 1000 hours had a larger number of accidents than would be expected by chance. This was viewed as an indicator that pilots are not fully proficient at the completion of the replacement training course. This situation is not surprising, and was confirmed during informal discussions with squadron pilots. The difference between pilot confidence and pilot ability that occurs between the time a pilot completes 500 hours and the 700-hour mark has been noted by various observers. Junior pilots believe they are fully qualified. They are certified as fully qualified (combat ready), but they still need additional practice to reach their maximum potential. For this reason, the training TERs were used in the final calculations (Reference Table 7).

A-7 historical data for FY82 is presented in Table 14. FY82 dollars are used for all calculations. No assumptions on inflation were made. Table 15 presents the data on reduced flying costs for low level training and increased simulator costs.

The amortization period is the length of time required for savings realized by simulated flight training to repay the research, development, and production costs of the simulator. Research dealing with amortization has tended to focus exclusively upon the savings incurred due to the lower

TABLE 14. A-7 AIRCRAFT HISTORICAL DATA FOR FY82

Aircraft A-7E	
Number of Aircraft	309.5
Utilization Rate	33.894
Flight Hours (year)	125,882
Hourly Costs	
Fuel	892.28
Other	231.18
Total	1123.46
Annual Costs (millions)	
Fuel	112.3220
Other	29.1014
Total	141.4234

TABLE 15. A-7 COST BENEFIT (FY82 DOLLARS)

MISSION	LOW LEVEL FLIGHT	RANGE FLIGHT
10% Flight Hour Reduction	6294.1	3147.05
Aircraft Cost per Hour	1123.46	1123.46
Operational Cost Savings	7071169.6	3535584.8
Cost Correction Factor	2	4
Corrected Cost Savings	14,142,339	14,142,339
Accident Savings (10%)	538,852.16	875,634.76
Value of 10% Reduction	14,681,191	15,017,974
Training TER	0.57	0.35
Simulation Time Required	11,042	8,992
Cost/Hour	262.5	262.5
Yearly Simulation Operational Cost	2,898,525	2,360,400
Yearly Cost Benefit	11,782,666	12,657,574

operational and maintenance costs of the simulator (simulator time tends to be very inexpensive when compared to actual flight time). Accident costs, which are likely to occur with inexperienced pilots, constitute a second major expenditure which has been considered. In addition to the losses resulting from damages to the aircraft, this analysis considered benefits paid to survivors, medical costs, loss of highly trained personnel, and death gratuities.

Yearly cost benefits and the resulting amortization periods for the three situations are presented in Table 16. All three situations require the procurement of four simulators (two for each coast) at a total cost of $75 million.

TABLE 16. YEARLY COST BENEFIT

REDUCTION AND PHASE	REDUCED FLYING COSTS	INCREASED SIMULATOR COSTS	YEARLY COST BENEFIT	AMORTIZATION PERIOD
10% Navigation	14,681,191	2,898,525	11,782,666	6.36 years
10% Range	15,017,974	2,360,400	12,657,574	5.93 years
10% Range 5% Navigation	22,358,570	3,809,663	18,548,908	4.04 years

For the first two situations, where 10% of the flight time is reallocated, there are idle or unused simulator hours available. For navigation there are 4958 hours available, or about 1200 hours per simulator. For range training, there are 7008 hours available, or a total of 1750 hours per simulator. In the third siutation, 14513 simulators hours are allocated, leaving about 370 hours unused for each simulator.

SECTION 4
OBSERVATIONS AND RECOMMENDATIONS

4.1 OBSERVATIONS

4.1.1 Intangibles

In studies of simulator cost effectiveness there are always certain intangibles which must be recognized and considered. They are intangible in that they cannot be measured, nor can numerical costs or values be assigned to them. Put another way, there are inherent and important differences between aircraft and simulators that are believed, a priori, to have some effect on flight training. These include the effects of training flight at very low levels, combat training, dealing with emergencies and battle damage, and flight over hostile territory. They are largely unmeasurable, due to legal issues, danger to the pilot, danger to others, and costs.

Several pilots questioned in this study reported that, although NATOPS minimum altitude is 200 feet AGL, their Wing commanders have placed it higher, at 500 feet AGL. This could explain the good safety record of Naval pilots flying low level. They are not permitted to fly as low during training as they would in combat. Navy A-7 pilots averaged 0.79 mishaps per 100,000 hours flown in fiscal year 1982, whereas Air Force A-7 pilots, who have an official minimum altitute of 100 feet AGL, averaged almost twice as many mishaps, 1.35 per 100,000 hours. Although the NATOPS minimum is good in terms of saving lives, it may not be good in terms of training. Combat often requires levels of 100 feet and lower. If pilots do not experience low level flight in peacetime, they will not be prepared for war. Currently, when pilots are trained to fly low level at 500 feet AGL, the aircraft is actually serving as a "simulator" for low level flight. Apparently, commanders have decided that it is too costly in lives and aircraft, to train pilots at combat levels in the aircraft. In contrast to this, it is possible to fly a simulator at very low altitudes with no danger at all (except perhaps to the pilot's ego). The ability to train at realistic combat altitudes should result in better wartime performance.

A second difference between simulators and aircraft is that combat may be trained (quite safely) in a simulator; this is often a difficult and sometimes impossible task in an aircraft. Tracers, enemy fighters, and antiaircraft artillery can be simulated with greater ease and at lower cost than in an aircraft. In fact, the costs and difficulties of visually simulating hostile activity while training in actual aircraft are so great that few attempts are made to include such effects. In addition to these capabilities, the psychological stress induced by the sounds of combat (radio transmissions, etc.) can be produced without the danger of a stress-related aircraft accident or fatality.

It has been shown that simulators are more useful than aircraft in training pilots to deal with emergencies and battle damage. It is impractical as well as dangerous to try to train aircrews to cope with these situations in an aircraft. The simulator can better prepare the pilot to deal with these events should they occur in actual flight.

Another area in which simulators are superior to aircraft in training value is flight over hostile territory. With a hostile territory data base, simulators can be used to train pilots to fly in areas to which they would not normally have access.

In the areas of low level flight training, combat readiness training, preparing for flight over hostile territory, and dealing with emergencies or battle damage, the simulator has obvious advantages over training in the aircraft. Although these qualities are unmeasurable, it is important that they be considered in any study of simulator cost effectivness.

4.1.2 Instructor Training

In the process of answering the questionnaire used in this study, personnel at several bases commented that instructors needed better training in use of simulators. This raises a valid point, often overlooked in studies of simulator cost effectiveness: if instructors do not use the simulator to its full capability, cost-effective training may not be provided despite estimations and calculations to the contrary. For instance, two functions of the simulator which are often disregarded but which could be invaluable to training are the freeze and reset functions. The freeze button can be pushed any time during a simulated flight to stop action, giving the instructor and student an opportunity to discuss difficulties as they occur. This provides immediate feedback to the student, which improves learning. The reset function allows the instructor to change the area where the student is flying without requiring the student to complete the flight. This means that instead of wasting time practicing something the student already does well, the scenario can be switched and the simulator relocated to a different route segment. The reset function can permit reflying a particular navigation leg or final bomb run without wasting time flying back to the initial point.

Human beings are notoriously poor monitors, and it is easy for the instructor's attention to be diverted from the student's performance. One possible solution to this problem could be an automatic scoring system that keeps track of the student's mistakes, replaying them at the end of the flight. At the end of the student's flight, the instructor could discuss the mistakes with the student. In this way, all mistakes could be covered efficiently with little waste of time.

It is evident that instructor training plays an important role in simulator cost effectiveness. For simulator training to be of the greatest benefit, it is necessary for the instructor to be given good training and the knowledge to do their job well.

4.1.3 Simulator Quality

In assessing the cost effectiveness of flight simulators it becomes increasingly apparent that the issue of simulator quality is one of prime importance. This issue was brought up by naval aviators on several occasions during the course of this study. The consensus of most of the crewmembers questioned was that current simulators are simply not useful for training because the quality is too poor. In all, 35 of the 61 pilots who participated in the study commented on simulator quality. The majority of these comments specifically addressed visual quality.

Low level simulation capability at two of the bases visited for this project was found to be inadequate. Neither the FB-111 simulator at Williams AFB, nor the B-52 WST at Castle AFB are capable of providing effective low level training in their current configuration. The major problem with both simulators seemed to be one of an inadequate visual system.

Bickley (1980) states "with past simulators, the cost differential between simulator and aircraft training has been so great that a marginally effective simulator might be used to realize overall training savings." Unfortunately, simulators have grown too complex, and thus, too expensive, to allow for cost effectiveness with poor or even mediocre trainers. It became necessary to address quality in this study, although it was not a requirement, because transfer effectiveness is a function of quality. In order to obtain the data needed for the computation of TERs, personnel answering the questionnaire were asked to assume a high level of simulator quality and were presented with representative still and dynamic imagery (provided by NTEC) of good visual simulation as examples.

It seems essential that, if flight training is to be efficient and cost effective, simulation must be improved. Improvements must be made, especially in the area of visual scenes. Terrain boards have proven to be too small and too expensive. Computer generated imagery provides an interesting alternative, but questions addressing the level of detail and minimum field of view remain unanswered. The use of texture and stereoscopic viewing may be useful, but minimum levels have not been determined.

It is essential that simulators be improved if quality training is to be provided to aviators. Improved cost effectiveness and savings in terms of crewmembers' lives certainly justify these changes.

4.1.4 Augmentation

It seems apparent from the results of this study that an increase in cost effectiveness could be achieved by transferring low level navigation training hours in the aircraft to training in the simulator. It should be emphasized, however, that those hours in the aircraft be reallocated to training for other flight tasks.

The overwhelming consensus among those pilots involved in the study was that even a small cut in flight time is unacceptable, because they now fly a minimal number of hours. It is thus imperative that low level navigation training hours not be omitted totally, but rather reallocated to some other task. This time could then be supplemented by low level training in the simulator. Pilots seemed very enthusiastic about the idea of augmenting their flight time with simulator hours, as long as the simulator is of high quality. Our data seem to support this course of action.

4.1.5 Air-to-Ground Attack

In the process of analyzing the data for this project it became apparent that an increase in cost effectiveness could be achieved by simulating air-to-ground attack maneuvering as well as low level navigation. There are several reasons for this improvement. First, there appear to be more accidents during the aggressive maneuvering associated with air-to-surface weapon delivery than during the relatively smooth flying associated with navigation. By using the same basic visual simulator for air-to-surface weapon delivery and for low level navigation, its usefulness is increased without incurring additional costs; the number of accidents that can be prevented is also increased. This produces a direct benefit in cost savings. Secondly, because the visual data base for a target area is smaller than for an entire low level route, the simulation can be developed sooner and at lower cost. An earlier incommission date will produce savings earlier.

A typical low level route must be fairly long, in order to present navigational problems (such as wind) that promote learning. This presents problems for simulation, for it takes time and money to program the data base for the simulator, and the longer the route, the more expensive it will be in hours and funds. Air-to-ground attack simulation would be more efficient in this respect, since only a small area is required for the training of this task.

Another advantage to simulation of air-to-ground attack in addition to low level navigation is that there are more possibilities for the application of new technology in this area. For instance, we now have the ability to simulate moving tanks, trucks, ships, and aircraft by computer with a very realistic appearance. By providing moving targets, training is enhanced in two ways: (1) target detection and identification is practiced, that is, crews may be required to determine whether a vehicle or ship is hostile prior to attacking it; and (2) practice in tracking moving targets is provided. In addition, it is possible to use the same technology as that developed for low level flight to provide stationary military targets such as bridges or simple circular target rings.

Another benefit of using simulation for training air-to-ground attack is the material and time that will be saved. In a simulator, it is possible to re-arm while in flight; in an aircraft this is not possible. For weapons delivery sorties, an aircraft typically carries 6 practice bombs and 100 rounds of ammunition. It requires from 50 to 150 minutes of flight time to deliver the ordnance load. If a bomb pattern requires 2 minutes, it is possible to get 25 bomb deliveries in a 50-minute simulator sortie. This is four times as many as can be accomplished in the aircraft. Thus, a pilot can fire more rounds, drop more bombs, and receive more targeting practice than would be possible in an aircraft. Such an increase would permit a TER as low as 0.25 to still show an advantage.

The most important savings resulting from the simulation of air-to-ground attack is in lives. More accidents result from air-to-ground than from low level navigation although at least a portion of air-to-ground accidents do occur as a result of the low levels flown for this task. Therefore, simulation training of air-to-ground attack would not only be a cost-saver, but would help save more lives in both low level navigation and range training.

4.2 SUMMARY AND RECOMMENDATIONS

Development of a visual simulator for low level and range flight would have distinct training and cost benefits. Transfer Effectiveness Ratios were determined for several aircraft based on subjective estimates of pilots. Overall, the results indicated that A-7 training on the simulator would be cost effective despite the somewhat low TERs. The combined savings resulting from a 10 percent decrease in range flight hours and a 5 percent decrease in low level hours were determined for the A-7. Four simulators would be required to accommodate reductions of this magnitude. The savings resulting from the reductions in flight hours combined with the savings resulting from decreased accidents will amortize four simulators in 4.4 years.

4.2.1 Study Findings

a. Based on subjective estimates of pilots and crewmembers, a general function relating simulator hours and aircraft hours was developed for each aircraft. Using these functions, it is possible to determine the transfer effectiveness ratios for different combinations of simulator and flight hours.

b. Accident costs were determined on a yearly basis for each aircraft. These accident costs were based on the yearly accident rate, damages to the aircraft, benefits paid to survivors, and personal injury costs.

c. Savings resulting from a reduction in accidents were combined with reduced operational and maintenance costs of the aircraft to determine the total savings resulting from simulation.

d. Cost benefits were calculated for each aircraft based on a 10 percent reduction in low level and range hours. Generally, the cost benefits were positive at this point on the learning curve. It is likely, however, on these aircraft a higher cost benefit will result by using a more optimal mix of simulator and flight hours.

e. Based on a 10 percent reduction in total yearly range flight hours and a 5 percent reduction in yearly low level hours, the amortization period was determined for the A-7. Four simulators would be necessary to accommodate reductions of this magnitude. The four simulators would be amortized in 4.1 years.

4.2.2 Recommendations for Further Efforts

a. Perform a training requirements analysis to determine the hardware requirements for the proposed simulator system.

b. Consideration should be given to establishing the minimum visual cues necessary for successful performance of the flight task.

c. Consider the implementation of a program to integrate the proposed simulator visual system with existing simulator cockpits.

d. Review the possibilities of expanding the scope of the present effort to provide the proposed simulator technology for ultimate incorporation with the needs and missions of the rotary wing community.

e. The methodology and assumptions leading to the conclusions cited in this report should be verified in a follow-on study.

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GLOSSARY

AAA	Antiaircraft artillery.
A/C	Aircraft.
ACM	Air combat maneuvers.
AFB	Air Force Base.
AFHRL	Air Force Human Resources Laboratory.
AGL	Above ground level.
ASPT	Advanced System Pilot Trainer.
B/N	Bombardier-navigator.
CGI	Computer Generated Imagery.
CGSI	Computer Generated Synthesized Imagery.
COMFITAEWPAC	Commander, Fighter Airborne Early Warning Wing, Pacific Fleet.
CNATRA	Commander, Naval Air Training.
CNO	Chief of Naval Operations.
CQ	Carrier qualification.
DBGS	Data Base Generation System.
DF	Degrees of freedom.
DIG	Digital Image Generation.
DMA	Defense Mapping Agency.
EW	Electronic warfare.
FLIR	Forward Looking Infrared
FOT&E	Flight Operational Testing and Evaluation.
FRS	Fleet readiness squadron.
IFR	Instrument flight rules.

IMC	Instrument meteorological conditions.
LCCA	Life cycle cost analysis.
MCAS	Marine Corps Air Station.
MH	Man-hours.
MY	Man-years.
NAS	Naval Air Station.
NCLT	Night Carrier Landing Trainer
NOE	Nap of the earth.
NTEC	Naval Training Equipment Center.
OFT	Operational Flight Trainer.
OPNAVINST	Operational Navigation Instruction
ORDNANCE	Weaponry.
PERCENT TRANSFER	The amount of time saved in in-flight training due to the simulator and/or other training innovations.
POL	Petroleum, oil, and lubricants.
SIMSPO	Simulation Systems Programs Office.
SNS	Satellite Navigation System.
TA	Terrain avoidance.
TARPS	Tactical Action Reconnaissance Pod System.
TC	Terrain clearance.
TER	Transfer Effectiveness Ratio.
TEXTURE STREAMING	A visual cue.
TF	Terrain following.
TR	Terrain recognition.
TRANSFER EFFECTIVENESS RATIO	A comparison between flight hours saved and time spent in the simulator.

VFR	Visual flight rules.
VIS	Visual Imaging System.
WST	Weapons System Trainer.
WTT	Weapons Tactics Trainer.

APPENDIX A
QUESTIONNAIRE AND INTERVIEW FORMS

This appendix contains examples of the survey data collection material used to obtain the opinions of experienced pilots at various military air stations.

Surveys A and B were administered to experienced pilots. These surveys deal with data relevant to low level flight, low level training, and simulator effectiveness. A blank survey A and B questionnaire is included in this appendix.

(SURVEY A)

INSTRUCTIONS

As part of a low level flight training cost effectiveness study, NTEC has asked us to consider various factors involved in training pilots in such skills. What follows is a series of questions designed to gauge some of the facets of low level training.

There are two types of questions. The first type has a line scale beneath it. An example is given below.

EXAMPLE: How much of a pilots capacity for concentration is needed for low level flight?

0%	25%	50%	75%	100%

These questions should be answered by placing a mark on the line at the point you feel represents the best answer as shown in red above.

The second type requires a short written or verbal answer. Space necessary for your answer is provided.

To assure that each person interviewed uses the same terminology, the following definitions are provided:

LOW LEVEL FLIGHT - Any type of flight involving point-to-point navigation or maneuvers with an average altitude of 500 or less AGL. Takeoffs and landings or instrument approaches are not considered low level flight for the purposes of this questionnaire.

MINIMUM ENROUTE ALTITUDE (MEA) - Flight at a constant altitude high enough to clear the highest terrain in the flight corridor. No attempt is made to match the flightpath to terrain contours.

TERRAIN FOLLOWING (TF) - Minimum altitude maintained only by changes in pitch.

TERRAIN AVOIDANCE (TA) - Minimum altitude maintained by changes in pitch and roll.

PSYCHOLOGICAL STRESS - Anxiety or uneasiness caused by a great deal of demand being placed on the pilot.

Finally, careful consideration of each item on this questionnaire will be appreciated. Thank you for your cooperation.

1. How often do you engage in low level flight?

never	less than once per month	at least once per month but less than twice per week	at least twice per week but less than every day	every day

How long is a typical mission which involves low level flight?
(hours and minutes) ____________

2. How much time during this mission is spent in low level flight?
(hours and minutes) ____________

3. How much of your low level flight time is spent in Minimum Enroute Altitude flight?

0%	25%	50%	75%	100%

4. How much of your low level flight time is spent in Terrain Avoidance flight?

0%	25%	50%	75%	100%

5. How much of your low level flight time is spent in Terrain Following flight?

0%	25%	50%	75%	100%

6. How much physical stress is felt by pilots during low level flight?

low	moderately low	average	moderately high	high

7. How much Psychological Stress is felt by pilots during low level flight in general?

low	moderately low	average	moderately high	high

On the same line (in question 7), mark the amount of psychological stress felt by pilots during low level flight at night with an N, during overcast weather with a W, during the day with a D, during a thunderstorm with a T and during an overcast night with NW. When complete, there should be six labeled marks on the line in question 7.

8. How much psychological stress is felt by pilots during high altitude navigation flight?

low	moderately low	average	moderately high	high

9. How high is pilot workload during low level flight?

low	moderately low	average	moderately high	high

10. How much of your low level training is non-productive time (i.e., ingress and egress to and from training area, etc.)?

0%	25%	50%	75%	100%

11. How adequate is your low level flight training in relation to your formation flight training?

much less adequate	slightly less adequate	equally adequate	slightly more adequate	much more adequate

12. What are the minimum weather conditions for scheduling a pilot in a training flight mission:

    100 hours after earning wings ______________________

    500 hours after earning wings ______________________

    Fully mission ready ______________________

13. How many low level practice sorties after undergradute pilot training does a pilot need to reach proficiency?

    In a simulator: ______________________________

    In an aircraft: ______________________________

14. Is it desirable to simulate turbulence, weather, and darkness conditions before the student aviator actually experiences them?

15. How many hours of simulation are accomplished in each of the following training phases?

    Transition:

    Instrument:

    Formation:

    Navigation:

16. What conditions of flight training at the undergraduate level are not currently being simulated?

    Takeoff ______________________________

    Landing ______________________________

    Instrument flight ______________________________

    Cockpit procedures ______________________________

    Formation ______________________________

    Visual flight ______________________________

    Other ______________________________

(SURVEY B)

Type of Aircraft ______________________
Total Flight Hours in Aircraft __________

The items stated below are open-ended questions to be used in assessing the cost effectiveness of visual simulation of low level flight. Please try to answer the questions as fully as possible. If the data for a particular question is not available at the time of interview, arrangements can be made to forward the material to Systems Research Laboratories, Inc. (SRL), Dayton, Ohio.

Thank you for your help with this survey.

1. How much time is spent flying low level now?

2. How much should be spent flying low level?

3. How much time is spent in the simulator per month now and how much should you have?

4. If you could augment your current flying hours with simulator hours, how many would you add in each of the following categories:

   formation __________________
   navigation __________________
   visual operations __________________

5. If your flying time was cut by 10%, how many simulator hours would it take to replace it?

   If your flying time was cut by 50%, then how many simulator hours would it take to replace it?

6. Of the following tasks during low level flight what per cent of each of these could be practiced to proficiency in a simulator?

Map reading ______

Other navigational tasks (such as flight log and calculation) ______

Correlation of map and visual scene ______

Aircraft flight control ______

Equipment operation:
- radio ______
- fuel ______
- armament ______
- IFF ______
- INS ______

Crew coordination ______

Interpretation of sensor displays ______

Mission tasks:
- target ID ______
- attack target ______
- avoid hostile gunfire/missiles/ aircraft ______

External communications ______

Deal with weather, lightning, turbulence, storms ______

Deal with emergency/battle damage ______

Change flight plan route or destination ______

7. What types of low level (e.g., point-to-point navigation) flight are currently being simulated at this facility?

a. Type of aircraft ______

b. Kind of low level maneuvers performed ______

c. Weather (IFR/VFR) ______

d. Terrain ______

8. Who is the simulator intended to train?

   a. Pilots only ____________

   b. Crewmembers (list) ____________________________

   c. Both ____________

9. Are cockpit environmental conditions as well as external flight conditions simulated?

   a. Turbulence ____________________

   b. Heat ____________________

   c. Workload ____________________

   d. External, non-relevant communications ____________________

   e. Lighting ____________________

   f. Sound ____________________

10. How many missions are flown involving low level flight per pilot?

    a. How many missions are flown involving low level flight per squadron?

    b. How many missions are flown involving low level flight per wing?

11. Please use this area for your comments. Comment on any costing or training areas you feel we may have overlooked.

APPENDIX B
SUMMARY STATISTICS OF QUESTIONNAIRE RESPONSES

This appendix contains the summary statistics for the questionnaires administered to Navy and Marine pilots. These statistics are grouped by question. Within each question the statistics are grouped by both aircraft and squadron type.

Also included is the number of respondents and the number not responding. Note that there were no operational F/A-18 pilots in the survey, nor were there any A-4 or F-4 training pilots in the sample.

QUESTION A-1: How often do you engage in low level flight?

0	2.5	5.0	7.5	10.0
never	less than once per month	at least once per month but less than twice per week	at least twice per week but less than every day	every day

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 3
Mean	= 5.38	Mean	= 7.4
Median	= 5.15	Median	= 7.5

AIRCRAFT: A-6

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 15	N	= 6
Mean	= 6.6	Mean	= 6.4
Median	= 6.5	Median	= 6.3

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 1
Mean	= 6.5	Mean	= 2.5
Median	= 6.4	Median	= 2.5

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 3 NR (1)	N	= 1
Mean	= 9.1	Mean	= 5
Median	= 9.8	Median	= 5

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 5.1
Median	= —	Median	= 5.0

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 5.	N	= —
Mean	= 5.7	Mean	= —
Median	= 5.0	Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 2	N	= —
Mean	= 5.7	Mean	= —
Median	= 5.7	Median	= —

QUESTION A-1A: How long is a typical mission which involves low level flight (hours)?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 3
Mean	= 1.9	Mean	= 2.3
Median	= 2.0	Median	= 2.5

AIRCRAFT: A-6

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 15	N	= 6
Mean	= 2.4	Mean	= 2.58
Median	= 2.5	Median	= 2.50

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 1
Mean	= 0.93	Mean	= 1.0
Median	= 0.94	Median	= 1.0

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 4	N	= 1
Mean	= 3.375	Mean	= 2.0
Median	= 3.500	Median	= 2.0

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 1.33
Median	= —	Median	= 1.5

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 5	N	= —
Mean	= 1.41	Mean	= —
Median	= 1.50	Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 2	N	= —
Mean	= 1.25	Mean	= —
Median	= 1.25	Median	= —

QUESTION A-2: How much time during this mission is spent in low level flight (hours)?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 3
Mean	= 1.04	Mean	= 0.83
Median	= 1.00	Median	= 0.83

AIRCRAFT: A-6

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 15	N	= 6
Mean	= 1.05	Mean	= 1.230
Median	= 1.00	Median	= 1.125

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 1
Mean	= 0.532	Mean	= 0.750
Median	= 0.500	Median	= 0.75

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 4	N	= 1
Mean	= 2.88	Mean	= 0.92
Median	= 3.25	Median	= 0.92

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 0.67
Median	= —	Median	= 0.60

AIRCRAFT: A-4

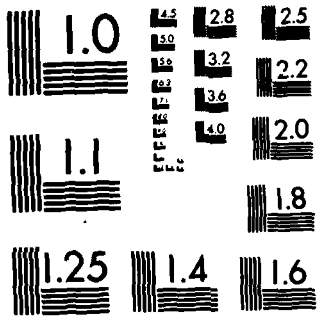
OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 3	N	= —
Mean	= 0.92	Mean	= —
Median	= 1.00	Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 2	N	= —
Mean	= 0.625	Mean	= —
Median	= 0.625	Median	= —

AD-A143 293 COST EFFECTIVENESS OF SIMULATION FOR LOW LEVEL FLIGHT TRAINING(U) SYSTEMS RESEARCH LABS INC WESTLAKE VILLAGE CA R P BATEMAN ET AL. MAY 83 NAVTRAEQUIPC-IH-352 2/2

UNCLASSIFIED F/G 5/9 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

QUESTION A-3: How much of your low level flight time is spent in Minimum Enroute Altitude flight?

0% 25% 50% 75% 100%

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 3
Mean	= 22.8	Mean	= 22.3
Median	= 13.5	Median	= 25.0

AIRCRAFT: A-6

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 15	N	= 6
Mean	= 29.47	Mean	= 20.17
Median	= 25.00	Median	= 11.50

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 1
Mean	= 35.30	Mean	= 12.00
Median	= 34.00	Median	= 12.00

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 3	N	= 1
Mean	= 77.67	Mean	= 25
Median	= 86.00	Median	= 25

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 24.25
Median	= —	Median	= 18.50

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 3	N	= —
Mean	= 7.67	Mean	= —
Median	= 7.00	Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 2	N	= —
Mean	= 50.00	Mean	= —
Median	= 50.00	Median	= —

QUESTION A-4: How much of your low level flight time is spent in Terrain Avoidance flight?

0% 25% 50% 75% 100%

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 3
Mean	= 50.30	Mean	= 54.00
Median	= 55.50	Median	= 50.00

AIRCRAFT: A-6

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 14	N	= 6
Mean	= 40.86	Mean	= 48.83
Median	= 38.50	Median	= 50.00

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 9 NR (1)	N	= 1
Mean	= 48.22	Mean	= 25.00
Median	= 50.00	Median	= 25.00

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 3	N	= 1
Mean	= 13.00	Mean	= 4.00
Median	= 11.00	Median	= 4.00

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 51.15
Median	= —	Median	= 55.00

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 5	N	= —
Mean	= 53.60	Mean	= —
Median	= 61.00	Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 2	N	= —
Mean	= 12.00	Mean	= —
Median	= 12.00	Median	= —

QUESTION A-5: How much of your low level flight time is spent in Terrain Following flight?

0%	25%	50%	75%	100%

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 10		N	= 3
Mean	= 39.10		Mean	= 51.00
Median	= 29.00		Median	= 25.00

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 15		N	= 7
Mean	= 44.27		Mean	= 50.50
Median	= 46.00		Median	= 50.00

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 9	NR (1)	N	= 1
Mean	= 42.11		Mean	= 75.00
Median	= 44.00		Median	= 75.00

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 4		N	= 1
Mean	= 7.00		Mean	= 4.00
Median	= 14.00		Median	= 4.00

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	=		N	= 4
Mean	=		Mean	= 42.75
Median	=		Median	= 48.00

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 5		N	= —
Mean	= 51.00		Mean	= —
Median	= 50.00		Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 2		N	= —
Mean	= 12.50		Mean	= —
Median	= 12.50		Median	= —

QUESTION A-6: How much physical stress is felt by pilots during low level flight?

0	2.5	5.0	7.5	10.0
low	moderately low	average	moderately high	high

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 10		N	= 2	
Mean	= 5.28		Mean	= 5.55	
Median	= 6.05		Median	= 5.55	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 14	NR (1)	N	= 5	NR (1)
Mean	=6.60		Mean	= 5.12	
Median	= 7.05		Median	= 5.00	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 9	NR (1)	N	= 1	
Mean	= 6.36		Mean	= 8.20	
Median	= 6.30		Median	= 8.20	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 4		N	= 1	
Mean	= 4.625		Mean	= 2.50	
Median	= 4.900		Median	= 2.50	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 4	
Mean	= —		Mean	= 7.02	
Median	= —		Median	= 7.10	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 5		N	= —	
Mean	= 5.16		Mean	= —	
Median	= 5.00		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1		N	= —	
Mean	= 75.00		Mean	= —	
Median	= 75.00		Median	= —	

QUESTION A-7G: How much Psychological Stress is felt by pilots during low level flight in general?

0	2.5	5.0	7.5	10.0
low	moderately low	average	moderately high	high

AIRCRAFT: A-7

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 9	NR (1)		N	= 2	NR (1)
Mean	= 6.97			Mean	= 7	
Median	= 6.9			Median	= 7	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 10	NR (5)		N	= 4	NR (2)
Mean	= 6.54			Mean	= 5.95	
Median	= 7.0			Median	= 6.83	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 6	NR (4)		N	= 1	
Mean	= 5.83			Mean	= 7.5	
Median	= 6.05			Median	= 7.5	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 2	NR (2)		N	= —	NR (1)
Mean	= 4/25			Mean	= —	
Median	= 4.25			Median	= —	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= —			N	= 4	
Mean	= —			Mean	= 6.87	
Median	= —			Median	= 6.7	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 3	NR (2)		N	= —	
Mean	= 6.87			Mean	= —	
Median	= 7.50			Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 1			N	= —	
Mean	= 8.7			Mean	= —	
Median	= 8.7			Median	= —	

QUESTION A-7N: How much psychological stress is felt by pilots flying low level at night?

0	2.5	5.0	7.5	10.0
low	moderately low	average	moderately high	high

AIRCRAFT: A-7

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 7	NR (3)		N	= 3	
Mean	= 8.99			Mean	= 9.17	
Median	= 9.5			Median	= 10	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 13	NR (2)		N	= 6	
Mean	= 8.62			Mean	= 8.65	
Median	= 8.60			Median	= 9.15	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 5	NR (5)		N	= —	NR (1)
Mean	= 7.72			Mean	= —	
Median	= 8.8			Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 4			N	= —	NR (1)
Mean	= 6.18			Mean	= —	
Median	= 5.4			Median	= —	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= —			N	= 3	NR(1)
Mean	= —			Mean	= 8.73	
Median	= —			Median	= 8.9	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 3	NR (2)		N	= —	
Mean	= 8.4			Mean	= —	
Median	= 8.5			Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 1	NR (1)		N	= —	
Mean	= 100			Mean	= —	
Median	= 100			Median	= —	

QUESTION 7-W: How much psychological stress is felt by pilots during low level flight in overcast weather?

0	2.5	5.0	7.5	10.0
low	moderately low	average	moderately high	high

AIRCRAFT: A-7

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	6	NR (4)	N	=	3	
Mean	=	7.68		Mean	=	8/43	
Median	=	7.5		Median	=	8.1	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	13	NR (2)	N	=	6	
Mean	=	7.53		Mean	=	7.27	
Median	=	7.5		Median	=	7.75	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	10		N	=	—	NR (1)
Mean	=	7.08		Mean	=	—	
Median	=	7.75		Median	=	—	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	3		N	=	—	NR (1)
Mean	=	6.8		Mean	=	—	
Median	=	6.2		Median	=	—	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	—		N	=	3	NR (1)
Mean	=	—		Mean	=	7.7	
Median	=	—		Median	=	7.3	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	5		N	=	—	
Mean	=	7.34		Mean	=	—	
Median	=	7.5		Median	=	—	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	1	NR (1)	N	=	—	
Mean	=	74		Mean	=	—	
Median	=	74		Median	=	—	

QUESTION A-7D: How much psychological stress is felt by pilots during low level flight during the day?

0	2.5	5.0	7.5	10.0
low	moderately low	average	moderately high	high

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 6	NR (4)	N	= 3	
Mean	= 5.13		Mean	= 4.27	
Median	= 6.3		Median	= 5.1	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 15		N	= 6	
Mean	= 5.39		Mean	= 4.95	
Median	= 6.0		Median	= 5.85	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 9	NR (1)	N	= —	NR (1)
Mean	= 5.3		Mean	= —	
Median	= 5.8		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= 1	
Mean	= 5.13		Mean	= 2.5	
Median	= 4.4		Median	= 2.5	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 3	NR (1)
Mean	= —		Mean	= 6.97	
Median	= —		Median	= 7.3	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 5		N	= —	
Mean	= 6.16		Mean	= —	
Median	= 5.7		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1	NR (1)	N	= —	
Mean	= 7.4		Mean	= —	
Median	= 7.4		Median	= —	

QUESTION A-7T: How much psychological stress is felt by pilots during low level flight in a thunderstorm?

0	2.5	5.0	7.5	10.0
low	moderately low	average	moderately high	high

AIRCRAFT: A-7

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 8	NR (2)		N	= 3	
Mean	= 8.1			Mean	= 7.7	
Median	= 9.0			Median	= 7.3	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 11	NR (4)		N	= 6	
Mean	= 7.04			Mean	= 7.45	
Median	= 7.4			Median	= 7.85	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 7	NR (3)		N	= —	NR (1)
Mean	= 7.46			Mean	= —	
Median	= 8.4			Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 3	NR (1)		N	= —	NR (1)
Mean	= 7.67			Mean	= —	
Median	= 7.3			Median	= —	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= —			N	= 3	NR (1)
Mean	= —			Mean	= 8.43	
Median	= —			Median	= 8.2	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 4	NR (1)		N	= —	
Mean	= 9.02			Mean	= —	
Median	= 9.1			Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 1	NR (1)		N	= —	
Mean	= 9.3			Mean	= —	
Median	= 9.3			Median	= —	

QUESTION A-7NW: How much psychological stress is felt by pilots flying low level during an overcast night?

0	2.5	5.0	7.5	10.0
low	moderately low	average	moderately high	high

AIRCRAFT: A-7

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 7	NR (3)		N	= 2	NR (1)
Mean	= 9.79			Mean	= 9.5	
Median	= 10.00			Median	= 9.5	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 13	NR (2)		N	= 6	
Mean	= 6.72			Mean	= 9.17	
Median	= 9.5			Median	= 9.35	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 4	NR (6)		N	= —	NR (1)
Mean	= 0.7			Mean	= —	
Median	= 9.7			Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 3	NR (1)		N	= —	NR (1)
Mean	= 3.0			Mean	= —	
Median	= 7.5			Median	= —	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= —			N	= 3	NR (1)
Mean	= —			Mean	= 9.37	
Median	= —			Median	= 9.30	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 3	NR (2)		N	= —	
Mean	= 9.27			Mean	= —	
Median	= 9.5			Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= —	NR (2)		N	= —	
Mean	= —			Mean	= —	
Median	= —			Median	= —	

QUESTION A-8: How much psychological stress is felt by pilots during high altitude navigation flight?

0	2.5	5.0	7.5	10.0
low	moderately low	average	moderately high	high

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 3
Mean	= 1.38	Mean	= 0.73
Median	= 0.55	Median	= 0

AIRCRAFT: A-6

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 14	N	= 6
Mean	= 1/4	Mean	= 2.5
Median	= 1.3	Median	= 2.5

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 1
Mean	= 1.25	Mean	= 0
Median	= 1.15	Median	= 0

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 4	N	= 1
Mean	= 1.9	Mean	= 2.5
Median	= 2.35	Median	= 2.5

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 3.85
Median	= —	Median	= 2.5

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 5	N	= —
Mean	= 2.06	Mean	= —
Median	= 2.5	Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 1 NR (1)	N	= —
Mean	= 2.5	Mean	= —
Median	= 2.5	Median	= —

QUESTION A-9: How high is pilot workload during low level flight?

0	2.5	5.0	7.5	10.0
low	moderately low	average	moderately high	high

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 3
Mean	= 8.89	Mean	= 8.9
Median	= 8.9	Median	= 9.2

AIRCRAFT: A-6

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 15	N	= 6
Mean	= 6.98	Mean	= 6.97
Median	= 7.5	Median	= 7.2

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 1
Mean	= 7.76	Mean	= 8.5
Median	= 9.5	Median	= 8.5

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 4	N	= 1
Mean	= 6.95	Mean	= 3/8
Median	= 7	Median	= 3.8

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 7.22
Median	= —	Median	= 7.5

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 5	N	= —
Mean	= 7.5	Mean	= —
Median	= 7.7	Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 1 NR (1)	N	= —
Mean	= 7.5	Mean	= —
Median	= 7.5	Median	= —

QUESTION A-10: How much of your low level training is non-productive time (i.e., ingress and egress to and from training, area, etc.)?

0% 25% 50% 75% 100%

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 3
Mean	= 30.6	Mean	= 41.67
Median	= 36.5	Median	= 40

AIRCRAFT: A-6

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 15	N	= 6
Mean	= 23.93	Mean	= 30.33
Median	= 23	Median	= 26.5

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 10	N	= 1
Mean	= 27.3	Mean	= 5
Median	= 25.5	Median	= 5

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 4	N	= 1
Mean	= 19	Mean	= 2
Median	= 14.5	Median	= 2

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 18.75
Median	= —	Median	= 25

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 5	N	= —
Mean	= 24.4	Mean	= —
Median	= 25	Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 2	N	= —
Mean	= 25	Mean	= —
Median	= 25	Median	= --

QUESTION A-11: How adequate is your low level flight training in relation to your formation flight training?

0	2.5	5.0	7.5	10.0
much less adequate	slightly less adequate	eqyally adequate	slightly more adequate	much more adequate

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 9	NR (1)	N	= 3
Mean	= 4.72		Mean	= 4.27
Median	= 5.0		Median	= 4.30

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 15		N	= 6
Mean	= 6.15		Mean	= 6.85
Median	= 7.4		Median	= 6.15

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 10		N	= 1
Mean	= 7.63		Mean	= 10
Median	= 6.25		Median	= 10

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 3	NR (1)	N	= 1
Mean	= 2.73		Mean	= 0
Median	= 2.8		Median	= 0

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= —		N	= 4
Mean	= —		Mean	= 5.48
Median	= —		Median	= 5.05

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 5		N	= —
Mean	= 8.12		Mean	= —
Median	= 8.00		Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 1	NR (1)	N	= —
Mean	= 10		Mean	= —
Median	= 10		Median	= —

QUESTION A-12A: What are the minimum weather conditions for scheduling a pilot in a training flight mission? 100 hours after earning wings

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS
200'/2	200 1/2	100-5
200'/1/2 NMVIS	3000/5	3000'/5 MI
3000/5	3000/5	3000/5
VFR	3000/5	N = 3
3000'/5	3000/5	
N = 10		

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
200 1/2	3000/5	NR (7)	1500'/5	NR (2)
VFR/IFR	300/5		3000/5	
1000/2			VFR	
300/1			VFR	
2000/4 MI			N = 4	
3000/5 MI				
N = 8				

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
3000/5	3000/5	NR (3)		NR (1)
2000/3	300' + 1 NM			
5000/7	3000/5			
3000/5				
N = 7				

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS
300/1	NR (3)	300/1
N = 1		N = 1

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS	TRAINING SQUADRONS	
	VFR	NR (1)
	3000/5	
	N = 3	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
3000/5	
3000/5	
3000/5	
3000/5	
3000/5	
N = 5	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS
300/1	NR (1)	
N = 1		

QUESTION A-12B: What are minimum weather conditions for scheduling a pilot in a training fighter mission 500 hours after earning wings?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
200 1/2	3000/5		1000/5	
200'/ 1/2 NMVIS	3000/5		3000'/5 MI	
3000/5			3000/5	
VFR			N = 3	
3000/5				
200 1/2				
N = 8				

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
200/ 1/2	NR (10)		1500'/5	NR (2)
IFR			3000/5	
200/ 1/2			200/ 1/2	
1000'/3 MI			1000'/3 NM	
3000/5			N = 4	
N = 5				

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
3000'/5 MI	3000/5	NR (3)	—	
1000/3	3000/5		—	
3000/5	200 1/2		—	
3000/5				
N = 7				

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
300/1	NR (3)		300/1	
N = 1			N = 1	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
			VFR	NR (1)
			VFR	
			3000/5	
			N = 3	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
3000/5				
3000/5				
5000/5				
2000/3				
2000/3				
N = 5				

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
200/ 1/2	NR (1)			
N = 1				

QUESTION A-12C: What are the minimum weather conditions for scheduling a pilot in a training flight mission Fully mission ready?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS
200 1/2	3000/ 1/5 MI	NR (2)	1 000/5
200'/ 1/2 NMVIS	3000/5		3000'/5
3000/5	3000/5		3000/5
VFR	200 1/2		N = 3
N = 8			

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS
200 1/2	500 1/2 MI	NR (10)	1500'/5NR (3)
IFR	3000/5		3000/5
200/ 1/2			200/ 1/2
N = 5			N = 3

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
3000 1/5 MI	3000/5	NR (3)		NR (1)
1000/3	200/ 1/2			
2000/3	3000/5			
3000/5				
N = 7				

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS
300/1	NR (3)	300/1
N = 1		N = 1

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS	TRAINING SQUADRONS	
	VFR	NR (1)
	VFR	
	3000/5	
	N = 3	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
3000'/5	—
3000'/5	—
5000/5	—
1000/3	
1000/3	
N = 5	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS
200/ 1/2	NR (1)	—
N = 1		—

QUESTION A-13A: How many low level practice sorties after undergraduate pilot training does a pilot need to reach proficiency? In a simulator:

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 5	NR (5)	N	= 2	NR (1)
Mean	= 4.4		Mean	= 3.5	
Median	= 2		Median	= 3.5	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 13	NR (2)	N	= 4	NR (2)
Mean	= 8.8		Mean	= 3.75	
Median	= 5		Median	= 2.5	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 5	NR (5)	N	= —	NR (1)
Mean	= 16.5		Mean	= —	
Median	= 10		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 2	NR (2)	N	= 1
Mean	= 6		Mean	= 10
Median	= 6		Median	= 10

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS		
N	= —	N	= —	NR (4)
Mean	= —	Mean	= —	
Median	= —	Median	= —	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 1	NR (4)	N	= —
Mean	= 0		Mean	= —
Median	= 0		Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 1	NR (1)	N	= —
Mean	= 1.5		Mean	= —
Median	= 1.5		Median	= —

QUESTION A-13B: How many low level practice sorties after undergraduate training does a pilot need to reach proficiency? In an aircraft:

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (2)	N	= 3	
Mean	= 11.25		Mean	= 11	
Median	= 8.00		Median	= 9	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 15		N	= 5	NR (1)
Mean	= 12.60		Mean	= 6.8	
Median	= 10.00		Median	= 5.0	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 10		N	= —	NR (1)
Mean	= 20.65		Mean	= —	
Median	= 13.75		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 2	NR (2)	N	= 1	
Mean	= 3		Mean	= 4	
Median	= 3		Median	= 4	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 4	
Mean	= —		Mean	= 7.375	
Median	= —		Median	= 7.25	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 5		N	= —	
Mean	= 11.6		Mean	= —	
Median	= 12		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 2		N	= —	
Mean	= 5.75		Mean	= —	
Median	= 5.75		Median	= —	

QUESTION A-14: Is it desirable to simulate turbulence, weather, and darkness conditions before the student aviator actually experiences them?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
9 Yes	2 Yes
1 No	1 No

AIRCRAFT: A-6

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
15 Yes	6 Yes
0 No	0 No

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
8 Yes	1 Yes
1 No	0 No

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
3 Yes	1 Yes
0 No	0 No

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
	4 Yes
	0 No

AIRCRAFT: A-4

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
4 Yes	—
1 No	—

AIRCRAFT: F-4

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
2 Yes	—
0 No	—

QUESTION A-15A: How many hours of simulation are accomplished in each of the following training phases? Transition.

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (2)	N	= 3	
Mean	= 11.25		Mean	= 5.33	
Median	= 7		Median	= 8	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (7)	N	= 3	NR (3)
Mean	= 6.31		Mean	= 6.33	
Median	= 4.5		Median	= 6	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= 1	
Mean	= 8.57		Mean	= 0	
Median	= 5		Median	= 0	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= 1	
Mean	= 26.67		Mean	= 15	
Median	= 27		Median	= 15	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —	NR	N	= 4	
Mean	= —		Mean	= 9.25	
Median	= —		Median	= 8	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 2	NR (3)	N	= —	
Mean	= 9.75		Mean	= —	
Median	= 9.75		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —	NR (2)	N	= —	
Mean	= —		Mean	= —	
Median	= —		Median	= —	

QUESTION A-15B: How many hours of simulation are accomplished in each of the following training phases? Instrument.

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 9	NR (1)	N	= 2	NR (1)
Mean	= 6.11		Mean	= 8	
Median	= 3		Median	= 8	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (7)	N	= 4	NR (2)
Mean	= 6.625		Mean	= 6.25	
Median	= 3.5		Median	= 6.5	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 7	NR (3)	N	= 1
Mean	= 9.71		Mean	= 10
Median	= 5		Median	= 10

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 2	NR (2)	N	= 1
Mean	= 13		Mean	= 3
Median	= 13		Median	= 3

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 7.625
Median	= —	Median	= 6.25

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 5	N	= —
Mean	= 5	Mean	= —
Median	= 5	Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= —	NR (2)	N	= —
Mean	= —		Mean	= —
Median	= —		Median	= —

QUESTION A-15C: How many hours of simulation are accomplished in each of the following training phases? Formation.

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 9	NR (1)	N	= 3
Mean	= 2.2		Mean	= 0
Median	= 0		Median	= 0

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 10	NR	N	= 3
Mean	= 0.2		Mean	= 0
Median	= 0		Median	= 0

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 7	NR (3)	N	= 1
Mean	= 1.14		Mean	= 0
Median	= 0		Median	= 0

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 3	NR (1)	N	= 1
Mean	= 0		Mean	= 0
Median	= 0		Median	= 0

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= —		N	= 4
Mean	= —		Mean	= 3.75
Median	= —		Median	= 0

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 5		N	= —
Mean	= 0		Mean	= —
Median	= 0		Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= —	NR (2)	N	= —
Mean	= —		Mean	= —
Median	= —		Median	= —

QUESTION A-15D: How many hours of simulation are accomplished in each of the following training phases: Navigation?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (2)	N	= 3	
Mean	= 3.25		Mean	= 0	
Median	= 0		Median	= 0	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 9	NR (6)	N	= 3	NR (3)
Mean	= 4.89		Mean	= 12.67	
Median	= 4		Median	= 8	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= 1	
Mean	= 2.14		Mean	= 0	
Median	= 0		Median	= 0	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 2	NR (2)	N	= 1	
Mean	= 10		Mean	= 0	
Median	= 10		Median	= 0	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 3
Mean	= —	Mean	= 1.33
Median	= —	Median	= 0

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 5	N	= —
Mean	= 1.2	Mean	= —
Median	= 0	Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= —
Mean	= —	Mean	= —
Median	= —	Median	= —

QUESTION A-16: What conditions of flight training at the undergraduate level are not currently being simulated?

a. Take-off
b. Landing
c. Instrument flight
d. Cockpit procedures
e. Formation
f. Visual flight

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
a.	3	a.	0
b.	4	b.	0
c.	0	c.	0
d.	0	d.	3
e.	8	e.	3
f.	5	f.	1

AIRCRAFT: A-6

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
a.	2	a.	0
b.	2	b.	0
c.	1	c.	0
d.	1	d.	0
e.	11	e.	4
f.	8	f.	4

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
a.	—	a.	—
b.	—	b.	—
c.	—	c.	—
d.	—	d.	—
e.	—	e.	—
f.	—	f.	—

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
a.	2	a.	0
b.	3	b.	0
c.	2	c.	0
d.	1	d.	0
e.	6	e.	1
f.	4	f.	1

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
a.	—	a.	0
b.	—	b.	0
c.	—	c.	0
d.	—	d.	0
e.	—	e.	3
f.	—	f.	0

QUESTION A-16 (cont'd)

AIRCRAFT: A-4

	OPERATIONAL SQUADRONS	TRAINING SQUADRONS
a.	3	—
b.	3	—
c.	1	—
d.	1	—
e.	3	—
f.	3	—

AIRCRAFT: F-4

	OPERATIONAL SQUADRONS	TRAINING SQUADRONS
a.	0	—
b.	0	—
c.	0	—
d.	0	—
e.	1	—
f.	1	—

QUESTION B-1: How much time is spent flying low level now (hours per week)?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 5	NR (4)	N	= 2	NR (1)
Mean	= 1.95		Mean	= 4.25	
Median	= 1.25		Median	= 4.25	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 9	NR (6)	N	= 5	NR (1)
Mean	= 2.4		Mean	= 3.6	
Median	= 1.33		Median	= 2.5	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 3	NR (6)	N	= 1
Mean	= 7.92		Mean	= 1.25
Median	= 7.5		Median	= 1.25

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= —	NR (4)	N	= 1
Mean	= —		Mean	= 2
Median	= —		Median	= 2

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 3
Mean	= —	Mean	= 1.79
Median	= —	Median	= 1.87

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 5	N	= —
Mean	= 1.4	Mean	= —
Median	= 1	Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= —	NR (2)	N	= —
Mean	= —		Mean	= —
Median	= —		Median	= —

QUESTION B-2: How much should be spent flying low level (hours per week)?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (7)	N	= 2	NR (1)
Mean	= 3.83		Mean	= 5.5	
Median	= 3		Median	= 5.5	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (8)	N	= 4	NR (2)
Mean	= 3.87		Mean	= 4.19	
Median	= 3		Median	= 3.5	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 5		N	= 1	
Mean	= 4.88		Mean	= 0	
Median	= 3.75		Median	= 0	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —	NR (4)	N	= 1	
Mean	= —		Mean	= 8	
Median	= —		Median	= 8	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 4	
Mean	= —		Mean	= 3.5	
Median	= —		Median	= 3	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 5		N	= —	
Mean	= 2		Mean	= —	
Median	= 1.5		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —	NR (2)	N	= —	
Mean	= —		Mean	= —	
Median	= —		Median	= —	

QUESTION B-3A: How much time is spent in the simulator per month now (hours per month)?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 10		N	= 3	
Mean	= 6		Mean	= 0.5	
Median	= 0		Median	= 0.5	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 13	NR (2)	N	= 6	
Mean	= 2.69		Mean	= 6.67	
Median	= 2		Median	= 3.5	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (2)	N	= 1	
Mean	= 0.31		Mean	= 3	
Median	= 0		Median	= 3	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= 1	
Mean	= 4.67		Mean	= 15	
Median	= 5		Median	= 15	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= —	NR (4)
Mean	= —		Mean	= —	
Median	= —		Median	= —	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 4	NR (1)	N	= —	
Mean	= 1.625		Mean	= —	
Median	= 1.5		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 2		N	= —	
Mean	= 1.25		Mean	= —	
Median	= 1.25		Median	= —	

QUESTION B-3B: How much time should you have in the simulator per month (hours per month)?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 5	NR (5)		N	= 2	NR (1)
Mean	= 1.6			Mean	= 5	
Median	= 2			Median	= 5	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 12	NR (3)		N	= 5	NR (1)
Mean	= 4.75			Mean	= 8.4	
Median	= 3.5			Median	= 3	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 4			N	= —	NR (1)
Mean	= 4.875			Mean	= —	
Median	= 4.25			Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 2	NR (6)		N	= 1	
Mean	= 12			Mean	= 20	
Median	= 12			Median	= 20	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= —			N	= 3	NR (1)
Mean	= —			Mean	= 6.13	
Median	= —			Median	= 5	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 4	NR (1)		N	= —	
Mean	= 2.25			Mean	= —	
Median	= 2.5			Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 2			N	= —	
Mean	= 1.25			Mean	= —	
Median	= 1.25			Median	= —	

QUESTION B-4A: If you could augment your current flying hours with simulator hours, how many would you add in formation flight (hours per month)?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS				TRAINING SQUADRONS	
N	= 9	NR (1)		N	= 3
Mean	= 0.81			Mean	= 1.67
Median	= 0			Median	= 0

AIRCRAFT: A-6

OPERATIONAL SQUADRONS				TRAINING SQUADRONS	
N	= 13	NR (2)		N	= 6
Mean	= 1.65			Mean	= 3.58
Median	= 0			Median	= 1.5

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS				TRAINING SQUADRONS	
N	= 7	NR (3)		N	= 1
Mean	= 0.71			Mean	= 0
Median	= 0			Median	= 0

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS				TRAINING SQUADRONS	
N	= 1	NR (3)		N	= 1
Mean	= 0.5			Mean	= 3
Median	= 0.5			Median	= 3

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= —			N	= 3	NR (1)
Mean	= —			Mean	= 0.33	
Median	= —			Median	= 0	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS	
N	= 4	NR (1)		N	= —
Mean	= 0			Mean	= —
Median	= 0			Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS	
N	= 2			N	= —
Mean	= 0.25			Mean	= —
Median	= 0.25			Median	= —

QUESTION B-4B: If you could augment your current flying hours with simulator hours, how many would you add in in-flight navigation?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 6	NR (4)	N	= 3
Mean	= 2.17		Mean	= 2.67
Median	= 1.5		Median	= 0

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 14	NR (1)	N	= 6
Mean	= 3.5		Mean	= 4.33
Median	= 2		Median	= 0

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 5	NR (5)	N	= 1
Mean	= 3.4		Mean	= 8
Median	= 2		Median	= 8

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= —	NR (4)	N	= 1
Mean	= —		Mean	= 0
Median	= —		Median	= 0

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS		
N	= —	N	= 3	NR (1)
Mean	= —	Mean	= 0	
Median	= —	Median	= 0	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 4	NR (1)	N	= —
Mean	= 0		Mean	= —
Median	= 0		Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 2	N	= —
Mean	= 2.75	Mean	= —
Median	= 2.75	Median	= —

QUESTION B-4C: If you could augment your current flying hours with simulator hours, how many would you add in visual operations (hours per month)?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (2)	N	= 2	NR (1)
Mean	= 3.875		Mean	= 4	
Median	= 2		Median	= 4	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 10	NR (5)	N	= 6
Mean	= 2.5		Mean	= 4.25
Median	= 1		Median	= 4

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 6	N	= 1
Mean	= 4.67	Mean	= 0
Median	= 3	Median	= 0

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= —	NR (4)	N	= 1
Mean	= —		Mean	= 3
Median	= —		Median	= 3

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS		
N	= —	N	= 2	NR (2)
Mean	= —	Mean	= 0.5	
Median	= —	Median	= 0.5	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 4	NR (1)	N	= —
Mean	= 2.75		Mean	= —
Median	= 3		Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 2	N	= —
Mean	= 6	Mean	= —
Median	= 6	Median	= —

QUESTION B-5A: If your flying time was cut by 10%, how many simulator hours would it take to replace it?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= 2	NR (1)
Mean	= 8.14		Mean	= 5.25	
Median	= 3		Median	= 5.25	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 12	NR (3)	N	= 5	NR (1)
Mean	= 4.325		Mean	= 5.12	
Median	= 4		Median	= 4	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3		N	= —	NR (1)
Mean	= 6.67		Mean	= —	
Median	= 7.5		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 2	NR (2)	N	= 1	
Mean	= 25		Mean	= 9	
Median	= 25		Median	= 9	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 1	NR (3)
Mean	= —		Mean	= 1.5	
Median	= —		Median	= 1.5	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (2)	N	= —	
Mean	= 4.3		Mean	= —	
Median	= 2		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1	NR (1)	N	= —	
Mean	= 40		Mean	= —	
Median	= 40		Median	= —	

QUESTION B-5B: If your flying time was cut by 50%, then how many simulator hours would it take to replace it?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (7)	N	= 2	NR (1)
Mean	= 15		Mean	= 11.75	
Median	= 20		Median	= 11.75	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 5	NR (10)	N	= 2	NR (4)
Mean	= 13.1		Mean	= 45	
Median	= 12		Median	= 45	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —	NR (10)	N	= —	NR (1)
Mean	= —		Mean	= —	
Median	= —		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 1	N	= 1
Mean	= 250	Mean	= 30
Median	= 250	Median	= 30

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS		
N	= —	N	= —	NR (4)
Mean	= —	Mean	= —	
Median	= —	Median	= —	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 2	NR (2)	N	= —
Mean	= 7.25		Mean	= —
Median	= 7.25		Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 2	NR (1)	N	= —
Mean	= 200		Mean	= —
Median	= 200		Median	= —

QUESTION B-6A: What percent of map reading could be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (2)	N	= 3	
Mean	= 50.6		Mean	= 30	
Median	= 50		Median	= 40	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 14	NR (1)	N	= 4	NR (2)
Mean	= 57.14		Mean	= 67.5	
Median	= 65		Median	= 80	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= —	NR (1)
Mean	= 54.3		Mean	= —	
Median	= 50		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= 1	
Mean	= 50		Mean	= 5	
Median	= 50		Median	= 5	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 4	
Mean	= —		Mean	= 17.5	
Median	= —		Median	= 22.5	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 4	NR (1)	N	= —	
Mean	= 42.5		Mean	= —	
Median	= 37.5		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 2		N	= —	
Mean	= 47.5		Mean	= —	
Median	= 47.5		Median	= —	

QUESTION B-6B: What percent of other navigational tasks (such as flight log and calculation) could be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (2)	N	= 2	NR (1)
Mean	= 60		Mean	= 80.5	
Median	= 55		Median	= 80.5	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 14	NR (1)	N	= 4	NR (2)
Mean	= 64.29		Mean	= 42.5	
Median	= 80		Median	= 35	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (2)	N	= —	NR (1)
Mean	= 57.5		Mean	= —	
Median	= 65		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= 1	
Mean	= 50		Mean	= 20	
Median	= 50		Median	= 20	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 3	NR (1)
Mean	= —		Mean	= 31.67	
Median	= —		Median	= 30	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 4	NR (1)	N	= —	
Mean	= 68.75		Mean	= —	
Median	= 65.5		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 2		N	= —	
Mean	= 30		Mean	= —	
Median	= 30		Median	= —	

QUESTION B-6C: What percent of correlation of map and visual scene can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (2)	N	= 3	
Mean	= 46.25		Mean	= 33.5	
Median	= 40.00		Median	= 50	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 13	NR (2)	N	= 5	NR (1)
Mean	= 48.08		Mean	= 50	
Median	= 50		Median	= 60	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 5	NR (5)	N	= —	NR (1)
Mean	= 45		Mean	= —	
Median	= 30		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= 1	
Mean	= 50		Mean	= 25	
Median	= 50		Median	= 25	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 4	
Mean	= —		Mean	= 17.5	
Median	= —		Median	= 17.5	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 4	NR (1)	N	= —	
Mean	= 32.5		Mean	= —	
Median	= 25		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —	NR (2)	N	= —	
Mean	= —		Mean	= —	
Median	= —		Median	= —	

QUESTION B-6D: What percent of aircraft flight control can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	8	NR (2)	N	=	3	
Mean	=	50.6		Mean	=	66.6	
Median	=	50		Median	=	50	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	15		N	=	5	NR (1)
Mean	=	59.33		Mean	=	51	
Median	=	60		Median	=	60	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	5	NR (5)	N	=	—	NR (1)
Mean	=	36		Mean	=	—	
Median	=	40		Median	=	—	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	3	NR (1)	N	=	1	
Mean	=	75		Mean	=	60	
Median	=	75		Median	=	60	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	—		N	=	4	
Mean	=	—		Mean	=	13.75	
Median	=	—		Median	=	12.5	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	4	NR (1)	N	=	—	
Mean	=	43.8		Mean	=	—	
Median	=	37.5		Median	=	—	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS			
N	=	2		N	=	—	
Mean	=	37.5		Mean	=	—	
Median	=	37.5		Median	=	—	

QUESTION B-6E: What percent of radio operation can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (2)	N	= 3	
Mean	= 75.6		Mean	= 67.5	
Median	= 77.5		Median	= 60	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 15		N	= 4	NR (2)
Mean	= 91.3		Mean	= 56.25	
Median	= 100		Median	= 60	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= —	NR (1)
Mean	= 67.9		Mean	= —	
Median	= 75		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= 1	
Mean	= 78.33		Mean	= 80	
Median	= 75		Median	= 80	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 4	
Mean	= —		Mean	= 46.25	
Median	= —		Median	= 35	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (2)	N	= —	
Mean	= 86.67		Mean	= —	
Median	= 90		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1	NR (1)	N	= —	
Mean	= 100		Mean	= —	
Median	= 100		Median	= —	

QUESTION B-6F: What percent of fuel management can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= 3	
Mean	= 77.9		Mean	= 48.33	
Median	= 100		Median	= 70	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 15		N	= 4	NR (2)
Mean	= 87.3		Mean	= 68.75	
Median	= 100		Median	= 85	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= —	NR (1)
Mean	= 72.1		Mean	= —	
Median	= 75		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= 1	
Mean	= 100		Mean	= 100	
Median	= 100		Median	= 100	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 3	NR (1)
Mean	= —		Mean	= 25	
Median	= —		Median	= 30	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= —	
Mean	= 83.75		Mean	= —	
Median	= 80		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1	NR (1)	N	= —	
Mean	= 0		Mean	= —	
Median	= 0		Median	= —	

QUESTION B-6G: What percent of stores management can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

	OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 7	NR (3)	= 2	NR (1)
Mean	= 75		= 65	
Median	= 80		= 65	

AIRCRAFT: A-6

	OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 15	NR	= 4	NR (2)
Mean	= 86.3		= 70	
Median	= 90		= 85	

AIRCRAFT: AV-8

	OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 7	NR (3)	= —	NR (1)
Mean	= 67		= —	
Median	= 75		= —	

AIRCRAFT: S-3A

	OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 3	NR (1)	= 1	
Mean	= 86.67		= 100	
Median	= 100		= 100	

AIRCRAFT: F/A-18

	OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —		= 4	
Mean	= —		= 28.75	
Median	= —		= 30	

AIRCRAFT: A-4

	OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 4	NR (1)	= —	
Mean	= 53.75		= —	
Median	= 52.5		= —	

AIRCRAFT: F-4

	OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= 1	NR (1)	= —	
Mean	= 100		= —	
Median	= 100		= —	

QUESTION B-6H: What percent of IFF procedures can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= 3	
Mean	= 76.4		Mean	= 58.33	
Median	= 90		Median	= 75	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 15		N	= 3	NR (3)
Mean	= 91.67		Mean	= 80	
Median	= 100		Median	= 90	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= —	NR (1)
Mean	= 77.9		Mean	= —	
Median	= 80		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3		N	= 1	
Mean	= 91		Mean	= 100	
Median	= 100		Median	= 100	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 3	NR (1)
Mean	= —		Mean	= 51.67	
Median	= —		Median	= 40	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3		N	= —	
Mean	= 83.3		Mean	= —	
Median	= 80		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1	NR (1)	N	= —	
Mean	= 100		Mean	= —	
Median	= 100		Median	= —	

QUESTION B-6I: What percent of INS operation can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= 2	
Mean	= 77.9		Mean	= 77.5	
Median	= 75		Median	= 77.5	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 15		N	= 4	NR (2)
Mean	= 90.67		Mean	= 66/25	
Median	= 100		Median	= 72.5	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 5	NR (5)	N	= —	NR (1)
Mean	= 67		Mean	= —	
Median	= 80		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3		N	= 1	
Mean	= 96.67		Mean	= 100	
Median	= 100		Median	= 100	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 4	
Mean	= —		Mean	= 26.25	
Median	= —		Median	= 30	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (2)	N	= —	
Mean	= 75		Mean	= —	
Median	= 75		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1	NR (1)	N	= —	
Mean	= 100		Mean	= —	
Median	= 100		Median	= —	

QUESTION B-6J: What percent of crew coordination can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (7)	N	= 2	NR (1)
Mean	= 40		Mean	= 37.5	
Median	= 20		Median	= 37.5	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 15		N	= 4	NR (2)
Mean	= 77.67		Mean	= 65	
Median	= 80		Median	= 77.5	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1	NR (9)	N	= —	NR (1)
Mean	= 80		Mean	= —	
Median	= 80		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= 1	
Mean	= 96.67		Mean	= 50	
Median	= 100		Median	= 50	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 3	NR (1)
Mean	= —		Mean	= 11.67	
Median	= —		Median	= 15	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1	NR (4)	N	= —	
Mean	= 80		Mean	= —	
Median	= 80		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1	NR (1)	N	= —	
Mean	= 25		Mean	= —	
Median	= 25		Median	= —	

QUESTION B-6K: What percent of sensor display interpretation can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 6	NR (4)		N	= 2	NR (1)
Mean	= 68.3			Mean	= 67.5	
Median	= 65			Median	= 67.5	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 15			N	= 4	NR (2)
Mean	= 72			Mean	= 46.25	
Median	= 80			Median	= 42.5	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 5	NR (5)		N	= —	NR (1)
Mean	= 76			Mean	= —	
Median	= 80			Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 3	NR (1)		N	= 1	
Mean	= 96.67			Mean	= 60	
Median	= 100			Median	= 60	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= —			N	= 4	
Mean	= —			Mean	= 20	
Median	= —			Median	= 17.5	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 3	NR (2)		N	= —	
Mean	= 73.33			Mean	= —	
Median	= 80			Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= —	NR (2)		N	= —	
Mean	= —			Mean	= —	
Median	= —			Median	= —	

QUESTION B-6L: What percent of target ID can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 6	NR (4)		N	= 3	
Mean	= 50			Mean	= 33.3	
Median	= 45			Median	= 50	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 15	NR		N	= 4	NR (2)
Mean	= 43.33			Mean	= 31.25	
Median	= 30			Median	= 27.5	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 7	NR (3)		N	= 1	
Mean	= 51.1			Mean	= 50	
Median	= 80			Median	= 50	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 3	NR (1)		N	= 1	
Mean	= 100			Mean	= 100	
Median	= 100			Median	= 100	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= —			N	= 4	
Mean	= —			Mean	= 15	
Median	= —			Median	= 17.5	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 4	NR (1)		N	= —	
Mean	= 40			Mean	= —	
Median	= 37.5			Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS				TRAINING SQUADRONS		
N	= 1	NR (1)		N	= —	
Mean	= 50			Mean	= —	
Median	= 50			Median	= —	

QUESTION B-6M: What percent of target attack procedures can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= 3	
Mean	= 52.4		Mean	= 33.3	
Median	= 50		Median	= 50	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 15		N	= 4	NR (2)
Mean	= 50		Mean	= 42.5	
Median	= 40		Median	= 50	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= 1	
Mean	= 41.4		Mean	= 50	
Median	= 40.0		Median	= 50	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= 1	
Mean	= 83.33		Mean	= 80	
Median	= 75		Median	= 80	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 4	
Mean	= —		Mean	= 22.5	
Median	= —		Median	= 22.5	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 4	NR (1)	N	= —	
Mean	= 53.75		Mean	= —	
Median	= 55		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1	NR (1)	N	= —	
Mean	= 50		Mean	= —	
Median	= 50		Median	= —	

QUESTION B-6N: What percent of evasive techniques (for hostile aircraft, missiles, and gunfire) can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 6	NR (4)	N	= 3	
Mean	= 55		Mean	= 33.3	
Median	= 55		Median	= 50	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 15		N	= 4	NR (2)
Mean	= 43.67		Mean	= 35	
Median	= 30		Median	= 35	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= 1	
Mean	= 42.14		Mean	= 100	
Median	= 30		Median	= 100	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 3	NR (1)	N	= 1	
Mean	= 40		Mean	= 40	
Median	= 50		Median	= 40	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= —		N	= 4	
Mean	= —		Mean	= 25	
Median	= —		Median	= 27.5	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 4	NR (1)	N	= —	
Mean	= 31.25		Mean	= —	
Median	= 17.5		Median	= —	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 1	NR (1)	N	= —	
Mean	= 50		Mean	= —	
Median	= 50		Median	= —	

QUESTION B-60: What percent of external communications can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR(2)	N	= 2	NR (1)
Mean	= 68.75		Mean	= 55	
Median	= 70.00		Median	= 55	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 15		N	= 4	NR (2)
Mean	= 78.3		Mean	= 56.25	
Median	= 90		Median	= 60	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= —	NR (1)
Mean	= 60		Mean	= —	
Median	= 60		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 3	NR (1)	N	= 1
Mean	= 83.33		Mean	= 40
Median	= 100		Median	= 40

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 28.75
Median	= —	Median	= 27.5

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 4	NR (1)	N	= —
Mean	= 73.75		Mean	= —
Median	= 77.5		Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 1	NR (1)	N	= —
Mean	= 50		Mean	= —
Median	= 50		Median	= —

QUESTION B-6P: What percent of dealing with weather, lightning, turbulence, and storms can be practiced to proficiency in a simulator?

AIRCRAFT	OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
A-7	N	= 7	NR (3)	N	= 3	
	Mean	= 42.1		Mean	= 40	
	Median	= 25		Median	= 50	
A-6	N	= 15		N	= 4	NR (2)
	Mean	= 54.7		Mean	= 35	
	Median	= 50		Median	= 30	
AV-8	N	= 7	NR (3)	N	= —	NR (1)
	Mean	= 42.9		Mean	= —	
	Median	= 40		Median	= —	
S-3A	N	= 3	NR (1)	N	= 1	
	Mean	= 73.33		Mean	= 80	
	Median	= 80		Median	= 80	
F/A-18	N	= —		N	= 4	
	Mean	= —		Mean	= 31.25	
	Median	= —		Median	= 32.5	
A-4	N	= 4	NR(1)	N	= —	
	Mean	= 33.75		Mean	= —	
	Median	= 25		Median	= —	
F-4	N	= 1	NR (1)	N	= —	
	Mean	= 50		Mean	= —	
	Median	= 50		Median	= —	

QUESTION B-6Q: What percent of dealing with emergency/battle damage can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8	NR (2)	N	= 2	NR (1)
Mean	= 76.9		Mean	= 45	
Median	= 77.5		Median	= 45	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 14	NR (1)	N	= 4	NR (2)
Mean	= 76.07		Mean	= 65	
Median	= 87.5		Median	= 70	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR (3)	N	= —	NR (1)
Mean	= 65		Mean	= —	
Median	= 50		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 3	NR (1)	N	= 1
Mean	= 90		Mean	= 80
Median	= 90		Median	= 80

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 47.5
Median	= —	Median	= 50

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 4	NR (1)	N	= —
Mean	= 65		Mean	= —
Median	= 70		Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 1	NR (1)	N	= —
Mean	= 50		Mean	= —
Median	= 50		Median	= —

QUESTION B-6R: What percent of changing a flight plan or route can be practiced to proficiency in a simulator?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 8		N	= 2	NR (1)
Mean	= 89.4		Mean	= 77.5	
Median	= 95		Median	= 77.5	

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 14	NR (1)	N	= 4	NR (2)
Mean	= 85.7		Mean	= 63.75	
Median	= 100		Median	= 75	

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
N	= 7	NR	N	= —	NR (1)
Mean	= 67.1		Mean	= —	
Median	= 60		Median	= —	

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 3	NR (1)	N	= 1
Mean	= 93.33		Mean	= 90
Median	= 90		Median	= 90

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
N	= —	N	= 4
Mean	= —	Mean	= 33.75
Median	= —	Median	= 35

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 4	NR (1)	N	= —
Mean	= 65		Mean	= —
Median	= 70		Median	= —

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
N	= 1	NR (1)	N	= —
Mean	= 50		Mean	= —
Median	= 50		Median	= —

QUESTION B-7: What types of low level (e.g., point-to-point navigation) flight are currently being simulated at this facility?

	a. Kind of low level maneuvers performed	b. Weather (IFR/VFR)	c. Terrain
A-7	0	0	0
OPERATIONAL	0	0	0
SQUADRON	0	0	0
N = 10	0	0	0
	0	0	0
	0	0	0
	Strike	IFR	Flat
	6K-radar route	IFR	Flat
	NCLT	IFR/VFR	SED
	0	IFR	0
A-7	0	0	0
TRAINING	0	NCLT	Over water
SQUADRON	0	Night VFR/IFR	0
N = 3			
A-6	Terrain avoidance	IFR/night	All
OPERATIONAL	Terrain clearance/attack	IFR	Mountainous
SQUADRON	Night/IFR	Night/IFR	All
N = 13	TF and TA	IFR	Mountainous
NR(2)	Terrain clearance/avoidance	IFR	Mountainous
	Low level flight	IFR/VFR	Mountainous
	Terrain following/IFR	Night VFR/IFR	Level
	0	0	0
	Pop-up attacks	IFR - 75%	Flat
	0	0	0
	0	0	0
	Low level point to point	IFR	Flat
	0	0	0
A-6	Terrain avoidance/clearance	IFR	Mountainous
TRAINING	Low level radar	IFR	Mountainous
SQUADRON	IFR - low level	IFR	Mountainous
N = 4	Terrain clearance/avoidance	IFR	Mountainous
NR (2)			

QUESTION B-7 (cont'd)

	a. Kind of low level maneuvers performed	c. Weather (IRF/VFR)	d. Terrain
AV-8 OPERATIONAL SQUADRON N = 10	0	0	0
	0	0	0
	0	0	0
	0	0	0
	0	0	0
	0	0	0
	0	0	0
	0	0	0
	0	0	0
	0	0	0
AV-8 TRAINING SQUADRON N = 1	0	0	0
S-3A OPERATIONAL SQUADRON N = 4	MAD	—	Over water
	Over water	Depends on weather	Very Little
	As necessary	IFR/VFR	All
	ASW	IFR/VFR	Over water
S-3A TRAINING SQUADRON N = 1	0	Both	0
F-18 SQUADRON N = 4	Low level	IFR	Mountainous
	0	0	0
	0	0	0
	0	0	0
A-4 OPERATIONAL SQUADRON N = 5	0	0	0
	0	0	0
	0	IFR	0
	0	IFR	N/A
	Straight & level	IFR	Flat
F-4 OPERATIONAL SQUADRON N = 2	No response	No response	No response
	0	Both	0

QUESTION B-8: Who is the simulator intended to train?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
(10) Pilot only	(3) Pilot only

AIRCRAFT: A-6

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
(2) Pilot Only (1) Pilot and bombardier/ Navigator NR (2)	(2) Bombardier/Navigator NR (2)

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
(3) Pilot only (1) Both pilot and crewmembers NR (6)	(1) Pilot only

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
(2) Pilot and COTACS (2) Pilot, TACCOS, and SENSOS	(1) Pilot and COTACS

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
	(1) RPs and IPs (1) Pilot only (NR (2)

AIRCRAFT: A-4

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
(4) Pilot only (1) Pilot and crew	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
(1) Pilot only (1) Pilot and RIO	

QUESTION B-9: Are cockpit environmental conditions as well as external flight conditions simulated?

a. Turbulence
b. Heat
c. Workload
d. External, non=relevant communications
e. Lighting
f. Sound

AIRCRAFT: A-7

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
a.	6 Yes	2 No	a.	3 Yes	0 No
b.	0 Yes	8 No	b.	1 Yes	2 No
c.	8 Yes	0 No	c.	3 Yes	0 No
d.	4 Yes	4 No	d.	2 Yes	1 No
e.	6 Yes	2 No	e.	2 Yes	1 No
f.	7 Yes	1 No	f.	3 Yes	0 No

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
a.	8 Yes	5 No	a.	3 Yes	1 No
b.	6 Yes	7 No	b.	0 Yes	4 No
c.	12 Yes	1 No	c.	4 Yes	0 No
d.	8 Yes	5 No	d.	1 Yes	3 No
e.	10 Yes	3 No	e.	4 Yes	0 No
f.	12 Yes	1 No	f.	2 Yes	2 No

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
a.	0 Yes	4 No	a.	0 Yes	1 No
b.	0 Yes	4 No	b.	0 Yes	1 No
c.	2 Yes	2 No	c.	1 Yes	0 No
d.	2 Yes	2 No	d.	1 Yes	0 No
e.	1 Yes	3 No	e.	1 Yes	0 No
f.	2 Yes	2 No	f.	1 Yes	0 No

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
a.	4 Yes	0 No	a.	1 Yes	0 No
b.	3 Yes	1 No	b.	1 Yes	0 No
c.	4 Yes	0 No	c.	1 Yes	0 No
d.	3 Yes	1 No	d.	1 Yes	0 No
e.	4 Yes	0 No	e.	1 Yes	0 No
f.	4 Yes	0 No	f.	1 Yes	0 No

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS			TRAINING SQUADRONS		
a.	—		a.	1 Yes	1 No
b.	—		b.	0 Yes	2 No
c.	—		c.	2 Yes	0 No
d.	—		d.	1 Yes	1 No
e.	—		e.	2 Yes	0 No
f.	—		f.	2 Yes	0 No

QUESTION A-4 (cont'd)

AIRCRAFT: A-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
a.	4 Yes	1 No	a.	—
b.	0 Yes	5 No	b.	—
c.	4 Yes	1 No	c.	—
d.	4 Yes	1 No	d.	—
e.	1 Yes	4 No	e.	—
f.	3 Yes	2 No	f.	—

AIRCRAFT: F-4

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
a.	1 Yes	1 No	a.	—
b.	0 Yes	2 No	b.	—
c.	1 Yes	1 No	c.	—
d.	1 Yes	1 No	d.	—
e.	1 Yes	1 No	e.	—
f.	1 Yes	1 No	f.	—

QUESTION B-10: How many missions are flown involving low level flight per pilot?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
4 Per month	NR (1)	62.5%	NR (1)
3 per month		9	
2		N = 2	
4 per month			
10 per month			
2			
8			
10 per month			
10 per month			
N = 9			

AIRCRAFT: A-6

OPERATIONAL SQUADRONS			TRAINING SQUADRONS	
6 per month	3.5 per month	NR (1)	5	NR (1)
8 per month	12 per month		20	
80%	10 per month		2 per month	
3	90%		20	
3 per month	10 per month		3	
11 per month	0		N = 5	
9	80%			
N = 14				

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS			TRAINING SQUADRONS
10 per month	50	NR (2)	NR (1)
9 per month	10 hrs per month		
0	33%		
2.5 per month	8 per month		
N = 8			

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
2 flights	2
4	N = 1
0	
100%	
N = 4	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS	TRAINING SQUADRONS	
—	10 per course	NR (1)
—	1 per month	
—	5	
—	N = 3	

AIRCRAFT: A-4

OPERATIONAL SQUADRONS	TRAINING SQUADRONS
10	—
3.5 Per month	—
2 per month	—
4 per month	—
2	—
N = 5	—

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS
0	NR (1)	—
N = 1		—

QUESTION B-10A: How many missions are flown involving low level flight per squadron?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS

4	2	
3	8	
2	10	
4	10	
10		

N = 9
X = 5.89
Median = 4

TRAINING SQUADRONS

9	NR (2)

N = 1
X = 9
Median = 9

AIRCRAFT: A-6

OPERATIONAL SQUADRONS

6	12	NR (4)
3	10	
3	10	
3	11	
3.5	0	
9		

N = 11
X = 6.14
Median = 6

TRAINING SQUADRONS

5	NR (1)
5	
2	
5	
3	
3	

N = 5
X = 4
Median = 5

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS

10	10	NR (4)
9	2.5	
0	8	

N = 6
X = 6.6
Median = 8.5

TRAINING SQUADRONS

NR (1)

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS

2	NR (1)
4	
0	

N = 3
X = 2
Median = 2

TRAINING SQUADRONS

2
N = 1
X = 2
Median = 2

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS

—
—
—
—

TRAINING SQUADRONS

8
10
1
5
N = 4
X = 6
Median = 6.5

QUESTION B-10A (cont'd)

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS
10		—
3.5		—
2		—
4		
2		
N = 5		
X = 4.3		
Median = 3.5		

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS
0	NR (1)	—
N = 1		—
X = 0		—
Median = 0		—

QUESTION B-10B: How many missions are flown involving low level flight per wing?

AIRCRAFT: A-7

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
45 per week	NR (6)	62.5%	NR (2)
40 +			
24 per week			
6000 per month			
N = 4			

AIRCRAFT: A-6

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
80%		40 per month	NR (5)
155 per month		N = 1	
N = 2			

AIRCRAFT: AV-8

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
	NR (10)		NR (1)

AIRCRAFT: S-3A

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
0	NR (3)	75%	
N = 1		N = 1	

AIRCRAFT: F/A-18

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
			NR (4)

AIRCRAFT: A-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
66 per month	NR (4)	—	
N = 1		—	

AIRCRAFT: F-4

OPERATIONAL SQUADRONS		TRAINING SQUADRONS	
	NR (2)	None	

APPENDIX C

All questions presented in this appendix are generic in nature and are thus not intended to represent any specific question from the two data collection devices used. The comments represent responses which were unsolicited in some cases but were noted in the margins of the questionnaires or supplied as additional responses or clarifications. For the purpose of this appendix, respondants listed under the heading "Operational Squadrons" are members of Fleet Squadrons; those listed under "Training Squadrons" are members of a Fleet Readiness Squadron (FRS) or Readiness Air Group (RAG). All respondants are Navy or Marine pilots; the number in parentheses preceding the response or comment is the number of pilots generating that response. All comments are generalized (i.e., paraphrased).

1. QUESTION AREA: State the number of low level practice sorties in a simulator that are necessary to reach proficiency after undergraduate pilot training.

AIRCRAFT: A-7

Operational Squadrons
- (2) No such simulator is available in their community.
- (2) By definition, the FRS provides the required number of sorties; that is sufficient.

Training Squadrons
- (1) No such simulator is available in their community.

AIRCRAFT: A-6

Operating Squadrons
- (1) It is not possible to reach proficiency in a simulator.
- (2) It is necessary to combine simulator hours with flight hours to achieve proficiency.

Training Squadrons
- (1) It is not possible to reach proficiency in a simulator.

AIRCRAFT: AV-8A

Operational Squadrons
- (3) No such simulator is available in their community.
- (1) Dependent on the quality of the simulator.

Training Squadrons
- (2) No such simulator is available in their community.

AIRCRAFT: S-3A

No comments.

AIRCRAFT: F/A-18

Operational Squadrons
No comments.

Training Squadrons
- (1) No such simulator is available in their community.

AIRCRAFT: A-4

No comments.

AIRCRAFT: F-4

No comments.

2. QUESTION AREA: How much low level is actually flown?

AIRCRAFT: A-7

Operational Squadrons

(2) Total time is dependent on wing location; "it's hard to fly low levels in the middle of the ocean."

(1) Squadron tries to fly some low level on every flight.

Training Squadrons

(1) Total time is dependent on wing location.

AIRCRAFT: A-6

Operational Squadrons

(2) 80 to 90 percent of all flights involve low level.

Training Squadrons

(1) Pilots should fly low level as oten as possible to maintain proficiency.

AIRCRAFT: AV-8A

Operational Squadrons

No comments.

Training Squadrons

(1) Every tactical sortie should involve low level flight.

AIRCRAFT: S-3A

Operational Squadrons

(1) Low level, overwater flight is the only type of mission flown by the squadron.

Training Squadrons

No comments.

AIRCRAFT: F/A-18

No comments.

AIRCRAFT: A-4

No comments.

AIRCRAFT: F-4

No comments.

3. QUESTION AREA: How well can map reading be trained in a simulator?

AIRCRAFT: A-7

Operational Squadrons
(3) Map reading could be learned in a simulator if visuals were improved.

Training Squadrons
No comments.

AIRCRAFT: A-6

Operational Squadrons
(1) Squadron does not carry maps.
(1) Fidelity is too low for map reading because of visuals.

Training Squadrons
(1) Map reading could be practiced in a car.

AIRCRAFT: AV-8A

Operational Squadrons
(1) Could be learned in a simulator if it was also practiced in flight.
(1) Could be learned if visuals were improved.

AIRCRAFT: S-3A

No comments.

AIRCRAFT: F/A-18

No comments.

AIRCRAFT: A-4

No comments.

AIRCRAFT: F-4

No comments.

4. QUESTION AREA: How much psychological stress is felt during low level flight?

AIRCRAFT: A-7

Operational Squadrons
No comments

Training Squadrons
(1) Simulator cannot reproduce the anxiety felt during actual low level flight.

AIRCRAFT: A-6

Operational Squadrons
(1) Stress is dependent on altitude. At 300 to 500 feet AGL most stress is gone; at 150 to 300 feet AGL stress is moderate; below 150 feet AGL, stress is very high. Terrain considerations and IFR raises all stress levels.
(1) Stress is higher under all conditions if the terrain is mountainous.

Training Squadrons
(1) Low level flight simulation is of little use because it produces no psychological stress.

AIRCRAFT: AV-8A

Operational Squadrons
(1) It is necessary to actually fly low level, not just in the simulator, in order to experience psychological stress. Too much simulator use creates a false sense of security.

Training Squadrons
No comments.

AIRCRAFT: S-3A

No comments.

AIRCRAFT: F/A-18

No comments.

AIRCRAFT: A-4
Operational Squadrons
(1) Amount of stress depends on pilot experience.

Training Squadrons
No comments.

AIRCRAFT: F-4
No comments.

5. QUESTION AREA: How much physical stress is felt by pilots during low level flight?
AIRCRAFT: A-7

No comments.

AIRCRAFT: A-6

Operational Squadrons
(1) Physical stress is very dependent on terrain and tactics. Physical stress caused by external factors (turbulence, etc.) is very low.
(1) Physical stress depends on pilot experience.

Training Squadrons
No comments.

AIRCRAFT: AV-8A

Operational Squadrons
(1) Physical stress is dependent on pilot experience and ability.
(1) Physical stress depends on flight type and who the pilot is with.

Training Squadrons
No comments.

AIRCRAFT: S-3A

No comments.

AIRCRAFT: F/A-18

No comments.

AIRCRAFT: A-4

Operational Squadrons
(1) Physical stress depends on experience.

Training Squadrons
No comments.

AIRCRAFT: F-4

No comments.

6. QUESTION AREA: What weather conditions are required to schedule a low level flight?

AIRCRAFT: A-7

No comments

AIRCRAFT: A-6

Operational Squadrons
(3) There are no weather restrictions for low level flight 100 hours after earning wings.

Training Squadrons
(2) There are no weather restrictions for low level flight 100 hours after earning wings.

AIRCRAFT: AV-8A

No comments.

AIRCRAFT: S-3A

No comments.

AIRCRAFT: F/A-18

No comments.

AIRCRAFT: A-4

No comments.

AIRCRAFT: F-4

No comments.

7. QUESTION AREA: How does the quality of your formation flight training compare to your low level flight training?

AIRCRAFT: A-7

No comments.

AIRCRAFT: A-6

Operational Squadrons

(1) Formation training and low level flight training are conducted concurrently.

(1) Formation training is of minimal importance; training concentrates on low altitude flight.

Training Squadrons

No comments.

AIRCRAFT: AV-8A

No comments.

AIRCRAFT: S-3A

No comments.

AIRCRAFT: F/A-18

No comments.

AIRCRAFT: A-4

No comments.

AIRCRAFT: F-4

No comments.

8. QUESTION AREA: What altitude restrictions are maintained for your aircraft?

AIRCRAFT: A-7

No comments.

AIRCRAFT: A-6

Operational Squadrons
(3) Wing minimum is 200 feet AGL.

Training Squadrons
No comments.

AIRCRAFT: AV-8A

Operational Squadrons
(1) All low level flight in the squadron is a combination of TA or TF flight, depending on altitude.

Training Squadrons
No comments.

AIRCRAFT: S-3A

Operational Squadrons
(1) The S-3A always operates below 2000 feet AGL off the ship.

Training Squadrons
No comments.

AIRCRAFT: F/A-18

No comments.

AIRCRAFT: A-4

Operational Squadrons
(1) Squadron minimum is 500 feet AGL.

Training Squadrons
No comments.

AIRCRAFT: F-4

No comments.

9. QUESTION AREA: What is your opinion of simulator quality?

AIRCRAFT: A-7

Operational Squadrons
(4) Simulators in their community are too unrealistic to be of use.
(3) Simulators lack useful visuals.

Training Squadrons
No comments.

AIRCRAFT: A-6

Operational Squadrons
(5) Simulators in their community are too unrealistic to be useful.
(2) Simulators lack useful visuals.
(1) Simulator is useful for improving cockpit coordination during IFR and emergency procedures.

Training Squadrons
(4) Simulators in their community are too unrealistic to be useful.
(1) Simulators lack useful visuals.

AIRCRAFT: AV-8A

Operational Squadrons
(1) Simulators in their community are too unrealistic to be useful.
(1) Simulators lack useful visuals.

Training Squadrons
No comments.

AIRCRAFT: S-3A

Operational Squadrons
(3) Simulators in their community are too unrealistic to be complete.

Training Squadrons
(1) Simulators in their community are too unrealistic to be complete.

AIRCRAFT: F/A-18

Operational Squadrons
No comments.

Training Squadrons
(1) Simulators in their community are too unrealistic to be useful.
(1) Simulators lack useful visuals.

AIRCRAFT: A-4

Operational Squadrons
(2) Simulators in their community are too unrealistic to be useful.
(2) Simulators lack useful visuals.

Training Squadrons
No comments.

AIRCRAFT: F-4

No comments.

10. QUESTION AREA: Comment on simulator costs.

AIRCRAFT: A-7

Operational Squadrons
(2) Good training should not be sacrificed for costs.
(3) A low level flight trainer would not be cost effective.

Training Squadrons
No comments.

AIRCRAFT: A-6

No comments.

AIRCRAFT: AV-8A

Operational Squadrons
(2) Good training should not be sacrificed for costs.
(1) A low level flight simulator would be cost effective.

Training Squadrons
No comments.

AIRCRAFT: S-3A

No comments.

AIRCRAFT: F/A-18

Operational Squadrons
No comments.

Training Squadrons
(1) A low level flight simulator would not be cost effective.

AIRCRAFT: A-4

No comments.

AIRCRAFT: F-4

No comments.

11. QUESTION AREA: How useful are simulators during training?

AIRCRAFT: A-7

Operational Squadrons
(3) Simulators do not train pilots well for low level flight.
(2) Simulators could be useful for training low level flight.
(2) Simulators cannot replace flight time in training.

Training Squadrons
(1) Simulators do not train pilots well for low level flight.

AIRCRAFT: A-6

Operational Squadrons
(1) Simulators do not train pilots well for low level flight.
(2) Simulators could be ueful for training low level flight.
(1) Instructors need better training in the use of the simulator.

Training Squadrons
(1) Simulators cannot replace flight time in training.

AIRCRAFT: AV-8A

Operational Squadrons
(3) Simulators do not train pilots well for low level flight.
(3) Simulators could be useful for training low level flight.
(2) Simulators cannot replace flight time in training.

Training Squadrons
(1) Simulators do not train pilots well for low level flight.
(1) Simulators could be useful for training low level flight.
(1) Simulators cannot replace flight time in training.

AIRCRAFT: S-3A

Operational Squadrons
(2) Simulators do not train pilots well for low level flight.

Training Squadrons
(1) Simulators could be useful in training low level flight.

AIRCRAFT: F/A-18

Operational Squadrons
No comments.

Training Squadrons
(1) Simulators do not train pilots well for low level flight.
(1) Simulators cannot replace flight time in training.

AIRCRAFT: A-4

Operational Squadrons

(1) Simulators do not train pilots well for low level flight.

(1) Instructors need better training in the use of the simulator.

Training Squadrons

No comments.

AIRCRAFT: F-4

No comments.

12. QUESTION AREA: Is it desirable to simulate external environmental conditions (turbulence, etc) pair to a student experiencing them?

AIRCRAFT: A-7

Operational Squadrons
(2) Such simulation would be useful if it was realistic.

Training Squadrons
(1) It is good to simulate these effects to prepare the student. The NCLT provides these effects.
(1) The NCLT is an excellent example of this type of simulation.

AIRCRAFT: A-6

Operational Squadrons
(1) These conditions are currently being simulated.
(1) This simulation would be helpful. Training should always be geared toward the worst possible conditions to avoid surprises during the mission.
(1) Simulation would be useful if it was realistic.
(2) Practice would be useful becaue it is then one less variable for the aircrew to contend with.
(1) Possibly weather and darkness, but not turbulence.
(1) Simulation would be useful if each experience were briefed and debriefed, and the student monitored for usage of correct procedures.

Training Squadrons
(1) Simulation would be helpful, because "simulators seem worse than the actual aircraft, so it would be good practice."
(2) These conditions are currently being simulated.

AIRCRAFT: AV-8A

Operational Squadrons
(1) Something as simple as turbulence can make low level flight challenging.
(1) Simulation is not necessary.
(1) Simulate turbulence and weather only

Training Squadrons
(1) Such simulation would be useful in many poor or unusual conditions prior to actual conditions.

AIRCRAFT: S-3A

Operational Squadrons
(1) It is desirable and practical to simulate such conditions.

Training Squadrons
No comments.

AIRCRAFT: F/A-18

Operational Squadrons

(1) Simulate weather and darkness, but not turbulence.

(1) Simulation f such conditions would be desirable, but not necessary.

(1) It is desirable to simulate turbulence, weather, and darkness as well as threats.

Training Squadrons

No comments.

AIRCRAFT: A-4

Operational Squadrons

(1) Such simulation is desirable, except for darkness, because low level flights are not flown at night.

(1) Such simulation would be useful if it was realistic.

Training Squadrons

No comments.

AIRCRAFT: F-4

No comments

13. QUESTION AREA: If flight time was reduced by 10%, how many simulator hours would it take to replace it?

AIRCRAFT: A-7

Operational Squadrons
(3) Flight time cannot be replaced by simulator time.

Training Squadrons
No comments.

AIRCRAFT: A-6

Operational Squadrons
(2) Flight time cannot be replaced by simulator time.

Training Squadrons
(1) Flight time cannot be replaced by simulator time.

AIRCRAFT: AV-8A

Operational Squadrons
(1) Flight time cannot be replaced by simulator time.
(1) Time depends on simulator quality.

Training Squadrons
(2) Flight time cannot be replaced by simulator time.

AIRCRAFT: S-3A

No comments.

AIRCRAFT: F/A-18

Operational Squadrons
No comments.

Training Squadrons
(1) Flight time cannot be replaced by simulator time.
(1) Time depends on the quality of the simulator.

AIRCRAFT: A-4

Operational Squadrons
(1) Flight time cannot be replaced by simulator time.

Training Squadrons
No comments.

AIRCRAFT: F-4

Operational Squadrons

(1) Flight time cannot be replaced by simulator time.

Training Squadrons

No comments.

14. QUESTION AREA: How much simultor time would be necessary to replace a 50% reduction in flight time?

AIRCRAFT: A-7

Operational Squadrons
(3) A reduction of that size is irreplaceable.

Training Squadrons
(2) A reduction of that size is irreplaceable.

AIRCRAFT: A-6

Operational Squadrons
(6) Simulator time cannot replace flight time.

Training Squadrons
(3) Simulator time cannot replace flight time.

AIRCRAFT: AV-8A

Operational Squadrons
(5) Simulator time cannot replace flight time.

Training Squadrons
(3) Simulator time cannot replace flight time.

AIRCRAFT: S-3A

No comments.

AIRCRAFT: F/A-18

Operational Squadrons
No comments.

Training Squadrons
(4) Such a reduction is irreplaceable by simulator time.

AIRCRAFT: A-4

Operational Squadrons
(2) Such a reduction is not replaceable by simulator time.
Training Squadrons
No comments.

AIRCRAFT: F-4
Operational Squadrons
(1) Such a reduction cannot be replaced by simulator time.
Training Squadrons
No comments.

15. QUESTION AREA: What items are not currently simulated at the undergraduate level?

AIRCRAFT: A-7

Operational Squadrons
- (1) ACM (air combat maneuvering), low level flight, weapons delivery, and war at sea.
- (1) Bomb delivery.

Training Squadrons
- (1) Air-to-ground (AG) weapons delivery.

AIRCRAFT: A-6

Operational Squadrons
- (3) Night carrier landing (NCL).
- (1) Night carrier take-off.
- (1) System/visual ordnance.
- (1) Low level flight.

Training Squadrons
- (1) Visual bomb simulation.

AIRCRAFT: AV-8A

Operational Squadrons
- (2) ACM.
- (1) Air-to-air (AA) gunnery.
- (1) Bombing.
- (2) Low level navigation.
- (1) Photo reconnaissance.
- (1) Emergency conditions.

Training Squadrons

No comments.

AIRCRAFT: S-3A

Operational Squadrons
- (1) Low level flight
- (1) IFR, terrain recognition, and radar

Training Squadrons
- (1) Low level flight.

AIRCRAFT: F/A-18

Operational Squadrons

No comments.

Training Squadrons

(2) Low level navigation

(1) AA tactics and AG radar.

AIRCRAFT: A-4

Operational Squadrons

(1) Weapons delivery and AA tactics.

(2) Ordnance delivery.

Training Squadrons

No comments.

AIRCRAFT: F-4

No comments.

APPENDIX D
FIELD CONFERENCE POINTS OF CONTACT

Various military air stations and bases were visited to assess the current state of the art in visual systems, as well as to gather low level flight training and accident data. Following is a list of dates, contacts, and telephone numbers for the field conferences executed for the purposes of this study.

24 September 1982

NTEC was visited for the purpose of contract kick-off. Our points of contact were Dorothy M. Baldwin (305-646-5464) and Eugene Maldonato (609-428-4060).

6, 7 October 1982

The Pentagon was visited for the purpose of gathering aircraft costs and low level usage data. Our contact there was Commander Ken Fields (202-692-1234) (AV 222).

8 October 1982

Little Rock AFB was visited in order to study the transfer effectiveness of the C-130 simulator. Our contact was Major Mike Sieverding (AV 731-6235).

14 October 1982

Norfolk NAS was visited to obtain Navy aircraft incident data. Our point of contact was Dr. Mike Borowsky (804-444-2859) (AV 690).

15 October 1982

Oceana NAS was visited to gather data on the A-6 aircraft. Captain Steve Phimister was our point of contact (804-425-3286) (AV 274).

25 October 1982

Whidbey NAS was visited for the purpose of gathering data on the A-6 aircraft. Our point of contact was Lieutenant Commander Carl J. Roed (206-257-2211, ext. 2005) (AV 820).

26 October 1982

Yuma MCAS was visited for the purpose of gathering data on the AV-8, A-4, F-4, and A-6 aircraft. Our point of contact was Colonel R. C. Andries (602-726-3011, ext. 2224) (AV 957).

27 October 1982

Randolph AFB was visited to gather data on T-38 simulator transfer effectiveness and low level missions. Our points of contact were Colonel B. J. Rhoten (512-652-1110, ext 3510) and Major David Gates (ext. 4969) (AV 487).

28 October 1982

CNATRA was visited to gather training coursework material. Our contact was Commander Schroll (512-939-3991) (AV 861).

1 November 1982

NASA-Ames was visited to gather simulator data and aircraft incident data. Our points of contact were A. M. Cook (415-965-5162) and Dr. William Reynard (415-965-6467).

2 November 1982

Castle AFB was visited to study the B-52 WST's transfer effectiveness. Our contact was Lt. Colonel Osborn (209-726-2392) (AV 347).

3 November 1982

Lemoore NAS was visited to gather data on the A-7 and F/A-18 aircraft. Our contact was Lieutenant Commander Richard Steinestel (209-998-3631) (AV 949).

4 November 1982

Miramar NAS was visited to study the F-14 TARPS mission and need for simulator. Our point of contact was Commander W. R. Scott (714-271-3511, ext. 2211) (AV 959).

5 November 1982

North Island NAS was visited for the purpose of gathering data on the S-3A aircraft. Our point of contact was Leiutenant Commander Nemeth (714-437-6814) (AV 951).

8 November 1982

Williams AFB was visited for the purpose of gathering ASPT TER data. Our contact was Chief Warren Richeson (602-988-2611, ext. 6561) (AV 474).

9 November 1982

Cannon AFB was visited to gather information on F-111 flight simulator low level experience information. Our contacts were Colonel Joseph Stapleton (CMDR) (505-784-3311, ext. 3737) and Captain David Williams (ext. 2567) (AV 681).

18 November 1982

Cherry Point MCAS was visited for the purpose of gathering data on the AV-8 and A-6 aircraft. Our contacts were Captain Jim Harler (919-466-3448/2347), Al Behler (919-466-2212), and Major Crittenden (919-466-3194) (AV 582).

19 November 1982

Cecil Field NAS was visited to gather data on the A-7 and S-3A aircraft. Our contact was V. P. Murone (714-382-1110, ext. 4192) (AV 8767).

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