Finding the Right Balance

JOHN F. SCHANK • HARRY J. THIE • CLIFFORD M. GRAF II
JOSEPH BEEL • JERRY SOLLINGER

Simulator and Live Training for Navy Units

Prepared for the
United States Navy

NATIONAL DEFENSE RESEARCH INSTITUTE
RAND

The research described in this report was sponsored by the United States Navy. The research was conducted in RAND's National Defense Research Institute, a federally funded research and development center supported by the Office of the Secretary of Defense, the Joint Staff, the unified commands, and the defense agencies under Contract DASW01-95-C-0059.

Library of Congress Cataloging-in-Publication Data

Finding the right balance : simulator and live training for navy units / John Schank ... [et al.].
p. cm.
Includes bibliographical references.
"MR-1441."
ISBN 0-8330-3104-X
1. Naval tactics—Study and teaching—United States. 2. Naval tactics—Study and teaching—United States—Simulation methods. 3. Anti-submarine warfare—Study and teaching—United States—Evaluation. 4. Fighter pilots—Training of—Evaluation. 5. Effective teaching—United States. I. Schank, John F. (John Frederic), 1946– II. Rand Corporation.

V169 .F53 2002
359.4'071'073—dc21

2001057887

Published 2002 by RAND
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
201 North Craig Street, Suite 102, Pittsburgh, PA 15213
RAND URL: http://www.rand.org/
To order RAND documents or to obtain additional information, contact Distribution Services: Telephone: (310) 451-7002; Fax: (310) 451-6915; Email: order@rand.org

PREFACE

Tightening budget constraints and increasing access restrictions have reduced the U.S. Navy's ability to conduct tactical training at the unit level. At the same time that live training events have become more difficult to accomplish, significant technological advances have improved the productivity and realism in the modeling, simulation, and distributed training areas. However, the balance among live, simulated, and schoolhouse training events has not significantly changed since the 1970s.

The Manpower, Personnel, and Training section of the Assessments Division (N81) of the Deputy Chief of Naval Operations for Resources, Warfare Requirements, and Assessments tasked RAND to examine the current mix of tactical training events in two mission areas—antisubmarine warfare and strike—and for three platforms—F/A-18 and P-3C aircraft and the DDG-51-class destroyers. The objective of the research was to document the current and historical mix of training events, understand how other U.S. services and our allies conduct similar training, and recommend potential changes to the way the Navy conducts tactical unit training. This report describes the results of the research. It is intended for those with an interest in military training, particularly those with an interest in simulators and simulation.

This research was conducted for the U.S. Navy within the Forces and Resource Policy Center of RAND's National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the unified commands, and the defense agencies.

CONTENTS

FIGURES

TABLES

SUMMARY

BACKGROUND

The Navy trains its forces with a combination of classroom, simulated, and actual training events. The relation of these types of training events to each other and their relative proportions have not been closely examined in decades. However, the technological capabilities of simulators and classroom instruction have grown enormously. At the same time, the cost of actual training events has increased, and the opportunities to conduct them have decreased. Environmental restrictions, encroachment on training areas, and the decreasing tolerance of the civilian populace for the intrusion of military training have combined to make it more difficult to carry out the type of live training activities common 20 or even 10 years ago.

The Navy asked RAND's National Defense Research Institute to examine the three types of training to determine if a different mix of the three types might offer either training efficiencies or synergies.

RESEARCH OBJECTIVE AND APPROACH

Accordingly, we examined the three training modes with an eye to identifying alternative combinations that would enable Navy units to achieve desired levels of proficiency. We focused on fighter strike missions and antisubmarine warfare. We reviewed the training associated with three systems, two airborne and one surface: the F/A-18, the P-3C, and the DDG-51.

We also examined the training of similar systems in other services and in allied forces. We reviewed the Marine Corps training procedures for its F/A-18 aircraft and the Air Force procedures for the F-16. In allied services, we reviewed the Royal Air Force's training policies and procedures for the Tornado and the Nimrod and the French Navy's training for the Super Etendard and E-2C. We also reviewed the Royal and French navies' training for their surface antisubmarine forces. In addition, we reviewed the research on the trade-off between live and simulated training events.

WHAT WE FOUND OUT

First, we conclude that classroom training does not play a major role in any trade-offs. At the unit level, classroom training clearly plays a role. However, it does not figure into the point system that the Navy uses to gauge its training readiness. Furthermore, classroom training varies in formality and content. It tends to be tailored to the needs of a particular ship or squadron and typically results from the initiative of individual training officers. Furthermore, much classroom training is a precursor or adjunct to both live and simulation training and thus gets considered in our analysis of training. Because classroom training does not figure into the types of trade-offs we are considering, we exclude it.

Second, we find that simulators do not play a large role in the training of fleet F/A-18 pilots, who average only about one hour a month in simulators. Reasons for this modest contribution include poor accessibility to the simulators and a lack of fidelity between the simulation and the aircraft. This finding is consistent for the allied air force units as well. We also conclude that no sound basis exists for making judgments about the contribution of simulation training to pilot proficiency. Available studies tend to be dated and raise methodological issues, and no good baseline data are available to use for comparison. Finally, we conclude that some events cannot be simulated.

Third, in contrast to the fighter community, the airborne antisubmarine warfare community uses simulators extensively. For the P-3C crews, this is true both for the flight crew and for the Tactical Nucleus. The flight simulators replicate the flight environment of the P-3C pilots better than do those used by the F/A-18 pilots and thus enjoy wider acceptance. This wider acceptance reflects in the greater use of simulators by the P-3C crews. During the training before deployment, the P-3C crews average more than 14 hours of mobility simulation per month and more than 6 hours of tactical simulation. Although there are some differences, we also find that the allied airborne antisubmarine warfare units use simulators extensively.

Fourth, turning to the surface antisubmarine forces, we find that they too rely on simulators. The ships typically have on-board simulators that allow the sonar technicians to train on their own equipment, and they can do this whether under way or in port. They also have drones that can be launched when they are at sea, and these can emulate various types of targets. An extensively instrumented range off the coast of southern California also offers a range of simulation-supported training activity. Simulators also figure prominently in the training for foreign navies.

WHAT SHOULD THE NAVY DO?

The fighter community uses simulators the least of the three groups we examined. However, before the Navy makes any extensive effort to expand the use of simulators, it should first decide how it wants to measure readiness. Currently, it measures readiness by ensuring a given level of proficiency across a range of tasks. Put another way, it establishes a minimum level of proficiency, and once a unit meets that minimum, it is declared ready. Additional training presumably would improve unit proficiency in the various tasks, but the current system offers no incentive to do that. Indeed, it does not even have a way of reflecting it.

Second, the Navy should identify the goal of any future balance of training. For example, the goal might be the same level of proficiency as today but at less cost. Or it might seek more proficiency at the same cost.

If the Navy opts for a system that can recognize increased proficiency, it should then carry out a careful analysis of the benefit of simulators vis-à-vis live training. One focus of this analysis should be the relationship between simulators and proficiency for the different levels of fidelity. An early and important finding will be whether the needed levels are technically and economically feasible. However, the analysis needs to include a wide range of factors. It must be robust enough to show whether alternatives to increased simulator or live events might yield greater return. For example, the analysis must be complete enough to show whether it would be more cost-effective to increase retention bonuses and retain experienced pilots or fly more mission repetitions in a simulator. It also needs to detail the constraints that limit both simulated and live training, including what events cannot be simulated.

Finally, if the analysis shows that the Navy should increase simulator training, then the Navy needs more simulators and better ones. The current quality and availability are impediments that need to be overcome.

ACKNOWLEDGMENTS

The authors would like to thank Captain Matt Peters and Commander Robert Henderson for initiating the study effort and providing guidance and suggestions during the conduct of the research. Many U.S. Navy officers and civilians provided their time and expertise during the course of the research. Primary among these were Captain Robert Snyder of the Chief of Naval Operations staff; Lieutenant Commander Ed Kules of the Atlantic Fleet; Captain Mark Ensor, Commander Roger Henze, and Peter Glueck of the P-3C community; Commander James Stutz of the Strike Fighter Weapons School, Atlantic; and Captains Denny Wheeler and Dave Gelenter and Commander Mike Riddle of the Fleet ASW Training Center.

Jack Lovell and Mike Matt of Information Spectrum, Inc., provided valuable data and background information during the early phases of our study. Laura Junor, Laura Geis, and Alan Brown of the Center for Naval Analyses provided data and shared with us their expertise on Navy training. Bill Taylor of RAND shared his knowledge of Air Force training philosophy and practices. Randy Farley and Steve Streightiff of DynCorp described the training capabilities of SCORE.

Major Bond of the Marine Aviation Weapons and Tactics Squadron helped us understand Marine Corps F/A-18 training. Captain Philippe Alquier and Commander Jean-Marc Gerbier of the French Embassy in Washington, D.C., facilitated our visits with the French Navy staff in Toulon. We would also like to thank the many officers of ALAVIA and ALFAN who took the time to talk with us about the training of French Navy ships and aircraft. Particular among these are Captain Collonnier and Commander Heimferte of ALFAN and Captain Bru of ALAVIA. Special thanks goes to Captain Benedittini, the commanding officer of the Dupleix, who provided a tour of his ship and described the French training program.

Commander Stephen Braham and Wing Commander David Fidler of the British Embassy in Washington, D.C., and Commander Chris Lade, who was serving on the U.S. Navy staff in Washington, D.C., facilitated our visits with the Royal Navy and Air Force. At the British Embassy, Commander Gary Pettit was particularly helpful in sharing his knowledge of surface ship training in the Royal Navy. We would also like to thank the many officers of the Royal Navy and Royal Air Force who took the time to talk with us about the training of British ships and aircraft. Particular among these are Wing Commander Kevin Havelock, Wing Commander Jon Fynes, and Wing Commander John Babraff. Special thanks goes to Bharat Patel of the Defence Evaluation and Research Agency (DERA), who provided a review of research into simulator use in training. Within RAND, Audrey Caudle helped with research materials.

We also gratefully acknowledge the thorough and thoughtful reviews of our RAND colleagues Robert Button and William Taylor. Their efforts have made this a much more useful document.

Of course, all errors are the sole responsibility of the authors.

ACRONYMS

AAW	Antiair warfare
ACC	Air Combat Command
ACE	Aviation combat element
ACM/ACT	Air Combat Maneuvering/Aircrew Coordination Training
ACTS	AEGIS Combat Training System
AEO	Air electronics officer
ALFAN	French Navy Training Command
AMW	Amphibious warfare
AR	Aerial Refueling
ARG	Amphibious Ready Group
ASTT	Active Sonar Training Team
ASUW	Antisurface warfare
ASW	Antisubmarine warfare
ASWD	Aerial Specific Weapons Delivery
ATG	Afloat Training Group
ATRIMS	Automated Training and Readiness Information Management System
AWACS	Airborne Warning and Control System
BFTT	Battle Force Tactical Trainer
BIA	Battle Impact Assessment
BMC	Basic Mission Capable
BOST	Basic Operational Sea Training
BRAC	Base Realignment and Closure
C2W	Command and control warfare

CACC	Combat Air Command and Control
CART	Command Assessment of Readiness and Training
CAS	Close air support
CAX	Combined arms exercise
CCC	Command, Control, and Communications
CEP	Circular error probable
CFT	Cockpit familiarization trainer
CIC	Combat Information Center
CINCCENT	Commander in Chief, Central Command
CINCEUR	Commander in Chief, Europe
CINCPAC	Commander in Chief, Pacific
CMR	Combat Mission Ready
CNA	Center for Naval Analyses
CNO	Chief of Naval Operations
COMPTUEX	Composite Training Unit Exercise
CPT	Cockpit Procedures Trainer
CRP	Combat Readiness Percentage
CSAR	Combat search and rescue
CT	Continuation training
CVW	Carrier Air Wing
DAS	Deep air support
DERA	Defence Evaluation and Research Agency
DMT	Distributed mission trainer
DoD	Department of Defense
DOST	Development Operational Sea Training
EAF	Expeditionary Aerospace Force
ESM	Electronic Support Measures
EW	Electronic warfare
FAC(A)	Forward air controller (airborne)
FASO	Fleet Aviation Specialized Operational
FAST	Fleet Aircrew Simulator Training
FCD3	Fleet Classified Document

FCLP/EQ	Field Carrier Landing Practice/Expeditionary Qualifications
FE	Flight engineer
FEP	Final Evaluation Period
FH	Flying Hour
FLEASW-TRACEN	Fleet ASW Training Center
FMC	Fully mission capable
FOSF	Flag Officer Surface Flotilla
FOST	Flag Officer, Sea Training
FOTSC	Flotilla On-Board Training Support Cell
FRS	Fleet Replacement Squadron
FSO	Fleet Support Operations
FTU	Formal Training Unit
HARM	High-Speed Antiradiation Missile
HCM	Hours per crew per month
ICW	In conjunction with
IDTC	Interdeployment Training Cycle
IQT	Initial Qualification Training
ISIC	Immediate Superior in Command
JMOTS	Joint Maritime Operational Training Staff
JSF	Joint Strike Fighter
JTFEX	Joint Task Force Exercise
LAMPS	Light Airborne Multipurpose System
LANTIRN	Low-Altitude Navigation and Targeting Infrared for Night
LAT	Low-Altitude Tactics
LOS	Length of service
MACG	Marine Air Control Group
MACP	Marine Aviation Campaign Plan
MAD	Magnetic anomaly detector
MAG	Marine Air Group
MAGTF	Marine Air-Ground Task Force
MAW	Marine Aircraft Wing

MAWS	Missile Alert Warning System
MAWTS-1	Marine Aviation Weapons and Tactics Squadron–One
MCAS	Marine Corps Air Station
MCCRES	Marine Corps Combat Readiness Evaluation System
MEF	Marine Expeditionary Force
MEFEX	Marine Expeditionary Force Exercise
METL	Mission Essential Task List
MEU	Marine Expeditionary Unit
MIW	Mine warfare
MOB	Mobility
MOE	Measure of effectiveness
MOP	Measure of performance
MOS	Missions of State
MPA	Maritime patrol aircraft
MPS	Mission Performance Standard
MQT	Mission Qualification Training
MWSG	Marine Wing Support Group
NALCOMIS	Naval Aviation Logistic Command Information System
NAS	Naval Air Station
NATO	North Atlantic Treaty Organization
NATOPS	Naval Aviation Training Operations
NAVFLIRS	Naval Flight Record Subsystem
NFO	Naval flight officer
NS	Night Systems
NSAWC	Naval Strike and Air Warfare Center
OBT	On-board trainers
OCU	Operational conversion unit
OFP	Operational Flight Profile
OFT	Operational Flight Trainer
OJT	On-the-job training
OPS	Operational Performance Statement
OPTEMPO	Operational tempo

ORE	Operational Readiness Evaluation
OS	Operations Specialist
OST	Operational Sea Training
OTR	Operational Training Requirement
PACAF	Pacific Air Forces
PGM	Precision-guided munition
PMA	Primary Mission Area
PMR	Primary Mission Readiness
POE	Projected Operational Environment
PPC	Patrol Plane Commander
PPCP	Patrol Plane Copilot
PPNC	Patrol Plane Navigator/Communicator
PPP	Patrol Plane Pilot
PPTC	Patrol Plane Tactical Coordinator
PRISM-OC	Planning and Reporting Information System for Operational Capability
PTT	Part-Task Trainer
RAF	Royal Air Force
RAP	Ready Aircrew Program
RECON	Reconnaissance
RFA	Royal Fleet Auxiliary
ROC	Required Operational Capability
RWR	Radar warning receiver
SAR	Search and rescue
SATT	Squadron Advanced Tactical Training
SCORE	Southern California Offshore Range
SEAD	Suppression of Enemy Air Defenses
SFARP	Strike Fighter Advanced Readiness Program
SFTI	Strike Fighter Tactics Instructors
SFWT	Strike Fighter Weapons and Tactics
SH	Simulator hour
SLAM	Standoff Land-Attack Missile
SMD	Ship Manpower Document

SMOPS	School of Maritime Operations
SOAR	Southern California ASW Range
SONATA	Sonar Trainer
SORTS	Status of Resources and Training System
SSWD	Surface Specific Weapons Delivery
SS1/SS2	Acoustic sensor operators
SS3	Electronic warfare operator
ST	Sonar technician
STW	Strike warfare
TAC(A)	Tactical air controller (Airborne)
TACNUC	Tactical Nucleus
TART	Towed Array Reaction Team
TIALD	Thermal Imaging Airborne Laser Designator
TOT	Time over target
TPC	Tactical Proficiency Course
T-Rate	Training Rating (for SORTS)
TORT	Tactical Operational Readiness Trainer
TPA	Training Performance Statement
TSTA	Tailored Ships Training Availability
T&R	Training and readiness
UDP	Unit Deployment Program
UFT	Undergraduate Flight Training
USAF	U.S. Air Force
USAFE	U.S. Air Forces in Europe
USMC	U.S. Marine Corps
USN	U.S. Navy
USW	Undersea warfare
UTD	Unit training device
VFA	Fighter/Attack Squadron (Navy)
VMFA	Marine Fighter/Attack Squadron
VMFA(AW)	Marine Fighter/Attack Squadron (All Weather)
VMFAT	Marine Fighter/Attack Training Squadron

WST	Weapon System Trainer
WTI	Weapons and tactics instructor
WTM	Wing Training Manual
WTT	Weapons and Tactics Trainer
WTTP	Weapons and Tactics Training Program
WTU	Weapons and Tactics Unit

Chapter One

INTRODUCTION

BACKGROUND

The Navy training continuum moves from individual to unit to multiunit and finally to battle group–level training. This continuum has traditionally flowed from the classroom, to the unit location (naval base or naval air station), to the at-sea, or deployed, environment. Unit-level training is designed to achieve proficiency in all Primary Mission Areas (PMAs). These PMAs are specified in a weapon system's Required Operational Capabilities/Projected Operational Environment (ROC/POE) documents. Type Commanders and Immediate Superiors in Command (ISICs) manage a tiered Interdeployment Training Cycle (IDTC), which is structured to increase unit readiness progressively, peaking immediately before deployment. The foundation of this training process is platform-specific training matrices (e.g., DDG-51, F/A-18) that define specific events needed to meet readiness requirements and sustain mission proficiency in each PMA.

Navy unit training has traditionally focused on live training events. However, constrained budgets have led to a shortage of repair parts, fully mission capable aircraft, and systems needed to conduct live training. Also, access to training ranges has become more difficult in the face of increased opposition from environmental and local interest groups.

At the same time, significant technological advancements have improved productivity and realism in the modeling, simulation, and distributed learning areas. However, the balance among live, simulated, and classroom training have not changed significantly since the 1970s. Potential training efficiencies may exist that would streamline the training events during the IDTC while maintaining or increasing the desired levels of readiness and proficiency. For example, the naval aviation training standard of 83 percent Primary Mission Readiness, including the arbitrary 2 percent simulator programmatic cap, has not changed since the early 1980s. Similarly, the contributions of Advanced

Distributed Simulation have not been integrated into the overall training curriculum in the surface community.

In recent years, many units have struggled to deploy at the desired level of training readiness primarily because of resource constraints that have prevented the desired progressive increase in proficiency during the IDTC. Achieving proficiency in multiple mission areas exacerbates the challenge. This situation has generated concerns about proficiency in several challenging mission areas such as strike and antisubmarine warfare (ASW).

RESEARCH OBJECTIVES

The objective of this research is to examine alternative combinations of live, simulated, and classroom tactical unit training events to achieve desired levels of readiness and proficiency. The research concentrates on antisubmarine warfare and strike missions and describes the current unit training profiles for three systems: two U.S. Navy airborne systems (P-3C and F/A-18) and one sea-based system (DDG-51-class destroyers).

These training problems are not unique to the Navy but also afflict the other military services, our allies, and commercial institutions. Therefore, the research also examines how the training curriculums of these other organizations have evolved to help identify alternative mixes of live, simulated, and schoolhouse training events to achieve greater readiness and proficiency for naval units.

Finally, the research synthesizes the findings of previous research efforts on the trade-offs between live and simulated training events to identify the cost and readiness aspects of alternative training methods. Based on the current use of live, simulated, and classroom events for the Navy, other U.S. services, and our allies as well as the findings of previous research efforts, we describe the important issues in examining and evaluating alternative unit training syllabi. This report presents the results of the research.

DATA CAVEAT

Part of the research involved collecting and analyzing data on flying hours and simulator use for U.S. Navy units, for the Marine Corps and Air Force, and for British and French units. Unfortunately, there is no central source for the needed data within the Navy. We, therefore, received various data from numerous sources. The Center for Naval Analyses, Information Spectrum, Inc., and the East Coast P-3C Wings provided flying hour and simulator hour data for the U.S. Navy and Marine Corps units. We reconciled these data as best as we could, but there were differences resulting from where the organizations obtained the data and the underlying intent of their data collection.

The Air Force, British, and French data are based on information provided in various reports and on interviews with different organizations.

We caution readers that the data presented in this report are "best estimates" based on what was readily available for the analyses. The flying hour and simulator hour averages are best viewed from a relative perspective between the various cases we examined, not from the perspective of being absolutely correct. Our research focused on these relative differences and the trends in flying hours and simulator use over the last several years.

ORGANIZATION OF THE REPORT

The report is organized into two parts, a main body and a series of appendices. The appendices contain the bulk of the research gathered during the project. The specific material in each is described below. Those interested in the detailed information we gathered about the training programs of the Navy, other services, or our allies should refer to those appendices. The next chapter summarizes the appendices, indicating what we found about the different training programs and comparing training resources across the organizations. The third chapter addresses the trade-offs between live and simulated training. It summarizes the current body of research on this topic, compares the use of simulators across the three communities we surveyed, discusses what the Navy would have to do to encourage greater use of simulators, and offers a model to illustrate the nature of trade-offs between live and simulated training. We gathered our most extensive data on fighter training. We have therefore devoted a separate appendix to each organization that trains fighters, treating our allies as a single organization. We present the results of our research into the air and surface antisubmarine training in one appendix for each. The appendices are as follows:

- Navy F/A-18 Training
- Marine Corps F/A-18 Training
- Air Force F-16 Training
- Allied Fighter Training
- Air Antisubmarine Training
- Surface Antisubmarine Training.

Chapter Two

TRAINING

This chapter summarizes our research findings about the training of strike fighter and air and surface antisubmarine training.

NAVY F/A-18 TRAINING

The Navy's deployment cycles shape its pilot training. Carrier-based pilots follow a nominal 24-month cycle consisting of two parts: An 18-month IDTC and a six-month deployment on a carrier. The training is both progressive and repetitive. It is progressive in the sense that a series of progressive steps are designed to raise the pilots to peak proficiency immediately before deploying. It is repetitive in that at the end of the deployment the cycle begins again. Figure 2.1 shows a typical training cycle.[1]

The IDTC portion of the cycle divides into three phases—basic, intermediate, and advanced—and has two components: training ashore and embarked. The embarked component moves from basic skills (learning to work together as a crew) through intermediate (learning to operate as a member of a battle group) to advanced (operating as part of a fleet or in joint organizations). The ashore phase has only basic and intermediate components. In the basic phase, pilots hone individual skills and operate as members of two- and four-ship formations. The intermediate phase is a four-week session conducted at NAS Fallon, Nevada, for all of an air wing's squadrons. Training progresses from air wing tactics through those of an air campaign. NAS Fallon has an extensive range complex that allows digital recording of mission flight profiles for subsequent analysis and critique.

Inherent in this cycle is the recognition that the squadron will experience periods of decreased readiness when it returns from the deployment. Typically, a

[1]Appendix A contains a detailed description of the phases and components of the training cycle.

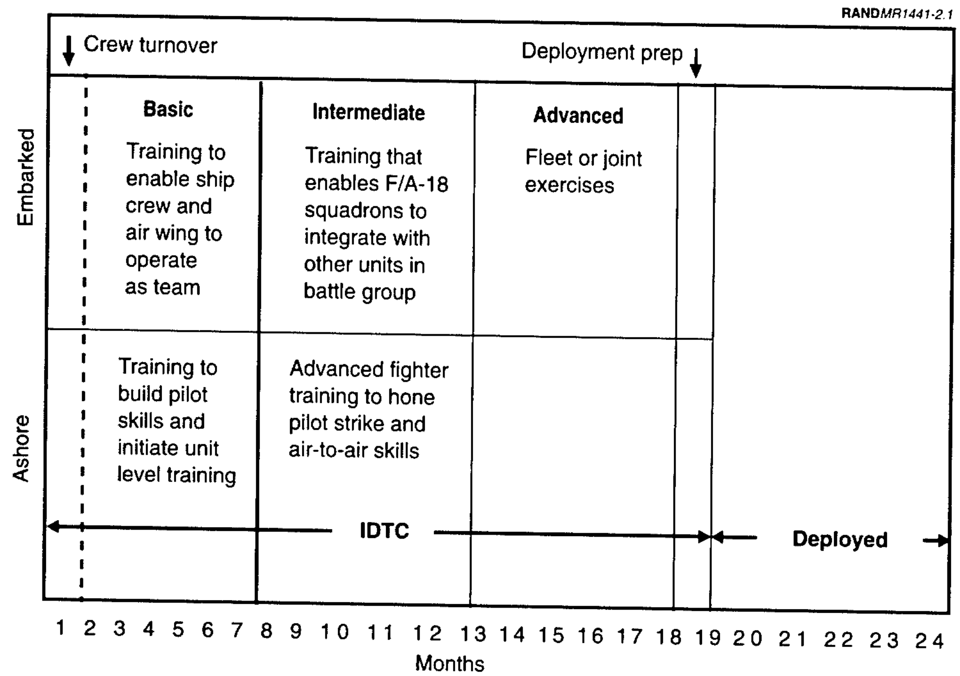

Figure 2.1—Typical Training Cycle

squadron will transfer personnel in and out of the squadron, send people on leave, accomplish deferred maintenance, and engage in other activities that temporarily lower readiness. The Navy finds this an acceptable approach because other squadrons are at a higher readiness level and can respond to emergencies.

The Navy determines what events constitute the training of the squadrons through a series of interlinked matrices, called training and readiness (T&R) matrices. Strike fighter pilots must demonstrate proficiency in seven PMAs. The following lists the seven PMAs for the F/A-18 in training priority order with a brief description of the desired mission outcomes:

- **Mobility** (MOB)—safely operate aircraft in all weather conditions, take off and land aboard the carrier, and aerial refuel.
- **Strike Warfare** (STW)—attack and destroy enemy targets employing a wide variety of air-to-ground munitions, conduct combat search and rescue (CSAR).
- **Antiair Warfare** (AAW)—maintain local air superiority and destroy enemy aircraft using air-to-air missiles and guns.

- **Amphibious Warfare** (AMW)—conduct close air support (CAS) missions.
- **Antisurface Warfare** (ASUW)—attack and destroy enemy ships.
- **Mine Warfare** (MIW)—deploy mines.
- **Command, Control, Communications**[2] (CCC)—tactically communicate.

The AMW, ASUW, and MIW PMAs represent refinements of the STW PMA; each embodies an inherent STW capability.

Each matrix consists of a series of missions and actions organized by PMA. Typically, a mission consists of several training actions. For example, a given mission, e.g., Offensive Counterair, may require 15 actions (e.g., high-fast intercept) to accomplish. Only one mission can be accomplished on a given sortie. However, several training actions can be completed. The T&R matrix provides the type commander what he needs to know to plan training. In addition to the task number (linked to a PMA) and title, it specifies the following:

- Whether the task must be flown, must be done in a simulator, or can be either.
- The emphasis level, essentially the importance of the task, which enables a commander to make choices in times of reduced resources.
- The "periodicity"—that is, how frequently the task must be performed.
- The points awarded for a task by PMA area; this is an accounting device that enables commanders to track readiness.

It is important to note that the matrices provide the basis for determining readiness and, by extension, training proficiency. Generally, once squadron's pilots have amassed a given level of points in the seven mission areas, the squadron is considered ready. No benefit accrues from additional flying, even though additional repetitions might represent a higher level of training proficiency. In this sense, the matrices represent a minimum acceptable level of proficiency.

F/A-18 squadron training has three components. Simulator and flight operations specified in the T&R matrices that raise the training readiness levels of squadron pilots constitute one. A second facet of squadron training is the Strike Fighter Weapons and Tactics (SFWT) program, (U.S. Navy, undated 1) which increases the tactical experience of squadron pilots and ensures tactical standardization. The SFWT program overlays the training specified in the T&R matrices and does not drive flight hour requirements. The last component of

[2]Navy F/A-18 squadrons fly no training missions solely dedicated to the CCC mission.

squadron training is participation in increasingly complex exercises geared to improve readiness and interoperability at the unit, battle group, and joint task force level.

Pilot training readiness in each PMA is attained by successfully completing training missions and training actions. Point awards determine successful completion. Readiness is maintained by successfully repeating the appropriate training mission or action periodically as a function of SFWT pilot experience. A maximum score of 100 points is possible in each PMA, though the number of points awarded for each varies. Flying more missions than those required does not garner additional points; pilots cannot accumulate more than 100 points in any PMA. The number of points in each PMA, the number and experience level of assigned pilots, and the number of on-board pilots who have expended certain weapons determine training readiness.

There are four training levels, T1 to T4, with 1 being the highest level. T&R matrices prioritize the percentage of pilots who should be current at each T-readiness level, which, in turn, relate to phases of the IDTC. This prioritization or emphasis is designed to assist squadron commanders in determining which missions should be flown during various phases of the IDTC.

To qualify in any mission or action, a pilot must meet the standards prescribed in the associated measures of performance (MOPs) and measures of effectiveness (MOEs).[3] To maintain qualification, pilots must refly the event within a time frame predicated on their SFWT experience level. There are four SFWT experience levels, L1 to L4, reflecting progression through the SFWT program:

- from recent FRS graduate (L1),
- to qualified wingman (L2),
- to qualified section leader (L3), and
- to qualified division leader (L4).

Last, each mission has a list of "Measures of External Mission Degrade" that specifies for applicable degradations beyond the control of the pilot the percentage mission/action PMA points will be reduced. This approach allows for partial completion, but full currency, when external factors preclude completing all of the mission's training objectives. The mission degrading categories include[4]

[3]MOPs identify knowledge, skills, and abilities of the pilot and relate to the process. MOEs identify quantifiable mission outcomes.

[4]Each of the briefing guides for training missions and actions in the WTM contains appropriate modifiers for these categories.

- mission requirements,
- lack of prescribed ordnance,
- range restrictions,
- reduced support asset(s),
- aircraft equipment constraints,
- performance constraints, and
- weather restrictions.

Table 2.1 displays the annual training requirements for a squadron to be at the "T1" level.

In addition to determining the training activities, the T&R matrices also dictate the training resources. These primarily involve flying and simulator hours, but they also specify required ordnance. The characteristics of pilots assigned to a squadron affect the number of flight hours. Junior pilots are thought to need more hours to gain proficiency in a task, and more experienced pilots fewer. The T&R matrices take the experience mix of the squadron pilots into account.

Figure 2.2 shows the annual flying hours programmed, budgeted, and flown for the F/A-18. The straight line of the programmed hours reflect the traditional 25 hours per crew per month the Navy has used. Generally, the Navy flies fewer hours than it budgets. Only in FY 1996 did hours flown exceed hours budgeted.

The T&R matrices also spell out the number of simulator hours by task. In general, junior pilots (L1 and L2) require about four hours a month, and experi-

Table 2.1

Approximate Annual PMA Training Requirements

PMA	Missions (Flight/Simulator)	Annual Sorties (Flight/ Simulator)	Annual Training Flight Hours	Annual Simulator Hours
AAW	9 (8/1)	81/17	114	17
STW	10 (8/2)	88/21	125	20
MIW	2 (1/1)	2/1	3	1
AMW	2 (2/0)	12/0	17	0
ASUW	1 (1/0)	2/0	3	0
MOB	6 (3/3)	25/12	43	9
CCC	0 (0/0)	0/0	0	0
Total	30 (23/7)	210/51	305	47

NOTE: Based on a squadron with a T1 training readiness rating and 17 pilots whose SFWT experience levels are at the minimum required for T1.

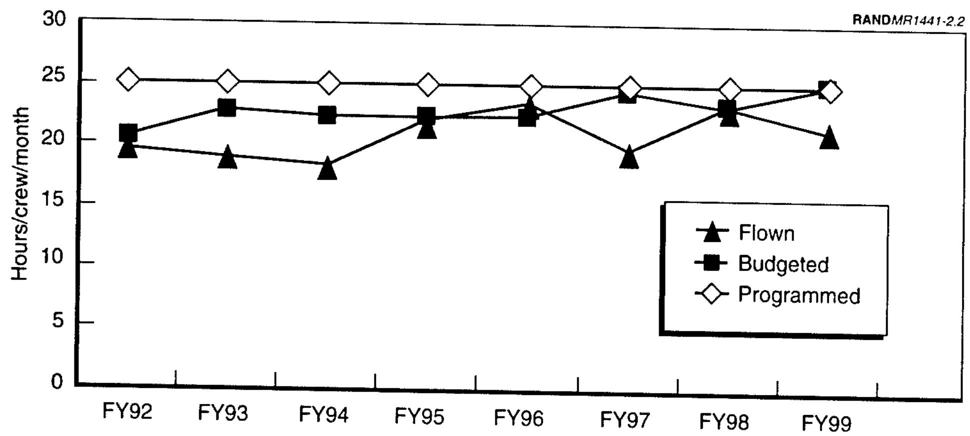

Figure 2.2—Annual F/A-18 Flying Hours

enced ones (L3 and L4) require about two. The Navy has four types of F/A-18 simulators, three of which are used by the active component. Each simulator is programmed with an Operational Flight Profile (OFP) used in the aircraft. The F/A-18 has been in the fleet for many years, and the OFPs have been changed several times. The most current OFP is 13C. As Table 2.2 shows, not all the simulators have the most current OFP. None of the Oceana simulators has the most current OFP. The problem posed by an out-of-date OFP is that pilots cannot use it for effective training, even if they wanted to. Thus, training has to be done using live flying hours.

A history of simulator use data appears in Figure 2.3. It shows that the Fleet Replacement Squadron (the institution training element that provides fighter pilots to the fleet) accounts for most of the simulator time (50–60 percent). Fleet squadrons use the simulators about 20 percent of the time, and the simulators stand idle about 20 percent of the time. The Fleet Replacement Squadrons (FRSs) are based at NAS Oceana in Virginia and NAS Lemoore in California, where they are co-located with operational squadrons. Thus, the fleet pilots have to share the simulators with those still in training.

Our interviews uncovered two reasons that fleet pilots do not use simulators more. One reason is the lack of current OFP profiles in the simulators. The 13C profile is available at Lemoore and Beaufort but not at Oceana. A second reason is availability or, more precisely, the timing of the availability. The FRS consumes most of the simulator time, and the fleet pilots believe that the scheduled times they receive are less desirable ones.

Table 2.2

Location and Configuration of F/A-18 Simulators

Air Station	Simulator	Cockpit #1 OFP	Cockpit #2 OFP
NAS Lemoore	WTT 1	OFP 13C	OFP 11C
	WTT 4	(F/A-18F mod)	OFP 91C
	OFT 1[a]	OFP 92A	N/A
	OFT 3	OFP 11C	N/A
NAS Oceana	WTT 3	OFP 11C	OFP11C
	WTT 5	OFP 91C	OFP 91C
	OFT 2	OFP 11C	N/A
	OFT 5	OFP 10A	N/A
MCAS Beaufort	WTT 7	OFP 11C	OFP 13C
	OFT 4	OFP 92A	N/A

[a]OFT = Operational Flight Trainer.

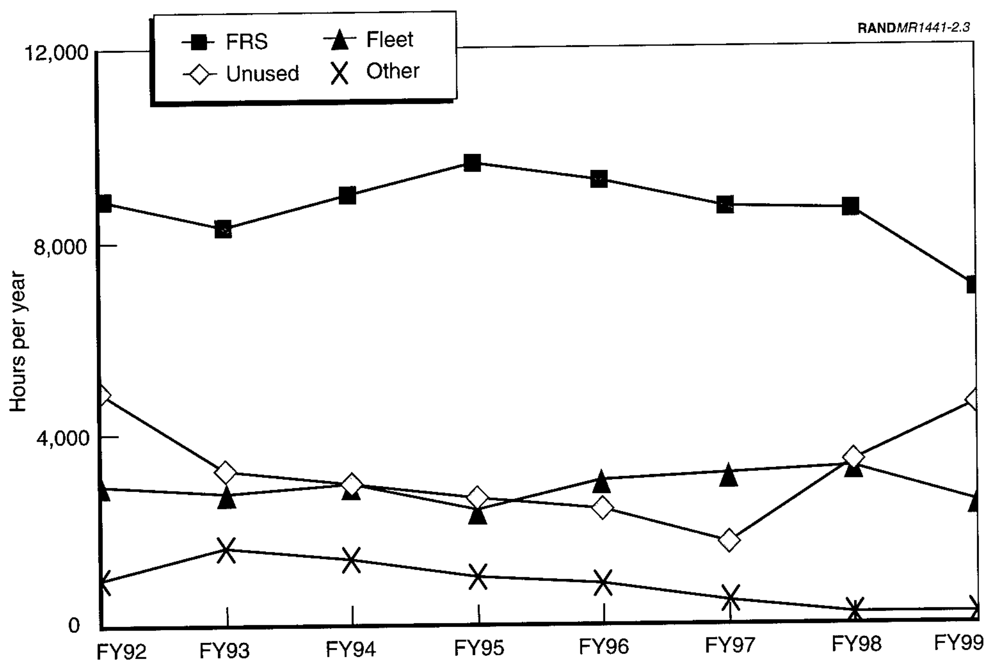

Figure 2.3—F/A-18 Simulator Usage

Conclusion

F/A-18 squadron training focuses on attaining and maintaining PMA qualifications and currency to have sufficient PMA points to attain desired T-ratings. Overlaying the missions and actions constituting the training requirements is the SFWT program, which ensures tactical standardization and provides a structured program to increase the tactical experience levels of F/A-18 pilots. Table 2.3 shows all of the PMA points a squadron can attain by flight or simulation missions and actions. STW and AAW, the two dominant warfighting PMAs, which take the most flight hour resources, can reach the T1 level (90 and 86 points, respectively) without conducting any simulator events. The MOB PMA, conversely, uses the OFT simulator for 30 percent of its maximum. There are not that many MOB training events; the simulator is used for Naval Aviation Training Operations (NATOPS) and instrument check flights and for carrier landing rehearsal, relatively unsophisticated missions. Despite the sophistication of the Weapons and Tactics Trainer (WTT) simulator, it has not yet fulfilled its promise to enhance tactical training.

In addition to the poor fidelity of (in particular) the WTT, there is the question of simulator versus pilot availability. While attention is being paid to whether the simulator's available time is used, fleet pilots expressed the concern that making the simulator more available to them was of greater importance.

MARINE CORPS F/A-18 TRAINING

Like the Navy, the U.S. Marine Corps flies F/A-18s. Most Marine Corps squadrons have a 30-month cycle involving a six-month deployment[5] followed by a 24-month turnaround. The USMC squadrons employed on aircraft carriers follow the same 24-month cycle (six months of deployment followed by an 18-month IDTC) as U.S. Navy squadrons. Marine Corps F/A-18 squadrons do not

Table 2.3

PMA Points by Training Event and Media

PMA	PMA Points			
	Flight Missions	Simulator Missions	Flight Actions	Simulator Actions
AAW	41	6	45	8
STW	43	5	47	5
MIW	28	18	50	4
AMW	37	0	59	4
ASUW	20	13	51	16
MOB	50	30	20	0
CCC	45	20	35	0
Percentage of Total PMA Points	38%	13%	44%	5%

NOTE: A pilot could attain a maximum of 700 total PMA points (100 points for each of the seven PMAs).

[5]The Marine Corps manages deployments under the Unit Deployment Program (UDP).

use a tiered readiness or "bathtub" approach to unit readiness that the Navy follows. Marine Corps squadrons strive to maintain high readiness levels at all times, usually C-2 or higher.

Each Marine Aircraft Wing (MAW) has a unique organizational structure. When the MAW deploys as the aviation combat element (ACE) for a Marine Expeditionary Force (MEF), the MAW headquarters functions as the ACE's command element. Marine Air Groups (MAGs), task-organized based on the assigned mission, are subordinate to the MAW. Typically, all F/A-18 units in the MAW will be grouped in a single fixed wing. The primary mission of the MAG is to provide AAW and offensive air support for the task force.

The Marine Corps considers aviation an integral part of the task force. The ACE is a versatile part of the task force's combined-arms team, complementing the ground combat element and combat service support element. The ACE's primary contribution is the ability to conduct the deep fight. The ACE is not a formal command. It is a task-organized Marine aviation force under a single commander within a task force. An ACE is usually composed of an aviation unit headquarters and various other aviation wings, squadrons, or their detachments.

The tasks of Marine aviation fall into six functional areas: offensive air support, AAW, assault support, air reconnaissance, electronic warfare, and control of aircraft and missiles. Marines employ the F/A-18A, C, and D aircraft in Marine Fighter/Attack squadrons (VMFAs) and F/A-18D in Marine Fighter/Attack (all weather) squadrons (VMFA[AW]s). Table 2.4 shows the six tasks of Marine aviation that the two types of squadrons fulfill.[6]

Unit training programs emphasize squadron qualifications and the overall combat readiness of the unit, facilitated by a standardized unit training pro

Table 2.4

Marine F/A-18 Aviation Mission Allocation

Squadron Type	Offensive Air	AAW	Assault Support	Reconnaissance	Electronic Warfare	Control of Aircraft and Missiles
VMFA F/A-18A/C	x	x	Escort	x	Support	Support
VMFA(AW) F/A-18D	x	x	Escort	x	Support	FAC(A)/ TAC(A)

NOTE: x indicates primary mission.

[6]For a discussion of the types of missions the squadrons carry out and a discussion of the broad aviation operations and training strategy of the Marine Corps, see Appendix B.

gression model that depicts the logical progression of qualifications. Training has four tiers. Crews progress from combat capable (when they leave the FRS) to combat ready to combat qualified. The last step in the progression is fully combat qualified, which involves the attainment of skills beyond those regarded as necessary for combat. Unit training programs are based on multi-tiered combat training phases for individual members.[7]

By way of illustration, Table 2.5 shows the flying and simulator requirements for Tier Three, combat qualified.

Three major training events take place during a squadron's turnaround cycle: a combined arms exercise (CAX), an air-to-air training detachment, and an air-to-ground training detachment. The combined arms exercise is conducted at Marine Corps Base Twentynine Palms, California, for squadrons from both coasts. This training exercise resembles Navy air wing integrated predeployment training conducted at NAS Fallon and provides substantial experience dropping high-explosive ordnance. The air-to-air detachment focuses on air-to-air tactics and weapons training. It is frequently accomplished at NAS Key West, Florida, or as part of a U.S. Air Force Red Flag or Green Flag exercise. Air-to-air training typically lasts two to three weeks. The air-to-ground training detachment is ideally completed prior to the CAX but may also be completed in conjunction with the CAX. It typically lasts two to three weeks and is usually completed on the West Coast for all squadrons because of greater range availability in the western continental United States. The air-to-ground detachment is not considered as critical for USMC squadrons deploying with Navy carrier air wings because of the extensive air-to-ground training conducted at NAS Fallon during integrated air wing predeployment training.

Table 2.5

F/A-18C Tier Three Training Requirements

Core Skill	Number of Flights	Flying Hours	Simulator Periods	Simulator Hours
LAT	2	2.0	0	0.0
Air to Air	12	15.6	1	1.0
Air to Surface	4	6.0	1	1.0
CAS	2	3.0	0	0.0
DAS	3	4.5	0	0.0
ASWD	3	3.5	1	1.0
SSWD	6/7	9/10.5	4	4.0
Night Systems	8	10.4	2	2.0
Total	40/41	54.0/55.5	9	9.0

[7]Figures 3.1 on pp. 3-9 and 3-10 of T&R Volume II depict the nominal core progression models for VMFA and VMFA(AW) crews.

The Marine Corps manages its readiness by Combat Readiness Percentage (CRP). A pilot trained at the first tier (combat capable phase or 100 series events) is considered to have 60 percent CRP. Table 2.6 shows the flight hours required to attain the higher tiers and the CRP associated with each.

The Marine Corps then establishes a minimum level of qualification on each of the tasks based on the number of pilots assigned to determine the core competency of the squadron. For example, a VMFA squadron must have 12 pilots competent in air-to-air missions to be rated core competent.

Table 2.7 shows the number of sorties needed to acquire and sustain proficiency by PMA for each type of squadron.

Table 2.6

Training Requirements for Various Series F/A-18

		F/A-18A		F/A-18C		F/A-18D	
Stage	CRP Earned	Sorties	Hours	Sorties	Hours	Sorties	Hours
Combat Ready	15	33	41.8	33	41.8	33	41.8
Combat Qualified	20	32	43.6	41	55.5	51	70.5
Fully Combat Qualified	5	10	14.6	15	22.1	10	14.6
Total	40	75	100.0	89	119.4	94	126.9

Table 2.7

Sorties Needed to Attain and Maintain PMA Qualifications

	VMFA				VMFA(AW)	
	F/A-18A		F/A-18C		F/A-18D	
Core Skill	Attain	Maintain[a]	Attain	Maintain[a]	Attain	Maintain[a]
Air to Air	26	18	26	18	26	18
Air to Surface	10	7	10	7	10	7
SSWD	6	3	7	4	7	4
ASWD	3	N/A	3	N/A	3	N/A
LAT	4	1	4	1	4	1
CAS	4	4	4	4	4	4
Night Systems	0	N/A	4[b]/8	N/A	8	N/A
Aerial Refueling	2	1	2	1	2	1
FCLP/EQ	2	N/A	2	N/A	2	N/A
DAS	5	4	5	4	5	4
CACC					10	2
Total	662	38	67[b]/71	39	81	41

[a]On a semiannual basis.

[b]Sorties required for F/A-18C night systems modified aircraft.

Turning to the use of simulators, the objective of the Marine Corps Simulator Master Plan is to conduct mission rehearsal in simulators before execution. The Marine Corps master plan assigns the following goals for use of aviation simulators:

- Serve as an adjunct to aircraft sorties.
- Maintain or increase combat readiness.
- Build pilot experience base.
- Ease the burden on aging and expensive aircraft.
- Offset range encroachment and weapons training.

Figure 2.4 shows the aggregate use of simulators by the Marine Corps F/A-18 community. The majority of simulator use is by the FRS with the fleet squadrons using the simulator for only approximately one hour per crew per month. A significant amount of available simulator time goes unused. The downward trend in simulator use over the past few years reflects the poor fidelity of the simulators compared with the actual aircraft. As with the Navy, the simulators have not kept pace with the upgrades made to the combat suite of the F/A-18s.

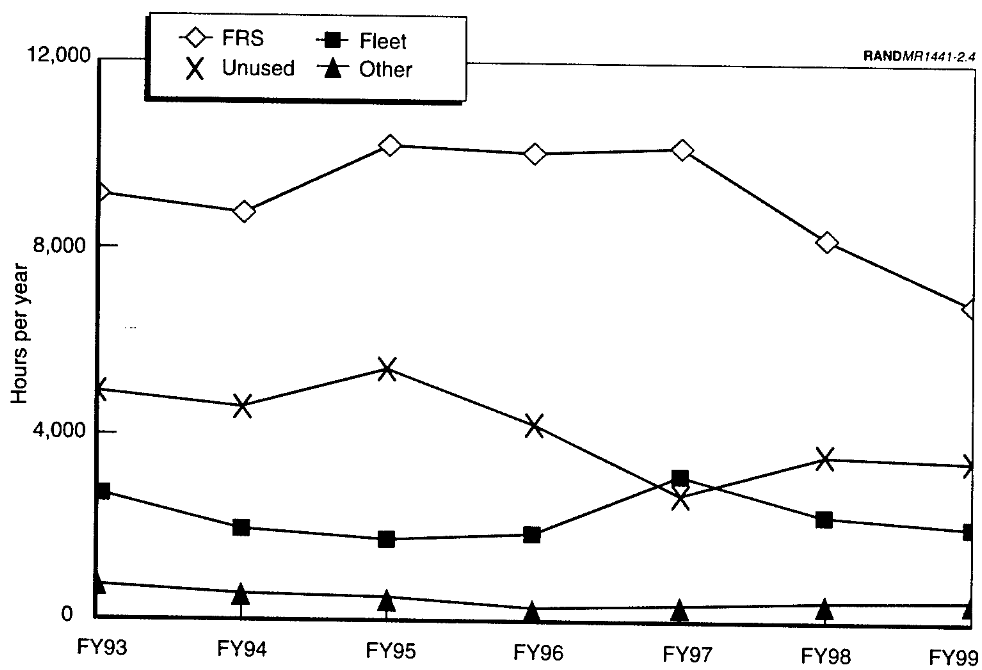

Figure 2.4—Aggregate USMC F/A-18 Simulator Use

Simulator-aircraft software mismatch, poor video representation and simulation inaccuracies limit the utility attained from simulator flights. The Marine Corps F/A-18 community feels that better simulators would not reduce the need for flight hours to conduct training but would provide increased resources to build the experience of the most-junior aircrews. Also, these most-junior pilots have time available in their workweek to take advantage of the increased simulator training and would benefit the most.

The Marine Corps plans to expand the use of its simulators, funding a series of upgrades with savings from the flying hour program. The plan calls for linking simulators to allow multiplane training with integrated threat scenarios. It plans for two networked simulators at each active-duty Marine F/A-18 base in the continental United States, one simulator for each overseas F/A-18 base, and one simulator for each reserve F/A-18 base not co-located with active-duty F/A-18 squadrons.

AIR FORCE F-16 TRAINING

The Air Force philosophy has been that all wings theoretically can go to war at any time and thus has not followed a deployment pattern of training. The Expeditionary Aerospace Force (EAF) concept is designed to balance deployment requirements across the force. The Air Force has 10 such organizations. Two are deployed or prepared to deploy at any one time for 90 days over about a 15-month cycle to meet known, rotational, steady-state deployments. Two additional wings share on-call responsibility for contingencies over a 90-day period. No long-term patterns have emerged as yet.

Sortie requirements are provided annually to each unit as a basis for building their training program. Units are required to have minimum number of pilots trained in special capabilities (e.g., instructor pilots, flight leads, CSAR). Some of these capabilities receive additional sorties. Pilots must fly all the directed sorties as a minimum, but the mix can vary to ensure inexperienced and experienced pilots can carry out such mission types as Basic Surface Attack, Surface Attack Tactics, Close Air Support, Suppression of Enemy Air Defenses (for designated units), Sweep, Force Protection, Defensive Counter Air, Air Combat Maneuvering, and Basic Fighter Maneuvers. Moreover, within the mission sortie allocation, pilots are expected to maintain required weapons qualification and become proficient in such tactical skills as dropping chaff.

The USAF uses a tiered training progression. Training programs are designed to move pilots from one qualification level to another. For example, the basic course in the Formal Training Unit (FTU) provides the training necessary for initial qualification of pilots in an aircraft and flying duties without regard to the unit's mission. Mission Qualification Training (MQT) and Continuation Training occurs in the operational unit. MQT is a unit-developed training program that provides the training necessary for initial qualification or requalification of pilots in a specific position to perform the mission assigned to that unit. Even though MQT is a unit-developed program, it must meet a detailed list of requirements spelled out in an Air Force instruction, F-16 Aircrew Training.[8] MQT, upgrade qualification training, and Continuation Training are a mix of classroom (ground), simulator, and flying training.

Following completion of MQT, a new pilot is certified as Combat Mission Ready (CMR). A more experienced pilot who has completed MQT and is being assigned to a wing pilot position that has a primary job performing wing supervision or staff functions that directly support the flying function is certified as Basic Mission Capable (BMC). As such, he should be familiarized in all, and may be qualified and proficient in some, of the primary missions tasked to the assigned unit and weapons systems. CMR positions are filled with pilots qualified and proficient in all of the primary missions tasked to the assigned units and weapons system. With some allowable exceptions, all squadron flying positions are designated CMR. CMR pilots must maintain currencies, accomplish all core designated flight training (sorties and events), and all mission ground training. Failure to complete training or maintain currencies results in regression to non-CMR status that requires a tailored program to regain CMR status. While non-CMR, a pilot may perform missions in which he or she is current, qualified, familiar, or proficient.

Continuation training is the highest tier in the training progression. Continuation Training is split into classroom (ground) training, including simulators, and flying training. Minimum simulator training requirements are set out. Tactical simulator missions may be accomplished in either the OFT, the WTT, or a unit training device (UTD).[9] Unlike the Navy, the Air Force's training squadrons are not co-located with the line squadrons, and therefore the line squadrons do not have to compete for access to the simulators. If a unit does not have access to these simulators, certain missions can be accomplished in the cockpit familiarization trainer (CFT). The CFT is a training device in which controls, switches, and instruments do not have to respond to trainee inputs. The WTT is a part-task training device while the UTD is a squadron-level trainer for emergency and instrument procedures and air-to-ground weapons employment. It has a high-fidelity cockpit replica for pilot interactions, an out-the-window visual scene, and an Instructor Operator Station.

---

[8]See *F-16 Aircrew Training*, Air Force Instruction II-2F-16, Volume I, May 1998.

[9]At one time, operational flight units had OFT, which dynamically simulates flight characteristics, but it became too expensive to upgrade their computers. OFTs are now available only at FTU.

F-16 squadrons build their flying hour program for training on the number of sorties needed to accomplish mission-related continuation training. Units are expected to design training programs to achieve the highest degree of combat readiness consistent with flight safety and resource availability. Training must balance the need for realism against the expected threat, pilot capabilities, and safety. Inexperienced pilots (fewer than 600 hours) are allocated more sorties to maintain BMC and CMR status than are experienced pilots. As shown in Table 2.8, in general, 72 sorties for inexperienced and 60 sorties for experienced pilots make up the annual sortie requirement for BMC and 116 and 96, respectively, make up the annual requirement for CMR.

Given these gross allocations, the issue becomes how readiness is measured. Hours per crew per month (HCM) is viewed as one measure, along with crew force experience levels, crew ratios, unit manning levels, equipment status, and level of spares. (Programmed versus actual HCM is a flying hour metric submitted by DoD as part of the Government Performance and Results Act.)

Figure 2.5 is a summary of HCM for F-16 squadron pilots[10] for the last 10 years. Since 1992, flying hours have been decreasing until recently. (The data before 1994 may not be comparable to 1994 and after. While both use flying hours and assigned squadron level pilots, both the numerator and denominator are from different databases beginning in 1994.)

The dark bar for 1999 shows sorties per month. A typical sortie uses about one hour and 40 minutes. The light bar in the figure shows that programmed flying

Table 2.8

Tiered Training Sortie Requirements for USAF F-16

Type Sorties for Ready Aircrew Program	Basic Mission-Capable (Inexper/Exper)	Combat Mission-Ready (Inexper/Exper)
Minimum Annual Sorties	72/60	116/96
Mission Sorties	32/24 (one per sortie)	112/98 (one per sortie)
Commander Option	40/36	10/10
Special Capabilities—e.g., Flight Lead, Instructor Pilot	16/22 (above annual min)	16/22 (above annual min)
Tactical and Weapons Events	64 (ICW Mission Sorties)	155 (ICW Mission Sorties)
Collateral; Attrition Sorties	As needed	As needed

NOTE: Annual sorties may not be reduced.

[10]Pilots are squadron pilots in flying positions. Data are tracked separately for wing staff/ supervisors and above wing pilots.

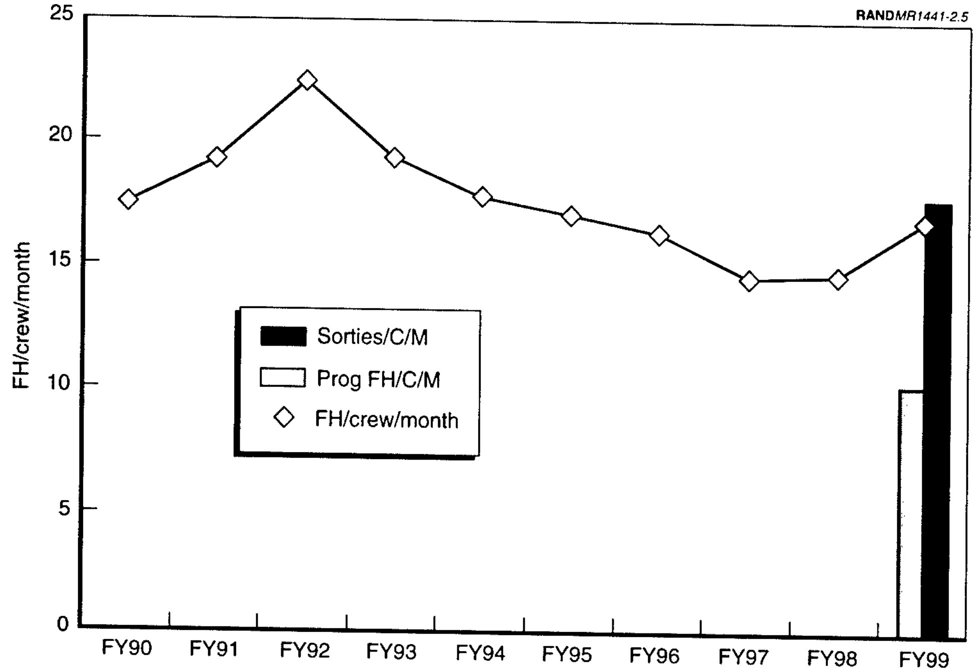

Figure 2.5—USAF F-16 Flying Hours

hours for 1999 were higher than actual flight hours. Actual hours may differ from programmed hours for several reasons. Flying hours are programmed using authorized strengths while actual HCM is based on assigned strengths. If a squadron or community is overmanned, the actual hours will be under the programmed hours. This occurs because a larger number of crews is used in the calculation, thus HCM declines. Also, over- or underexecution of the program affects HCM. In 1999, Air Combat Command (ACC) underexecuted the program, which drove actual HCM down. Moreover, squadron officers and wing staff have separate programmed hours, but if there are more staff flyers than authorized or if they fly at a greater rate than programmed, squadron HCM will decrease, which happened in the fighter community. Programmed HCM for squadron level pilots in the F-16 for 2000 is 15.9 for ACC, 19.0 for Pacific Air Force, and 17.3 for U.S. Air Forces in Europe.

Much of the recent Air Force discussion about simulators and their use has involved the Distributed Mission Trainer (DMT) for the F-15. The idea for the DMT originated in ACC. DMT is described as a system of linked, high-fidelity simulators that allow combat aircrews to train more effectively for an increasingly complex combat environment. Part of the follow-on debate about DMT dealt with the issue of using it to supplant or supplement flight hours. Eventually F-16 and other wings would be expected to join the DMT network. As of this writing, it is not clear that this vision will be achieved because the future status of the DMT is uncertain.

In the existing F-16 training program, both classroom and simulator training are specified as part of the unit ground-training requirement. There are minimum requirements to use the OFT for total sorties (12 inexperienced/eight experienced) of which eight and four, respectively, must be tactical sorties. These latter tactical simulator missions may be accomplished in the OFT, in the WTT, or in the UTD. The OFT dynamically simulates flight characteristics. The WTT is a part-task training device, while the UTD is a squadron-level trainer for emergency and instrument procedures and air-to-ground weapons employment. It has a high-fidelity cockpit replica for pilot interactions, an out-the-window visual scene, and an Instructor Operator Station. F-16 simulators are described as being behind the airframe and may never catch up.

ALLIED FIGHTER TRAINING

We next review the training of some U.S. allies. Specifically, we review the training of the Royal Air Force for its Tornado crews and that of the French Air Force for its Super Etendard crews.

Royal Air Force

The United Kingdom and the United States have different training philosophies. The United Kingdom trains to high standards in its training units. A pilot goes to a squadron fully capable. The U.S. military stops formal training earlier and places a larger burden of the training on the units than does the Royal Air Force (RAF).

Training progresses from initial flying training to basic and then advanced fighter training and then to an operational conversion unit (OCU). The training agency agrees with the RAF on the level of proficiency required of newly trained pilots across a range of flying and mission skills. The RAF differs from the USAF in that a wingman is trained to a higher level before reporting to a squadron and is capable of lead/mission completion. (This is similar to the U.S. Navy.)

Views on the number of required annual live flight hours vary widely. The NATO minimum is 180 hours (15 per month). RAF flying hours for jet pilots is between 180 and 240 per year (18.5 month on average). Of these hours, 150 hours (12–14 hours per month; 12.5 on average) are felt to be the minimum required to ensure safe flying. They also feel the additional increment for military elements of flying (e.g., warfare tactics) is about three hours per month or

36 per year for a total of 186 annual hours (15.5 hours monthly). The 180–240 hours include all flying (e.g., transit and overhead flights) not just military elements or high-quality flying, which is estimated at 75–80 percent of the total (15.5 hours per month).

RAF jet pilots are funded at 180 hours (15 per month). On average, they can fly more than budgeted. A desired number of monthly flight hours would be about 22.5, but they acknowledge it would be difficult to fly more than 28 hours per month given all the other things that pilots must accomplish.

The Tornado has fewer flying hours than maritime patrol aircraft (MPA) but far more sorties (a typical Tornado sortie is an hour and a half). The Red Flag exercise involves an intensive work-up. There is no deployment pattern except for Red Flag, and a more constant level of flying exists in the RAF.

The Flying Training Development Wing at RAF Halton helps to develop the training requirements for future RAF aircraft including the development of proposals on the mix of live and simulator training. Our comments here reflect the interviews we conducted with RAF officials.

The RAF uses simulators a good bit in their OCUs. But squadrons use simulators very little, perhaps one hour per month. The flight-hour-to-simulator ratios vary by stage in the training pipeline. For initial training (Hawk), there is a 5:1 (live:simulator) ratio using a legacy syllabus. They do 140 flying hours and 28 simulator hours. The new syllabus has a ratio of 1.8:1 with reduction of flight hours from 140 to 106, and an increase in simulator hours from 28 to 60. In the OCU the ratio is 4:1 with the legacy syllabus and a second-generation simulator. The ratio will go to 2:1 with a new simulator (80 flying hours and 40 simulator hours). For squadron continuation training, the current ratio is about 15:1 (180–240 flying hours to 12 simulator hours). A more realistic ratio will be 3:1 (180 flying hours to 60 simulator hours). The simulator hours will consist of one currency period and four tactical periods.

Many senior officers in the RAF have perceptions about simulators based on bad experiences. In the future, it will be necessary to think of simulator training not as "replacing" flight hours but as "enhancing" flight hours. The trade-off between live and simulator is too often perceived as a pendulum that swings one way or the other. In reality, the goal is neither flight nor simulator hours but training effectiveness. Flight hours should not be directly "traded" for simulator hours. Fewer flight hours could lead to the same training outcome given effective and efficient simulators. A pilot can do more complex things with a flight hour if the simulators are available to do less complex things and, as a result, flight hours could be reduced (resulting in reduced training cost) while increasing readiness.

The RAF is contemplating moving to the next generation of simulators. This move includes the concept of using simulators, in some cases, as a substitute for flying (as opposed to an adjunct to flying). Not all are ready to embrace this move, fearing that a loss of flight hours will inevitably translate to a loss of proficiency. Another concern is that simulator realism might become so good that it will have psychological effects on the user (related to the time difference between simulation doing something, or being perceived as doing something, and real-world time). There is also a concern that a simulator may not be able to generate a "fear factor" and that pilots will get complacent about mistakes.

French Navy Carrier Aircraft Unit Training

The French Navy operates various types of carrier aircraft, including the Super Etendard and the Hawkeye (E-2C).[11] The Super Etendards are allocated the strike missions against naval and land targets. The primary philosophy of the French Navy is to train as it fights and fight as it trains. Its leaders use extensive pre- and postflight debriefings to emphasize the objectives and conduct of training events. To compensate for limited assets, squadrons place special emphasis on ensuring that each flight hour and sortie results in high-value training. They minimize transit time (typical sorties last 1.5 hours and involve no refueling) during training flights and typically do not have indirect or overhead flights. They focus on mission planning and try to ensure that each flight accomplishes a number of objectives, so it is as productive as they can make it.

The French squadrons follow an Operational Training Program (similar to the U.S. Navy's T&R matrices) that coordinates training events for all pilots to ensure sufficient pilots are qualified for all missions. Given the small community, training is tailored to reflect the strengths and weaknesses of individual pilots. Squadron commanders typically know the capabilities of their pilots and structure an individual's training accordingly. In addition to successfully completing the various training events, pilots receive continuous subjective evaluations from their superiors.

The squadrons try to apportion flying hours linearly throughout the year. If exercises or deployments result in increased flying for a month, they will cut back their flying in the following months. The French Navy firmly believes that its pilots must fly at least 150 hours per year or problems will result.

Young pilots receive from 140 to 150 flying hours per year in the Super Etendard, supplemented with 40 to 50 hours of instrument training flight time in the

[11]The information about French aviation is drawn from the interviews we had with representatives of the French Navy.

Falcon 10, and 40 hours in a simulator. Operational pilots fly about 180 hours per year, and night carrier landing qualified pilots receive approximately 220 flying hours per year. Approximately 40 percent of their flight hours are dedicated to strike training. Each pilot drops one live bomb per year.

The French fighter squadrons have limited simulation assets. Their simulators have moderate reliability, moderate realism, and no ability to link together. They have fair visual displays but very little variation in the embedded training scenarios. The simulators are primarily used for "switchology" and safety of flight (a pilot who has not flown in 15 days or more, must use the simulator before the next flight). Only about 2 percent of their strike training is done on simulators.

The French attempt to keep the simulator software current with the versions on the operational aircraft. Although they have no simulation capability on board their aircraft carriers, they are planning to have a Rafale link simulator on the *Charles de Gaulle* when the Rafale program comes on line. In the interim, they are planning to upgrade the Super Etendard simulator. The Rafale program will include a network simulation capability and real-time replay of a training flight using videotape from cameras mounted in a pod on the aircraft. The Rafale simulator is part of the procurement contract although the aircraft will be introduced into the fleet before the simulator arrives.

COMPARISON OF UNIT TRAINING FOR FIGHTER AIRCRAFT

Table 2.9 compares the average flying hours and simulator hours per pilot per month for the various cases we examined in this chapter. The U.S. Navy, Marine Corps, and Air Force hours are the averages from 1999. The French and British hours are based on our best estimates. While the flying hours vary only slightly, the USAF, British, and French fighter units appear to use simulators for training more than either the Navy or Marine Corps.

Other important similarities and differences across the various services include:

- All unit training is based on the completion of specific events that lead a pilot and a unit to higher readiness levels. Because of their small military, the French tailor training to fit the needs of the individual pilot.
- All the services, except for the U.S. Navy, attempt to maintain consistent unit readiness levels. The U.S. Air Force (until recently), the British, and the French do not have fixed deployment and training cycles and attempt to keep units always prepared to "go to war." The U.S. Navy's deployment cycle and training philosophy leads to the readiness "bathtub" that has caused concern at the Chief of Naval Operations (CNO) level.

Table 2.9

Comparisons Across Fighter Units

Fighter Unit	Flying Hours per Pilot per Month	Simulator Hours per Pilot per Month
USN F/A-18		
Programmed	25.0	4.1
Executed	17.0	0.5
USMC F/A-18		
Programmed	25.0	4.5
Executed	20.0	0.7
USAF F-16		
Programmed	17.3	Unknown
Executed	16.9	1.5
NATO	15.0	Unknown
RAF Tornado		
Current	17.5	1.0
(JSF/Eurofighter) Future	15.0	5.0
French Super Etendard		
Current	16.7	3.3
(Rafale) Future	16.7	More

- The U.S. services have more primary mission responsibilities than our allies do. The French and British strive for specialists versus generalists. Possibly, they understand that they will be part of a multinational effort, such as the Persian Gulf War, and attempt to define their specific areas of expertise within the combined environment. The U.S. services, although recognizing that future engagements are likely to involve the armed forces of our allies, still retain the concept of being capable to conduct the battle without assistance from other countries.
- The British and French pilots have greater experience levels and more continuity in their units than U.S. pilots.
- All the U.S. services and our allies face relatively poor simulator fidelity and availability. All fighter-related simulators appear to be behind the operational capabilities of the aircraft. The Marine Corps is in the process of increasing its reliance on simulators in an attempt to reduce flying hours to conserve airframe life. The British have a future view of less flying and greater use of simulators.

AIRBORNE ANTISUBMARINE WARFARE TRAINING

We next describe the tactical training of U.S. Navy P-3C squadrons, focusing on ASW missions. The section also includes a description of the training philosophy and approach for British and French MPA units. We also compare training across the nations.

P-3C Training

Currently, there are 12 active-duty P-3C squadrons, divided into four wings, equally distributed between the East Coast and West Coast. All squadrons follow an 18-month cycle—a 12-month IDTC followed by a six-month deployment. Therefore, each wing typically has one squadron deployed with the other two in its IDTCs.

Each aircraft is manned with 11 crewmembers. Five crewmembers man the cockpit including three pilots (Patrol Plane Commander [PPC], Patrol Plane Pilot [PPP], and Patrol Plane Copilot [PPCP]) and two flight engineers (FEs). The six crewmembers manning the aft portion of the aircraft include two Naval Flight Officers (NFOs) (Patrol Plane Tactical Coordinator [PPTC] and Patrol Plane Navigator/Communicator [PPNC]), two acoustic sensor operators (SS1/SS2), one electronic warfare operator (SS3), and one in-flight technician (IFT). A subset of the crew, composed of the four positions considered essential for ensuring tactical mission crew coordination—the PPC, PPTC, SS1, and SS3—is referred to as the Tactical Nucleus (TACNUC). The manning of the TACNUC positions must remain consistent for all crew certifications and qualifications.

The P-3C has seven PMAs assigned:

- ASW
- ASUW
- Command and Control Warfare (C2W)
- CCC
- Intelligence
- MIW
- MOB.

The first six PMAs listed above address the tactical application of the P-3C aircraft as a weapon system. Training readiness in these tactical PMAs focuses on the crew versus the individual members of the crew. The MOB PMA differs from the tactical PMAs in that the successful completion of training events is associated with both the individual members of the crew and the coordinated crew as a whole. A crew's MOB readiness status is based on the aggregate of MOB training accomplished by individuals in the crew. Completion of the basic MOB training events is a prerequisite for the conduct of tactical operations.

At the beginning of the IDTC, individuals and crews restart the process of certification and qualification in the various training events in the T&R matrix. As training events are completed, points are accumulated in one or more of the PMAs.

The first key milestone in the training of a crew is completion of the Tactical Proficiency Course (TPC). The TPC is administered by each wing and is intended to enhance combat aircrew performance over the broad spectrum of the PMAs. The course emphasizes crew coordination, tactical awareness, and in-flight standardization. The three modules of the TPC are the Basic Module (one day of classroom instruction plus one ASW session on the Weapon Systems Trainer [WST]), the ASW Module (three days of classroom plus two ASW sessions on the WST), and the Multimission Module (two days of classroom plus two ASW/ASUW sessions on the WST). A crew remains TPC-current as long as at least two of the TACNUC completed TPC with that crew.

Each crew has seven individual T-Rates, one for each PMA, which are combined into an overall T-Rate for the crew. A crew is considered combat ready in a PMA if its T-Rate is T2 or better in that PMA.

A crew's overall readiness, or T-Rate (overall), is determined based on the lower level derived from the following criteria (from the WTM):

- T-Rate (overall) is equal to the lowest of the individual PMA T-Rates, unless the crew is limited to that level by only one PMA, in which case its T-Rate (overall) is equal to one level higher than the lowest PMA T-Rate.
- T-Rate (overall) may not be higher than the T-Rate for MOB.

Each crew completes a series of classroom events, training qualifications and certifications, and operational exercises during the IDTC. In general, training progresses from the classroom to a simulator to live flights.

The number of training events in each PMA, along with the annual flying hour and simulator hour requirements per crew are shown in Table 2.10.

Figure 2.6 shows the aggregate monthly flying hours per P-3C crew programmed, budgeted, and actually flown over the past several years. Since FY 1994, programmed hours have been constant at 50 hours per crew per month. The budgeted hours are typically, by policy, 83 percent of the programmed figure. The actual hours flown were usually equal to or greater than the hours budgeted.

Table 2.10

P-3C PMA Training Events and Hours (per Crew)

PMA	Number of Events	Event Hours	Annual Flying Hours[a]	Annual Simulator Hours[a]
MOB	9	32	244	175
C2W	1	4	12	4
ASW	6	24	80	36
INT	3	10	30	0
ASUW	5	16	48	4
MIW	1	2	2	0
Total	25	88	416	219

[a]Annual hours are a multiple of event hours based on the currency period for an event. These hours include "on station" time only and do not include the transit times necessary to reach operating areas.

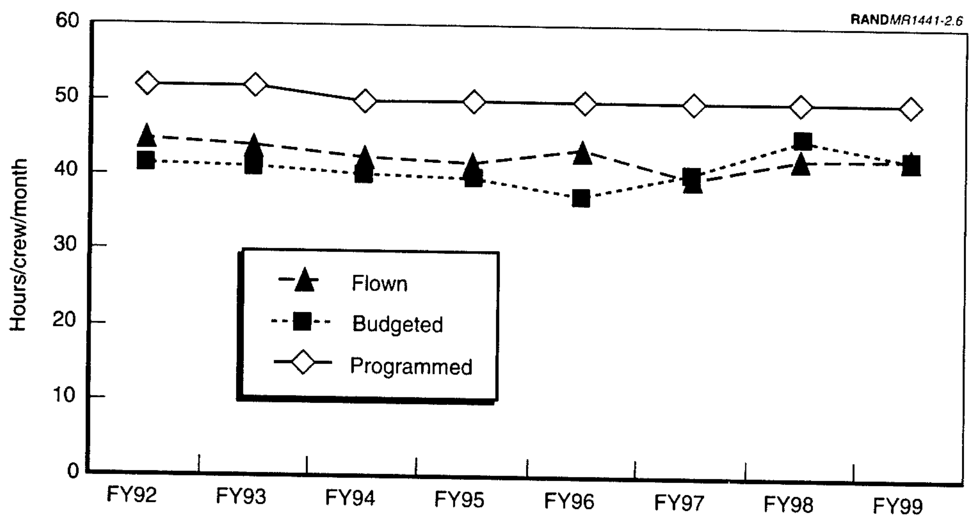

Figure 2.6—Aggregate P-3C Flying Hours per Crew per Month

The P-3C community uses simulators extensively for training both individuals and crews. Twelve of the 25 events in the T&R matrix require some degree of training on a simulator resulting in an annual requirement for 219 simulator-training hours.[12] Many of the 11 events require a crew to practice first on a simulator and then conduct the event in flight. Unlike in the fighter world, the operational squadrons use the majority of the available simulator time. Our

[12]The 12 events requiring simulators include seven of the nine MOB events, three of the six ASW events, one of the five ASUW events, and the one C2W event.

review of the data suggests an average simulator usage of approximately 21 hours per crew per month during the IDTC.[13]

Figure 2.7 shows the annual simulator use from FY 1992 to FY 1999. As with the F/A-18, the FRS uses a substantial amount of the available simulator time, but the use by the fleet pilots is greater.

The P-3C has an extensive suite of simulators to support the training. The P-3C simulators include the following:

- OFT for training pilots and flight engineers in general airmanship including emergency procedures. Nondeployed pilots typically spend approximately two hours in the OFT each month.
- Tactical Operational Readiness Trainer (TORT) provides synthetic signatures for the training of the various sensor positions.

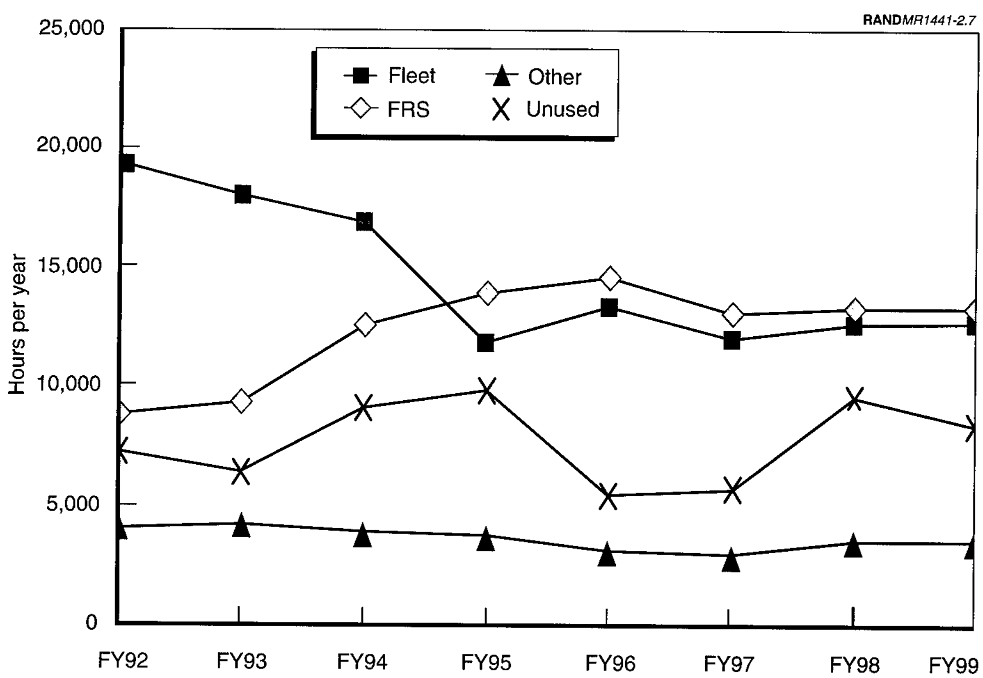

Figure 2.7—Aggregate Simulator Usage in the P-3C Community

[13] Averaging across all crews yields 14 hours of simulator use per crew per month. During any given month, one-third of the squadrons, and therefore crews, are deployed.

- Weapons Systems Trainer (WST) is formed when the OFT and the TORT operate in a coupled mode. This allows the flight crew to participate in the tactical exercise while engaged in a simulated flight.
- Acoustic Part-Task Trainer (PTT) provides tactical, high-fidelity acoustic and Extended Echo Ranging training.
- Cockpit Procedures Trainer provides cockpit familiarization training for pilots and flight engineers at a fraction of the cost of the OFT.

Sensor Station Three PTT provides nonacoustic (e.g., radar, infrared, and magnetic anomaly detector [MAD]) operator training through synthetic or actual signatures.

Allied Training

Royal Air Force. The Nimrod MR2 is the RAF maritime patrol aircraft used primarily in the roles of maritime surface surveillance, ASUW, ASW, and search and rescue (SAR). It can also assist in other missions, such as enforcing UN sanctions. The aircraft is fitted with radar and magnetic and acoustic detection equipment.[14] Its weapons include Stingray torpedoes for ASW, Harpoon missiles for ASUW, and Sidewinder missiles for self-defense.

The RAF uses an ab initio training concept. It trains six student crews each year and then assigns individuals to various operational crews. It normally takes seven months for an individual to achieve limited combat-ready status. After graduation, individuals have nine months to gain combat-ready status, in which they are recertified every 12 months. If the crew as a whole is limited combat-ready, the crew must go through a six-month training evolution, which includes live flights, simulator time, and an evaluation.

The Nimrod has a crew of 13 that utilizes five of the aircrew trades in the RAF. A crew, once constituted, stays together in training and operations. Two pilots and an air engineer make up the flight deck, while two navigators and an air electronics officer (AEO) work alongside seven air electronics operators in back of the plane. The Nimrod captain can be a pilot, a navigator, or the AEO.

The Nimrod has no tactical display on the flight deck so the operators in the back of the plane must verbally provide the complete combat picture. There-

[14]Although retaining the airframe of the MR1, the Nimrod MR2 has completely updated search sensors with advanced radar, new sound detection equipment, and a vastly increased computer capacity. Nimrod 2000 will replace the MR2 fleet in a refurbishment program managed by British Aerospace. The refurbished aircraft, to be delivered between 2001 and 2006, will have new wings, BMW/Rolls-Royce fuel-efficient engines, modern control systems, "glass" cockpit instrumentation, and a comprehensive suite of the latest sensor, computer, and communications equipment.

fore, the flight deck officers primarily operate the aircraft while one of the navigators in the back of the aircraft actually coordinates the missions.

The Operational Training Requirements are composed of four areas, each with multiple training events.

1. For the flight deck (pilots), some events are done either live or on a simulator while other events can only be done live or only done on a simulator (e.g., stalling).
2. Crew emergency training (e.g., ditching skills) is accomplished with half live flying and half simulator time.
3. Role training is all simulator based and includes a search and rescue exercise. This type of simulator training is perceived as better than the training value of actual operations because Nimrods normally go on operations autonomously and thus have no assets to train with. Occasionally a crew can integrate with an ongoing exercise for live training, but this is a bonus.
4. Weapons training consists of ground-based lectures and a simulator event to practice procedures. This resembles the training procedures of the OCU. Crews first hear material in a classroom, then practice on a simulator, then test on a simulator, and then actually perform the procedure in the air.

Each crew has a minimum of 30 hours of live training per month. The minimum has been constant over time, but actual flying hours have been decreasing toward this minimum. The crew captain can select specific training missions for up to 30 percent of the 30-hour requirement. A typical crew-training sortie can last up to eight hours and be flown anywhere between Iceland and the west coast of France.

Approximately 10,000 flying hours are budgeted per year for the base. After conducting tasked operations, the remainder of the hours are used for training. Actual hours flown per month can swing widely month to month. Each crew receives about 360 flying hours per year. Of this, about 11 percent goes for ASW operations; 20 percent is of no training value (e.g., ferrying); 40 percent is for training (core plus three roles plus pilot training and exercise support); the remainder is used for targets of opportunity training, exercises, and non-ASW operations (in support of other departments). For the training part, an experienced officer estimated that about 50 percent is ASW, 35 to 40 percent is ASUW, and 10 to 15 percent is SAR.

Nimrod crews make heavy use of simulators. There is a mandated level of currency in certain events to include time in a very good Full Mission Simulator. This includes 10 five-hour sessions per crew every six months. The Nimrod also has an embedded acoustic simulator so it can train against simulated targets during flights. This on-board acoustic training computer is considered key to success. Crewmembers can disconnect it to do cubicle exercises on long transits. Each pilot gets three hours per month in the dynamic simulator. Nimrods also have acoustic, navigation, electronic warfare, and radar cubicles, and each operator must perform one cubicle event per month to keep up individual qualifications.

French Navy. The French Navy operates several MPA squadrons composed of different types of aircraft. Two squadrons of the Atlantique 2 aircraft have the basic missions of ASW and ASUW that include locating enemy ships and submarines, which they can subsequently attack and destroy. Secondary missions include intelligence gathering, search and rescue, humanitarian operations, and joint operations with the French Navy, Air Force, and Army.

Each crew has 13 members—two pilots (pilot and co-pilot), two flight engineers, one tactical coordinator, three acoustic operators, two or three radio/navigation operators, and two or three electronic transmission operators. Once formed, a crew will stay together for three to four years.

The French MPA community places special emphasis on crew stabilization and integrated training. During the training process, the focus is on crew qualification, not qualification of individual members of the crew. Training is first done as a crew and then advances to cooperation between crews and eventually to battle group training. Although the French Navy once considered having specialized crews for specific missions, all crews are trained in all missions.

Like their counterparts in the fighter community, each crew must accomplish a series of training events to become operationally ready to perform the range of maritime patrol missions. The community has performed analyses to determine which events can be accomplished in a simulator and which must be done with live flights.

Typical crews fly 300 to 350 hours per year, of which approximately 30 percent is dedicated to ASW training events. These live events include at least one flight per week to ensure safety of flight. Sorties can last 10 to 12 hours, of which transit time can be as low as one hour for local missions and up to five hours for missions in the Indian Ocean region. Although they have no operational training ranges, the MPA squadrons receive excellent support from French and other European nations' submarines for training. Each crew will drop one torpedo annually in training. Every two years, one crew in each squadron will fire an Exocet missile. The live-fire flight is supplemented with one three-hour flight simulator event and one, four-hour tactical simulator event.

Simulators are important to French maritime patrol training because the forces are moving to less flying time and more simulator use. Typically, crews use simulators to plan and practice (rehearse) before they fly a mission. Simulators are located at each base as well as at the training squadron. All the crewmembers, including the pilots, use the tactical simulator. Only the pilot, copilot, and flight engineer use the flight simulator. The simulators are kept current with any changes to the aircraft. There are no on-board simulation capabilities. The flight simulator emphasizes such procedures as instruments and emergency actions.

Previously, the French maritime patrol community would use 15 actual flights of 1.0 to 1.5 hours to ensure aircrew qualifications. The last flight was basically an examination conducted by the squadron commanding officer. The cost of this method (approximately $10,000 per flight) was judged to be prohibitive, and emphasis shifted to the use of the simulator. Now, there are 10 to 12 simulator events and then two live flights, the second of which is the examination.

Comparison of Unit Training for MPA

Table 2.11 compares the average flying hours and simulator hours per crew per month for the U.S. Navy P-3Cs, the British Nimrods, and the French Atlantiques. The executed flying hours and tactical mission simulator hours for the P-3C are based on the data for the East Coast squadrons and represent averages for FY 1999. The mobility simulation hours for the P-3C are the total hours minus the tactical mission hours.[15] The British and French values are our best estimates based on discussions with the Nimrod and Atlantique communities.

The average flying hours per crew per month for the P-3Cs are much greater than the flying hours for the Nimrods and Atlantiques. However, the average of 45 hours per month is really not representative of the P-3C community. During their IDTC, the P-3C crews fly an average of approximately 30 hours per month, while during deployments, the crews average close to 70 hours per month. The

Table 2.11

MPA Flying and Simulator Hour Comparisons

	Flying Hours per Crew per Month		Simulator Hours per Crew per IDTC Month		
	Programmed	Executed	Mobility	Tactical	Total
USN P-3C	50	45	14.4	6.6	21.0
RAF Nimrods	30		3.0	9.3	12.3
French Atlantiques	27		3.5	6.2	9.7

[15]The mobility simulator hours calculated in this fashion compare favorably with the monthly mobility simulator hours in the WTM (see Table 3.1 in the WTM).

P-3C flying hours during the IDTC are virtually identical to the flying hours for the Nimrods and Atlantiques.

The similarity among the flying hours in the three communities is striking considering other differences between the three cases. The British Nimrods and the French Atlantiques have far fewer missions than the P-3Cs. Where the P-3Cs have seven primary missions (and seven secondary missions), the British and French MPA have only three, with some specialization among their squadrons. Also, the British and French have greater crew experience levels and continuity. These factors suggest they can attain the same levels of readiness as the P-3Cs with fewer flying hours.

One difference in flying hours might be how transit and other indirect time factor into the flying hour averages. The P-3C flying hours include only "on-station" hours. The French and British values may include transit time biasing their flying hours upward compared with the P-3C. An alternative explanation is that all three communities fly similar hours, but the French and British concentrate more of their hours on ASW missions and attain a higher degree of proficiency in ASW missions. Unfortunately, further data and information are needed to understand the similarities and differences in the flying hour programs, and simulator usage, in the three communities.

Table 2.11 shows that the tactical mission training simulator hours are similar for the P-3Cs and the French Atlantiques. What is striking is that the British appear to use about 50 percent more hours for tactical mission training compared to both the P-3Cs and the Atlantiques. Also, both the French and British use far fewer simulator hours for the training of their pilots and flight engineers compared with the P-3Cs. The small number of mobility related simulator hours might be due to the higher experience levels of the British and French crews compared with the experience level of the average P-3C crew or to the British and French lack of the IDTC/deployment pattern of the P-3Cs.

SURFACE ASW TRAINING

This section describes the tactical training of DDG-51-class ships, focusing on the ASW mission. It also describes the training philosophy and approach for British and French ASW ships. It concludes with a comparison of U.S., British, and French tactical unit training.

DDG-51 Training

DDG-51-class destroyers, like most U.S. Navy ships, typically deploy for six months at a stretch. The IDTC is currently about 18 months. When a ship returns from deployment, the first six months of the IDTC is devoted to crew leave, ship maintenance, and a ship shakedown period to prepare the ship and crew for the training prior to the next deployment. The training phase of the IDTC is approximately 12 of the 18 months.

Various ratings under the Status of Resources and Training Systems (SORTS) are used to describe the ability of the ship's personnel and equipment to perform the various wartime missions. In the training area, the ratings range from M-4, the lowest or least ready, to M-1, the highest or most ready.[16] The objective of the training portion of the IDTC is to bring the ship to the M-1 level by the end of the Advanced Phase of training.

The approximately 12-month training portion of the IDTC is broken into three phases: Basic, Intermediate, and Advanced.[17] The Basic Phase lasts about six months and is the responsibility of the type commanders and the ship's commanding officer. It concentrates on unit-level training, emphasizing mobility (navigation, seamanship, damage control, engineering, and flight operations), basic command and control, weapons employment, and warfare specialties. The goal for the ship is the M-2 level of proficiency in all mission areas by the end of the Basic Phase. The Intermediate Phase lasts approximately three months and concentrates on warfare team training and initial multiunit operations. During this phase, ships begin to develop warfare skills in coordination with other units while continuing to maintain unit proficiency. The Intermediate Phase involves one or more combined (i.e., multiunit) exercises.

The last two months of the IDTC is the Advanced Phase, which continues to develop and refine integrated battle group warfare skills and command and control procedures. The objective of this phase is to ensure that all units in the battle group are prepared to support the group commander's specific mission requirements. A joint exercise involving multiple surface, air, and subsurface units is part of the Advanced Phase. By the end of this phase, a unit should have completed all training events and exercises and be M-1 in all mission areas.

The number of training events designated for each phase of the IDTC for Pacific Fleet[18] DDG-51-class destroyers is shown in Table 2.12. Certain training events,

---

[16]Training events are "zeroed" (i.e., set to M-4) at the start of an overhaul or major maintenance period of six months or longer. Ships in an overhaul status are assigned an M-5 rating, which is raised to M-4 on completion of the overhaul.

[17]The training objectives and approach for all ships during the IDTC are outlined in the *Surface Force Training Manual* (U.S. Navy, 1999b). This basic instruction is supplemented by *Surface Force Training Manual Bulletins* that provide more specific mission area and other selected training information and guidance.

[18]Certain events accomplished during the Basic Phase by Pacific Fleet ships, particularly those that involve the use of live fire ranges, are accomplished during the Intermediate Phase by Atlantic Fleet ships.

because of their particular importance in maintaining operator or team proficiency, must be repeated at regular intervals. These are listed in Table 2.12 as repetitive events. For example, the ASW training event "Acoustic Environment Prediction" (ASW-2-SF) must be repeated every three months to maintain the M-1 proficiency level. If not, the proficiency level drops to M-2 after three months, M-3 after six months, and finally, M-4 after nine months.

The end of the Cold War and the collapse of the Russian submarine force led to reduced priority for ASW training. Other missions, such as AAW, land strike, and ASUW, now have higher priority, both in operations and training. ASW training has also shifted focus from the threat of nuclear-powered, deep-water submarines to diesel-powered submarines in shallow waters. Advances in stealth techniques for diesel-powered submarines plus detection difficulties in a littoral environment have made the ASW mission even more difficult.

The lack of real-world training opportunities compounds this difficulty. The U.S. Navy has no adequate shallow-water training areas and few opportunities exist for ASW teams to practice against diesel submarines. Foreign submarines are rarely available as potential training targets and, even when they participate in joint and combined exercises, their operations are often restricted or orchestrated. Therefore, although ASW is part of training during the IDTC, there is little opportunity to practice that training in a purely "live" environment, especially when deployed.

The Navy's *Surface Force Training Manual* allows certain training events to be accomplished through the use of training devices and simulators. Often, these

Table 2.12

Pacific Fleet DDG-51-Class T&R Events

Mission Area	Basic	Intermediate	Advanced	Equivalencies	Repetitive Events
Amphibious Warfare	2	0	0	1	2
Antiair Warfare	22	4	4	20	3
Command and Control Warfare	14	7	3	2	9
CCC	28	1	0	7	29
Fleet Support Operations	11	0	0	0	11
Intelligence	7	0	10	0	0
Mine Warfare	1	0	0	0	1
Mobility	46	1	1	0	36
Noncombat Operations	18	0	0	0	14
Strike Warfare	2	0	0	0	2
Surface Warfare	13	3	0	7	10
Undersea Warfare	20	15	7	26	23

SOURCE: U.S. Navy, 1999b.

devices input signals or scenarios into the actual on-board equipment to simulate a contact or other needed training input (i.e., they stimulate the equipment). An "equivalency" may be granted when the objective of a training event is essentially fulfilled through the use of on-board or shore-based training devices.

Because of the lack of real-world targets, almost all ASW training involves some degree of simulation. The *Surface Force Training Manual* recognizes the need for simulation by allowing simulator equivalencies for 26 of the 42 ASW training events. Individual ships typically have on-board trainers that stimulate the ship sonar equipment through the input of recorded data. The Fleet ASW Training Center also has a Tactical Control Device that sends signals to the on-board trainers when a ship is at the pier. These devices allow the sonar technicians (STs) on a ship to train with their own equipment. The center has various simulators it uses for individual and unit and team courses. These simulators are generic in nature in that they do not attempt to emulate in detail any specific system. The 14A12 trainer focuses on single-ship training and has a high-fidelity display but a low-fidelity interface.

The Battle Force Tactical Trainer (BFTT) is a new system that will eventually replace the Tactical Control Device. BFTT is capable of supporting all mission areas and allows connecting multiple ships to provide task group training. It operates via telecommunication lines and is currently limited to training at the pier (versus while at sea). BFTT is being installed on the new-construction DDG-51-class ships.

Two other devices used by ships in ASW training are the Mk. 30 and the Mk. 39. They are small, torpedo-shaped devices launched from the ship to simulate targets. They have numerous transit profiles and signal packages to emulate various types of real-world targets. The Mk. 30s cost several thousand dollars and are recovered after each use. The Mk. 39s are relatively inexpensive and are, therefore, treated as expendable.

Allied Training

Royal Navy. The Flag Officer, Sea Training (FOST), is responsible to the Commander in Chief Fleet for surface ship training to meet current and contingent tasks. Since the concept of Operational Sea Training (OST) was established in 1958, the various training syllabi to meet this responsibility have been adapted to keep pace with significant changes in the roles and composition of the fleet. ASW training progresses through a series of steps from job analysis (training needs), to training design, to training execution, to on-the-job training (OJT), and finally to the trained individual. There is external quality control between the trained individual and job analysis, which completes a feedback loop.

The Royal Navy's concept of training for a ship and crew involves deployment cycles. These cycles are like those of the U.S. Navy in that a ship enters a refit or maintenance period, trains up, then deploys for about six months, returns for stand-down and maintenance, and then trains up for another deployment. During the "in-port" period, there may be a number of shorter at-sea periods.

Individuals have a training performance statement that sets forth the percentage of skills to be taught initially in the classroom. This ranges from CAT 1 (90–100 percent) to CAT 4 (25–49 percent). Key warfare and safety skills are trained to CAT 1. Other skills are trained to between CAT 2 and 4. The school and the fleet decide in advance which skills are taught at HMS *Dryad* and which in the fleet, attempting to teach the skill where the equipment is available.[19] Fewer individual skills are taught in the schoolhouse, which means that more shipboard training is needed. Sixty percent of training is at sea. Ships provide OJT and track progress through the use of task books for each occupation.[20] Individuals move up a performance ladder over time. On a ship, there is never a fully trained ASW team. Probably two of four team members are in some stage of development because of turnover, etc. Sixty percent of ASW training is now at sea with on-board equipment.

Collective ASW training is the responsibility of the department head. The department head can use FOSF (Flag Officer Surface Flotilla) ASW staff and its sea-riding visits. FOSF staff makes administrative visits to a ship 12 weeks before OST or on return from deployment to check material and organizational fitness. They make a routine in-harbor visit one month prior to OST and then routine sea visits during pre-OST shakedown and when requested. The squadron ASW staff also does sea-riding visits for a "quality control top-up."

ASW Tier One training during OST uses simulators and is mainly procedural, not tactical, training. The focus is on teamwork under stress. The Planning and Reporting Information System (PRISM) is used to track ASW training accomplishments and manpower flows. Based on manpower status, training status, and other resource status, PRISM can compute ship ASW (and other mission area) capability. Tier One is the start of ASW unit-level training that will continue throughout the entire cycle based on FCD3 requirements.

The French Navy. French naval ships have the capability to conduct all missions for which they were designed. However, many ships tend to specialize in

---

[19]The Royal Navy School of Maritime Operations at HMS *Dryad* was formed in 1974 and is one of the principal shore establishments. Warfare training for naval officers and ratings from an elementary stage to the most-advanced levels are provided there.

[20]Officer training is more subjective and usually time-based—i.e., has been doing this task for so long therefore qualified (or not).

one or a few missions, such as AAW or ASW. For example, an ASW frigate will focus on that mission during its training cycle using a special training package tailored to ASW operations. The ships based in Brest tend to concentrate on ASW, while those in Toulon emphasize amphibious operations. The French Navy operates approximately 13 destroyers and 24 frigates that are either deployed overseas or based in France.

Crew training is done in the fleet and is the responsibility of the French Navy Training Command (ALFAN) and the ship's commanding officer. ALFAN has about 80 instructors between Toulon and Brest, divided into several specific departments (e.g., engineering, damage control). Its training facilities are adjacent to the piers providing easy access for a ship's crew. The ALFAN instructors, like all petty officers, rotate from the fleet to the school on a fairly regular basis. Some stay at the school for as little as six months.

ALFAN conducts its training in three phases: Initial, Basic, and Operational. The Initial Phase emphasizes the safe operation of the ship. The Basic Phase concentrates on the operation of equipment and systems. The Operational Phase qualifies the ship in all warfare mission areas. For a frigate, the ALFAN training time lasts approximately six weeks (slightly longer for an aircraft carrier).

Once ALFAN has completed its training, the responsibility for training reverts to the commanding officer of the ship. The French Navy has a system similar to the U.S. Navy's T&R matrix that defines specific training events for the ship. For a French Navy frigate, approximately 200 actions must be completed within specific time periods to maintain qualification in all warfare areas.

The French system results in points being awarded for different training actions with the specific points awarded based on the importance of the event. Total points relate to qualifications in the following way:

- 0 to 50 points—restricted qualifications.
- 50 to 80 points—normal qualification.
- 80-plus points—superior qualification.

Each ship maintains a "board" that lists the actions for each warfare area. Each month, the actions accomplished are scored and weighted by event importance to provide the resulting points earned. The board shows the points in each warfare area for the preceding 12 months, which assists the commanding officer in determining what training actions must be accomplished.

Simulation is authorized for some of the 200 training events. For some of the events that may use a simulator, simulation is restricted to a specific percentage of the training time. In ASW, for example, a French frigate must maintain currency in 25 events, 10 of which may be simulated. Of these 10 events, 30 percent of the points may come from using the simulator (e.g., if an event requires 10 hours of training, three hours can be accounted for on simulators). Each frigate has four or five ASW training periods against an actual submarine each year to maintain their qualifications.

While a ship is in port, the crew can use the ALFAN simulators for training. These "simulators" take a different design approach from that we observed elsewhere. The simulators are PCs that emulate on the screen the displays and switches of specific equipment (which differs from the U.S. Navy's approach of providing equipment and then simulating the inputs and outputs). Using software, crewmembers can more easily imitate the specific equipment of the combat information center of any ship. ALFAN maintains separate contracts to keep its software upgraded as equipment changes aboard the ships. No passive sonar capability is currently on the simulators, although ships have the ability to simulate this capability.

COMPARISON OF SURFACE SHIP ASW TRAINING

Both similarities and differences exist between the ASW training of U.S. Navy DDG-51-class ships and the ASW training for French and British Navy ships. The primary difference is the number of missions each navy assigns to its ships. The U.S. Navy DDG-51-class ships have 10 warfare mission areas plus two ship related (mobility and fleet support operations) mission areas. Each mission area has numerous events that a ship must accomplish to reach desired readiness levels for deployment. British and French ships have far fewer warfare mission areas, allowing them to specialize and concentrate their training. There is also a movement, at least in the French Navy, to specialize individual ships in specific mission areas.

Another factor that influences the training of French and British is the greater experience levels and operational continuity of their officers and enlisted crewmembers. While the typical career pattern for U.S. Navy officers takes them away from the operational ship world to various headquarters and staff assignments, French and British naval officers may stay in the operational community throughout their careers. Enlisted sailors in the French and British navies also have longer initial service commitments than those of U.S. Navy sailors. The greater experience levels and continuity of crews helps reduce the overall training requirements for French and British ships.

Although recent changes in the conduct of training during the IDTC allows U.S. Navy ships to determine their specific training needs and "pull" the needed support from the training community, each DDG-51-class ship still undergoes the same basic set of training events. Training for British and French ships is more tailored to the needs of specific ships because of the smaller overall number of ships. Also, the British and French have one primary organization involved with the training of their ships—ALFAN for the French and FOST for the British. Several organizations are involved in the training of DDG-51-class ships, especially in the area of ASW training.

Putting those basic differences aside, all training for these U.S., British, and French naval personnel is events-based, requiring the completion of a set of specified events to attain operational capability. Also, all three navies extensively use some form of simulation for their ASW training. The U.S. and British forces tend to duplicate operational equipment at their training locations, while the French emulate the displays and controls of various equipment using software on desktop computers.

Chapter Three

TRADE-OFFS BETWEEN LIVE AND SIMULATED TRAINING

The last chapter described the training programs for F/A-18, P-3C, and DDG-51 units, summarizing how live, simulated, and classroom events are used to bring units to desired readiness levels before operational deployments. This chapter examines the trade-offs between accomplishing events in a live mode and a simulator. It summarizes our research into the training of the Navy, Marine Corps, Air Force, and others and describes the results of previous research efforts on the use of simulators for training. It broadly discusses the trade-offs between live and simulated training and presents a theoretical model structure that captures many of the variables that must be considered when deciding how best to use live and simulated actions for unit-level training.

FOCUS ON LIVE AND SIMULATED EVENTS

Although three broad types of events—live, simulated, and classroom—are integrated in Navy unit-level training, our focus is on the trade-offs between live and simulated events. We do not concentrate on classroom training for several reasons.[1] Classroom training, although discussed in some unit's T&R manuals, earns no "points" when calculating a unit's readiness status. That is, formal classroom training courses receive no credit toward a unit's readiness measure. Specific courses for individuals or for coordinated unit operations are described in various training manuals. However, these classroom events are typically not part of a unit's T&R matrix.

Second, classroom training is often accomplished on an informal basis. A unit training officer or a ship's department head may schedule classroom sessions on a regular basis to describe and discuss aspects of equipment or operations. For example, the ASW training officer on a ship may designate a specific day

[1]We will also not dwell on other distinctions that could be made among on-the-job training, team training, and self-study.

each week for the ASW team to meet and discuss relevant topics. This type of classroom training results more from the initiative of individuals responsible for unit training than from formal guidelines and requirements.[2]

Third, some classroom training is better placed in the category of simulation training. For example, when a work group goes to a fleet training center while in port for schoolhouse training, it often uses a simulator capability resident there as part of the instruction.

Our focus on live and simulated training events for unit training does not suggest that classroom training is not important but rather that it does not have trade-offs of the type that primarily concern us. Classroom training is usually a precursor to both live and simulator training. It is useful in describing and discussing concepts and basic operations and should precede either live or simulated training. The British, for example, have a practice of first discussing concepts in a classroom environment before practicing those concepts either on a simulator or on the actual equipment. In this context, it appears that at the unit level, most classroom training is either informal or in conjunction with a live or synthetic training event.

FOCUS IS ON SYNTHESIZING EXISTING RESEARCH

Because of time and resource limitations, we were not able to perform experimental research on the advantages and disadvantages of live versus simulated training. Such experimental studies would involve setting up two groups to accomplish specific training objectives. One group would use simulators; the other would use live training. The performance of the two groups along several dimensions would then be measured and compared to understand the impact of the two methods of training. To the best of our knowledge, no such controlled studies have recently been accomplished for unit-level training, especially in the F/A-18, P-3C, and DDG-51 communities.[3]

Malmin and Reibling (1995a; 1995b) discuss the difficulties of conducting transfer of training experiments especially for high-performance aircraft. Cost, ability to control all factors, safety considerations, and methodological issues dealing with sample sizes and measurement are among the reasons so few studies of this type have been done. Seaman reviewed simulator studies in

---

[2]Navy Instruction 3120.32C states that classroom training is most effective when there is a need to provide and discuss information and instruction under controlled conditions.

[3]Experimental studies comparing the advantages and disadvantages of live and simulated (or computer-based) training have been accomplished for individual training or for training in basic concepts and operations. See, for example, Winkler and Polich (1990); Moody et al. (1993); and Farris et al. (1993).

three categories: surveys of pilot opinions about simulators, measured performance improvement in simulators from simulator use, and transfer of training studies for improved flight performance due to simulator training. The latter category uses control groups as a way to compare simulator training to flight training. The Navy employed such a study in 1975 with F-4J students as did the Air Force in 1977 with F-4 simulators and in 1980 with F-4 weapons instructors. These were air-to-air studies, and no known studies of this type have been done since.

The head of French aviation told us that the French had conducted one experiment in the MPA community in which crews who had simulator practice performed better than crews who had not. Caretta and Dunlap (1998) surveyed transfer of training effectiveness studies for the period 1986–1997 to examine the effectiveness of flight simulators as augmentation for "hands-on" flying training. They could identify only 13 studies related directly to transfer of training from the simulator. Results indicated that simulators are useful for training landing skills, bombing accuracy, and instrument and flight control. Many of these studies raised methodological concerns, and none dealt with complex pilot skills.

Several studies have identified the feasibility and advisability of substituting simulator training for live training. Roof (1996) studied qualification events for the F/A-18, SH-60B, and P-3C to determine whether such qualifications might be done in the simulator and, if so, what the cost-efficiency would be. Roof developed "must-fly" criteria, applied the criteria to the training matrix, and allowed events that did not meet the criteria to be done in the simulator. Some of the F/A-18 events he identified were strike-related. All P-3C events that passed his criteria screen were allocated flight hours in the training matrix, and none was designated for movement to the simulator. He then compared appropriate flight hour costs and simulator costs for the events. He concluded that there are significant financial savings from moving certain qualifications to the simulator with little or no degradation in training or safety. Kapos Associates (1998) conducted a study for Pacific Fleet on the ability of available, programmed, and future simulators to substitute for underway/in-flight exercises. The greatest potential for cost avoidance using simulators as a substitute exists in aviation with modest cost avoidance in surface forces. Moreover, the cost avoidance in flight training could be increased by

- adding simulators for training events already authorized for them,
- using existing simulators for more events and accepting some degradation in readiness, and
- using simulators in training events where major learning objectives would be achieved but simulators are now not authorized.

In surface training, using simulation in events not now authorized but considered appropriate would also lead to cost avoidance. Strike and ASW events were considered in the Kapos analysis.

Other studies focus on use of simulators to augment live training. Information Spectrum, Inc., conducted a recent study (Fleet Aircrew Simulator Training [FAST]) that showed how enhanced simulator fidelity could increase simulator training events in several mission areas and, in particular, from nine to 16 events for strike in the F/A-18 and from three to six events for ASW in the P-3C. The thrust of this effort was to show how training opportunities per crew per month could be increased through supplementary simulator training to eliminate training deficiencies caused by increasing complexity and task load.[4] Fidelity improvements in simulators would be applied to augment, not replace, current flying hour resources.

Our objective was to draw the salient points on the trade-offs between live and simulated training from previous research (the bibliography lists the various studies and reports we identified), from interviews with trainers, operators, and others in the community and from our observations on F/A-18, P-3C, and DDG-51 training. We attempt to synthesize the important points and findings from these three sources to gain a better understanding of the advantages and disadvantages of both live and simulated training.

Certain central points emerged from our examination of previous research and from the comparative analysis in the three communities we studied. These include the following:

- All peacetime training involves some degree of simulation. It is important to distinguish what aspects of a training event are being simulated and which are accomplished live.
- Simulation is used to different degrees by different communities. Past experiences and cultural biases influence the extent to which specific communities, especially the strike fighter community, use simulators. Simulators are used more often for events that involve the analysis of input data, as in the ASW community, versus events that rely on the operator's response to environmental and situational factors, as in fighter STW training.

[4]This is a key concept, to which we return later. Proficiency increases with repetition. The "steepness" of the learning curve at various numbers of repetitions governs improved performance from each additional repetition. No one knows the true shape of these curves, so it is hard to measure training proficiency. The training matrices used by the Navy designate minimum proficiency qualification standards based on the professional, albeit subjective, judgment of the trainers. If the standards are achieved, so is training readiness. Thus, the goal of unit training is not to increase proficiency but to meet a minimum standard.

- All communities could benefit from a greater use of simulation, but those communities must
  - establish relationships between simulator T&R (or, preferably, proficiency),
  - determine where and how to use simulation and live training,
  - recognize the use of simulators in their T&R matrices and encourage their use, and
  - provide the funding necessary to meet the needed availability and fidelity of simulators for unit training.

DISTINGUISHING BETWEEN LIVE AND SIMULATED TRAINING

The boundary between live and simulated training is not a sharp one. In fact, all training involves some degree of simulation. Typically, "live" training implies the exercise of the operational platform while "simulated" training suggests the operational platform is not exercised but rather is replaced by another device (i.e., the simulator). This is the distinction we commonly use throughout this chapter.

However, a training event typically involves a number of "things" in addition to the operational platform. For example, strike and ASW training events require the use of certain equipment on the operational platform, such as a radar, sonar, or target designator. Also, a "target" is often needed to train against, and finding and striking that target may involve dealing with various "threats," such as electronic countermeasures or enemy attack, and "environmental conditions," such as noise, motion, and weather. Finally, strike training may involve not only a target but also delivery of weapons or munitions. Any of these elements of a training event can be live or can be simulated. For example, a live strike-training event may involve the use of training munitions or simulated threats.

When the term "live training" is used, most people think of flying the aircraft or steaming the ship. But even this straightforward distinction is not always true. For example, ASW teams can be training with simulated threats (i.e., the equipment is stimulated by inputting preprogrammed signals) when the ship is steaming or the patrol aircraft is on a mission. In that case, the ship or aircraft is being exercised in a live mode, but the mission training involves simulation.

With this broader view of live versus simulated events, we see that almost all P-3C and DDG-51 ASW training events have some degree of simulation. Flying the aircraft or steaming the ship provides valuable training experiences for the operators of the platform but not necessarily to the "operators" of the ASW mission. Because there have been few, if any, real-world "targets" since the end of the Cold War, ASW training is accomplished with either recorded signatures input to the ship equipment (i.e., the equipment is stimulated) or against "friendly" targets such as U.S. or allied submarines. Even the signatures and operations of friendly targets may be scripted or constrained in different ways.

SIMULATION USE BY DIFFERENT COMMUNITIES

As we describe in the appendices and summarize in Chapter Two, different communities use simulated training to different degrees. Table 3.1 summarizes the use of simulated training by F/A-18, P-3C, and DDG-51 units in terms of how often the units use simulation in their training programs and the fidelity and availability of the simulators.

In Table 3.1, fidelity relates to the quality of the simulators or how well the simulators replicate the specifics of the training objective. Availability refers to the time available to the units for using the simulators. It includes measures of quantity, location, maintainability, and supervision.

F/A-18 Unit Simulator Use

Our analysis finds that the F/A-18 community does not use simulators much in unit training, an average of only approximately one hour per pilot per month. This is especially true in the training for strike missions. Eight of the 30 events in an F/A-18 unit's T&R matrix allow the use of simulators; only three of the 10 strike-related events recognize the contribution of simulation. Even when simulators are used to accomplish nonstrike-related training events, the "points" or credit resulting from those events are typically reduced. That is, a unit receives more credit toward attaining desired readiness levels for a live event than for one on a simulator.

One of the main problems with recognizing the contribution of simulators for training F/A-18 Hornet units has been their historically low fidelity and availability. To date, simulators do not provide the types of environmental responses or mission realism desired by fleet Hornet pilots. Simulators typically lack

Table 3.1

Simulator Use in Different Communities

	Current Use by Units	Fidelity	Availability
F/A-18 Strike	Very little	Poor	Poor
P-3C ASW	About half of training	Fair/good	Fair/good
Surface ASW	Almost all of training	Fair/good	Fair/good

currency with the operational equipment. Delays in procurement or failure to fund necessary upgrades severely limit the fidelity of F/A-18 simulators. To have any training value at all, both the Navy and the Marines must upgrade their F/A-18 simulators to match changes in the aircraft's operational flight programs. Also, current simulator training is typically unsupervised and often takes the form of unstructured free play, which may not accomplish training objectives. Greater simulator fidelity comes at a cost and, typically, units would rather see the extra money spent on more aircraft, spare parts, or munitions.

F/A-18 simulators are purchased primarily for use by the fleet readiness squadrons with little recognition of the potential use by operational squadrons. Operational pilots have access to the training squadron simulators in the evenings or on the weekends when they are not in use by the FRS. Given the heavy demands on a squadron pilot's time, it is not surprising that the operational units use the simulators very little. Additionally, deployments to NAS Fallon for STW Strike Fighter Advanced Readiness Program (SFARP) and for Carrier Air Wing detachments are peak periods for STW training, but no simulators are at Fallon. Lastly, though the decline in STW readiness during carrier deployments (typically for lack of suitable ranges) is perceived as a problem, no Navy initiatives have been put forward to develop F/A-18 simulators for use on carriers.

The Navy strike fighter squadrons are not unique in their low use of simulators for unit training. Air Force, Marine Corps, British, and French fighter units do not use them much either for unit training because of their poor fidelity and availability. The Marines and British are starting to give greater recognition to use of simulators as they seek either to reduce the high costs of live training or conserve the limited life of operational aircraft.

Of the three communities we studied, the F/A-18 units use the simulators the least. To increase that use, several improvements must happen to integrate simulators more fully into their unit training. The fidelity and availability of simulators must increase to the point that fighter pilots see their benefit in training. This requires additional funding for simulators—specifically for simulators designed to meet fleet training needs. Correcting these problems should help deal with any cultural biases that may have developed. Greater simulator recognition must be included, and encouraged, in the training programs. The strike fighter community must see simulators as a complement to live training, not as a substitute.

P-3C Unit Simulator Use

The P-3C community has typically relied on simulators for a significant portion of its unit training. Thirteen of the 25 events in the T&R matrix involve simulators, with four of the six ASW events accomplished on a simulator. The T&R matrix suggests the requirement for 219 annual hours of simulator use, including 175 hours for mobility training and 36 hours for ASW training. Our data from East Coast P-3C squadrons suggest P-3C crews use the simulators for mission training (e.g., ASW) during their IDTC approximately 6.5 hours per month. Most of this simulator time is dedicated to ASW training. P-3C pilots do much of their aircraft navigation and safety of flight training (i.e., training related to the mobility mission area) on a simulator.

P-3C simulators have acceptable fidelity and good availability. A P-3C has more similarities with a commercial aircraft than it does with a fighter in terms of a pilot employing the aircraft in the performance of a mission. Various environmental factors, such as motion and g forces are not driving issues in the fidelity of a P-3C simulator. Also, ASW simulators can replicate the equipment on the aircraft to a high degree, and preprogrammed signals representing enemy submarines provide effective training. The needs of the operational units are considered when P-3C simulators are procured. Therefore, there is sufficient time during weekdays for operational crews to use the simulators. However, the use data show that simulator use takes place at home station because the deployed sites do not have simulators.

The use of simulators in the Navy P-3C community is consistent with how other countries use simulators for MPA unit training. The French and British MPA units, for example, also rely heavily on simulators for training.

Although the P-3C community uses simulators extensively, an opportunity exists to increase their contribution to training. The P-3C does not have a deployable simulator or an on-board simulator. Therefore, during the six-month deployments and during training or operational missions, simulators are not available for training. An on-board simulation capability involving the stimulation of the actual aircraft equipment, similar to what is available in the RAF Nimrods, would help keep P-3C crews current in various ASW training events.

We recognize that many P-3C aircraft are at or approaching the end of their design life and that the age of the aircraft should factor into any decision to develop an on-board simulator. However, the Navy should consider placing such a simulator in the aircraft that replaces the P-3C. An on-board simulator would provide a rich training opportunity for the crews.

DDG-51 ASW Simulator Use

Almost all DDG-51 ASW training is accomplished with some degree of simulation. Twenty-six of the 42 ASW-related events in the DDG-51 training matrix specifically allow the use of simulators. DDG-51 ships can accomplish the other ASW-related events using either simulated targets or while the ship is tied up at the pier. Few, if any, events require the ship to be under way. As a matter of fact, a ship can typically accomplish all its ASW training during a single day on the Southern California Offshore Range (SCORE).

Simulation of some degree is used in surface ship ASW training because of the nature of the ASW mission.[5] Technicians on the ship listen for signals and try to identify the source. Once contacts are made, they are tracked and may be fired on. The ASW team typically never sees the target, unlike strike fighter STW missions, where the target must be acquired before attack. From the point of view of the ASW team, it can accomplish approximately the same level of training when the ship is tied to the pier and external signals are sent to the equipment.

ASW operations typically involve many diverse units, such as surface ships, helicopters, submarines, and MPA. Contacts, once made, are often passed to other platforms for tracking and attack. Although individual training is important for ASW operations, coordinated team or multiunit training is potentially more important.

Because of the reliance on some aspect of simulation in almost all their ASW training, DDG-51 simulator training assets typically have acceptable fidelity and availability. Ships or schools may have a library of prerecorded signals that are used to stimulate the on-board equipment. Also, on-board trainers are available to the ASW team. Finally, the BFTTs are becoming more widely available (depending on continued funding) on various platforms and are being installed on new DDG-51 ships during construction.

The use of some form of simulation for ship ASW training is consistent in the various cases we examined. The British and French naval ships also use simulation to a high degree during their training periods. In fact, both the British and the French may use simulation more than U.S. Navy ships currently do.

RELATIONSHIP BETWEEN TRAINING AND PROFICIENCY

Training methods (simulators or traditional live training events) provide proficiency (percentage of maximum performance achievable on any task) that depends among other things on task characteristics and complexity. Moreover, proficiency measures performance and increases with the number of repeti-

[5]ASW training for P-3C crews is more like the training for ship ASW teams than for F/A-18 training. Both the P-3C and the DDG-51 teams are isolated to a large degree from the operations of the platform.

tions. The first time a task is undertaken, performance is liable to be minimal. If this zero-practice minimum met a level of performance sufficiency, there would be little value in training for it. The first training repetition increases proficiency rapidly. With additional training sessions, the rate of improvement decreases, but the level of proficiency continues to increase until a maximum is reached. If a task were not practiced for some period, proficiency at doing the task would degrade to some minimum level. (The concept of periodicity also gets at task decay, which is a related but somewhat different problem from proficiency as we are defining it. Periodicity deals with performance decay per unit of time. Proficiency as we are using it deals with performance buildup per repetition of a training event.) Each task-method pair has different proficiency outputs that would need to be assessed by mission subject matter experts.

One can generalize to show the relationship between performance and various levels of proficiency, including qualification or certification. The notional curve in Figure 3.1 relates performance to repetitions. How many repetitions are needed to achieve maximum performance? Army empirical analysis (Djang et

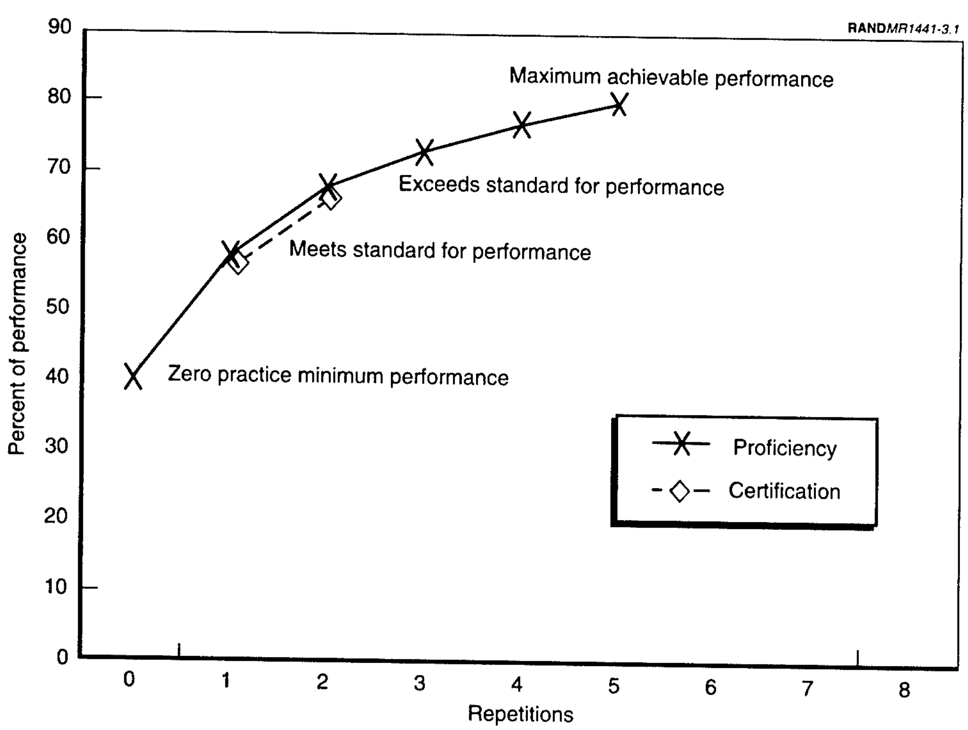

Figure 3.1—Notional Performance-Repetitions Relationship

al., 1998)[6] determined that, on average across tasks, additional repetitions beyond eight yield little to no additional increase in performance for all training methods. In their review of simulator studies, Caretta and Dunlop (1998) discuss a study that concluded that pilots with 40 to 60 simulator trials exhibited better landing skills than pilots with 20 trials do. A study of air-to-ground missions showed bombing accuracy improved as a result of simulator training, but improvement leveled off after 24 simulator sorties, with no increase in accuracy for additional simulator time. This latter conclusion is similar to results of a CNA study for live performance that showed a marked increase after a few repetitions and a leveling off after many repetitions.[7]

Certification (minimum accepted qualification) and proficiency are both measures of performance. A fundamental problem is to determine the number of repetitions of a training event that creates certification, the number of repetitions that leads to maximum proficiency, and the mix of training methods that provides either certification or proficiency at least cost. The T&R matrices include the minimum number of repetitions for an event needed for certification and in some cases maximum total repetitions. Repetitions beyond these garner no additional credit. It is not clear whether these maximum repetitions represent maximum certification value or maximum proficiency value, but it appears to be the former. As a general rule, the matrices capture the steepness of the early part of the learning curve for each training method as a basis for certification. In general, the T&R matrices do not appear to be concerned with training proficiency beyond that.[8] The objective is to minimize cost, given certification of some minimum performance level. The competing model is to maximize effectiveness given available resources of money, availability, and time. With this latter formulation, one would be better able to assess the substitution of one training method for another (e.g., simulator for live) or the increase in effectiveness by adding more of one or both resources. What is the correct objective? How many repetitions should be bought?

WHERE AND HOW TO USE SIMULATION

While the basic trade-off issue is to determine the relative frequency of a set of training events by either live training or by simulation, some events may only be feasible in a simulator, and some are best flown live. Simulator-only training might typically be for events that are high risk or infeasible to emulate live.

---

[6]Most of this discussion is drawn from here.

[7]Results reported at 70th Military Research Operations Research Society Symposium, June 2000.

[8]Training effects are usually measured in two ways: improvement in the mean level of performance and reduction in variance in performance around the mean. The T&R matrices are attuned more to readiness and concentrate on demonstrating performance minimums.

Examples would include safety-of-flight events. Aircraft-only training might typically be for events that involve pilot responses to physiological cues (e.g., high-G maneuvering) or for subevents that cannot be simulated, such as live ordnance expenditure. Some training events should use a mix of live and simulation. One could introduce or practice the event on a simulator and then conduct the exercise live. Or for multiple iterations of an event, some live iterations could be replaced with simulators. We saw evidence of this with the French MPA community, where it consciously introduced a simulation as practice before live flying and where it reduced the amount of flying time by allowing simulation of what had previously been live events. Verification of proficiency remained a flying event, but much of the practice was changed to simulation.

As discussed earlier in this section, measuring the effectiveness of simulator training is difficult. The British in their Flying Training System study state that no authoritative work has concluded that synthetic training can replace live flight training, although studies do conclude that it can enhance flight training and there is a temptation to carry out the majority of flying training in a simulator on cost grounds alone. Without empirical evidence, we are left with the following conclusions based largely on those who have aviation experience:

- Simulation is effective in a number of areas such as introduction, practice, "swithchology," procedures, NATOPS, and rehearsal.
- Live training may be needed for learning perceptual-motor skills.
- Simulators are not substitutes for flight time. They provide complementary and supplementary training to reduce training deficiencies brought on by increased complexity and task load.
- Pilot experience is a factor in simulator value. A synergy exists between simulator and flight hours for young pilots in which rehearsal in a simulator should precede actual flying. Experienced pilots can show currency in various areas using a simulator without having to fly the event.
- The kind of platform is also a factor in simulator value. Fighter tasks place a premium on sensory inputs and situational awareness, and thus more flying time is required. Other aircraft have more tasks that can be done in simulators.
- Tactics are a factor in simulator value. Weapons can be learned in simulators and evaluated live. Crew coordination works well in the simulator but force-on-force simulations require more work.
- Negative training needs to be avoided. Simulators become predictable and teach some inappropriate responses. Simulators may also give a false sense of accomplishment.

HOW TO ENCOURAGE GREATER USE OF SIMULATORS

At least three major changes in the environment are needed to encourage greater use of simulators.

First, a relationship must be established between training events and proficiency so that more emphasis is placed on repeating an event to gain maximum proficiency. Simulators have a more distinct cost advantage as the number of repetitions increases. Currently, readiness is based on event qualification and measures minimum acceptable levels of proficiency. No measured readiness benefit has been detected for increased proficiency beyond the minimum qualification level. A training benefit occurs with more practice repetitions (up to a maximum for an event), but the existing measurement system gives that benefit no value.

Second, cultural biases with respect to simulation must be overcome—in particular, flying hours as the dominant metric drives the aviation culture and the behavior of pilots. Logged simulator hours are not accorded any respect in military aviation. The simulator role in training, readiness, and pilot experience must be firmly established. The British, in an unpublished study, concluded that dogma should not prevent the transfer of currently live flying events to simulators where the transfer of training effectiveness has been shown.

Third, necessary investment in the fidelity and availability of simulators must be made. Studies[9] have shown that successful transfer of training may not require high-fidelity simulators or whole-task training. Other studies by the Defence Evaluation and Research Agency (DERA) have shown that complex tasks that cannot be done well live can be simulated with high expected training benefits.[10] In this study, the British constructed a fourth-generation synthetic training environment and then surveyed pilots who had used it to determine how well certain missions and tasks could be trained compared with existing simulators and live flying training.[11] The results shown in Figure 3.2 illustrate that the current generation of simulators did not fare well on mission tasks. The concept simulator fared better and scored above aircraft on several tasks.

Aircraft flying got high marks in training for some mission tasks (e.g., tactical formation, visual low level, overall situational awareness, low-altitude tactics)

---

[9]For example, see Caretta and Dunlop (1998).

[10]The results of this study were briefed to us by Bharat Patel, a member of the DERA staff.

[11]A fourth-generation simulator refers to a future simulation, in which initial training would be conducted followed by consolidation training in an aircraft. See Appendix D for a more complete explanation.

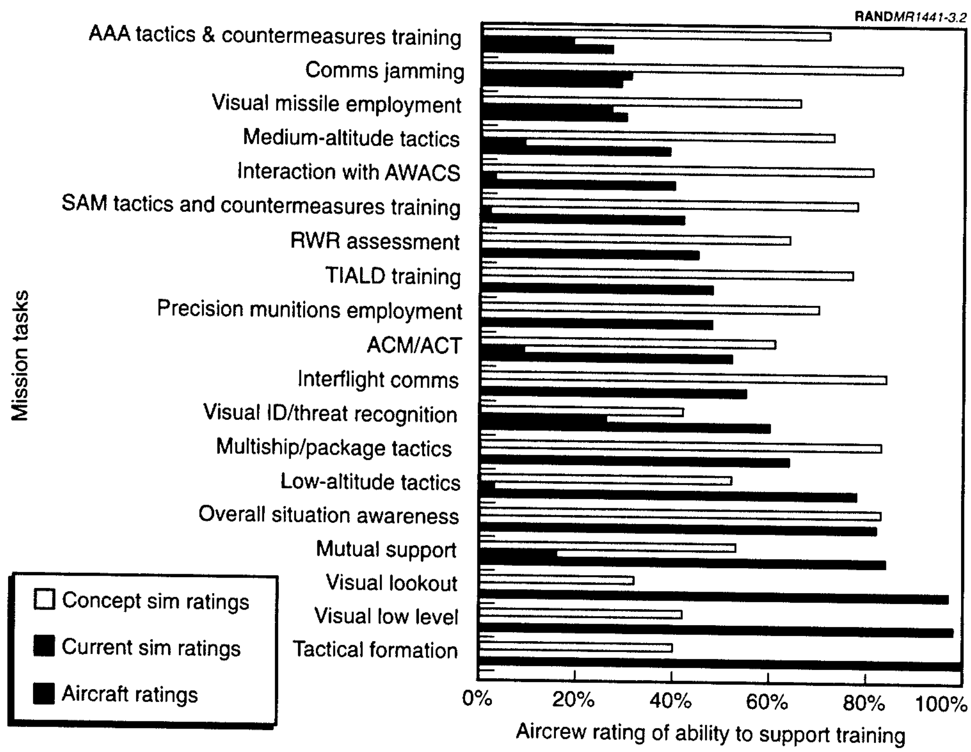

Figure 3.2—Results from DERA Study

but low marks in others (e.g., medium-altitude tactics, visual missile employment, communications jamming, antiair tactics, countermeasures training). The new simulators received satisfactory (greater than 50 percent) ratings in almost all tasks. Their lowest marks were in those mission tasks scored highest for live aircraft while their highest marks were in mission tasks where the aircraft were lowest. This reinforced other views that one might fly the same number of hours but for different mission tasks than currently. But it is a chicken-and-egg problem. The new simulators only deliver training value when there are enough of them to train with—real simulators and not concepts (or promises) for them are needed. Moreover, a gap occurs between the introduction of a simulator and the ability to translate its use to readiness and proficiency growth.

All training resource requirements must be balanced. Focusing only on live vis-à-vis simulator training masks the relationships among all the resources needed for effective training. This will be discussed in greater detail in the next section.

BALANCING TRAINING RESOURCES: TRADE-OFFS BETWEEN LIVE AND SIMULATED TRAINING

We use the example of training for aviation STW to discuss trade-offs. A trade-off substitutes one means for another to achieve objectives within a set of constraints. In the aviation community, this is typically framed as a substitution of simulator hours for flying hours. While these two means are often articulated formally, the objectives and constraints are less explicitly stated and may change depending on who is debating the trade-off.

If we take a high-level view of relating resources to readiness, four broad elements are available for a trade-off:[12]

- Overall budget dollars (e.g., could be more or less of them).
- Training resources (the budget dollars could buy more or fewer flying hours or simulator hours or buy other resources, such as spare parts).
- Training programs (specification of training events and their frequency).
- Output, which might be pilot readiness or pilot proficiency (could choose to measure one or both).

The typical trade-off analyzed and discussed is resources (simulator hours for flight hours), but one could change, or hold constant, any variable within the four elements. During the course of our interviews with operators and trainers and based on our review of studies, at least these trade-offs were discussed:

- Trade-Off 1: Substitute simulation hours for flight hours to achieve the same levels of pilot qualification and same squadron readiness at lower cost. Studies show the feasibility and cost savings under the assumptions that the substitutions were legitimate and the simulators were available.
- Trade-Off 2: Add simulator hours to flight hours to achieve greater pilot proficiency at higher cost. This is the trade-off suggested by the Navy's FAST plan. Pilot proficiency must be the desired objective because it is not clear that pilot qualification would change by simply adding simulation hours to a training program that already produces qualification through flying hours.
- Trade-Off 3: Modify the training program (events, periodicity) to achieve the same squadron readiness for available flight and simulator hours with the current readiness standard. The goal of this trade-off appears to be to

[12]We do not mean to imply that these are the only important components. Clearly, experienced pilots and adequate ranges and airspace are central to good training. However, they do not lend themselves to trade-offs.

reestimate the training matrices to preserve readiness measures when resources decline.

- Trade-Off 4: Modify the readiness standard (e.g., number of qualified pilots) to achieve squadron readiness for available flight and simulator hours and the current training program. This is a variant of the previous trade-off.
- Trade-Off 5: Modify training (long-term, multivariable) to achieve maximum pilot proficiency at the same cost. This is the trade-off discussed by the RAF. In this view, many additional variables (e.g., simulator fidelity, aircraft availability) are brought into the equation.

Numerous variables within the four broad elements of budget, training resources, training program, and output are involved that are often not considered or are considered fixed. The trade-off of flight hours for simulator hours may be too simple because it does not explicitly consider many other factors that matter. Table 3.2 lists some of them.

All of the variables shown in Table 3.2 are means. Potential objectives these means are intended to attain are to maximize pilot proficiency (maximum proficiency in performing an event) or pilot readiness (demonstrated minimum qualification to perform an event). Constraints could be squadron readiness (aggregate level of qualified pilots) or cost. One might construct a problem statement to maximize pilot readiness (or pilot proficiency) by varying the means while staying within cost and squadron readiness parameters. Other problem statements are also possible. The crux of the trade-off may be the decision about objectives. Which does the Navy desire as a basis for performance in any trade-off analysis: pilot readiness (minimum qualification) at acceptable (minimum) cost or maximum pilot proficiency within resource availability?

Table 3.2

Some Factors for Trade-Off Consideration in the Long Term

Variable	Short Term	Long Term
Flying hours	Vary	Vary
Simulator hours	Vary	Vary
Simulator availability	Fixed	Vary
Simulator fidelity	Fixed	Vary
Aircraft availability	Fixed	Vary
Pilot time available	Fixed	Vary
Number of pilots	Fixed	Vary
Pilot experience	Fixed	Vary
Training program	Fixed	Vary
Readiness standard	Fixed	Vary

The time horizon typically used to discuss the trade-off is in terms of the annual budget or training program. This short time horizon limits the trade-off to the means of flying hours and simulator hours because these can be varied in the short term. A longer time horizon allows for such other variables as simulator fidelity to factor into the trade-off calculation. We discuss more of these variables below as we show how a theoretical model might be constructed. Moreover, the trade-off of flying hours for simulator hours is difficult because flying hours represent more than just the means to a training objective. Flying hours are the dominant metric for the aviation industry, and the worth of a pilot is judged on the amount of flying hours accumulated. Desired behaviors are supposed to be the basis for performance metrics. In this case, the existing performance metric (flight hours) is driving pilot behavior (accumulate flight hours). Until that culture changes, simulator hours are perceived as an unwelcome addition to the pilot's flying day.

Time in a pilot's day, simulator fidelity and availability, the availability of aircraft, and pilot experience can all be treated as variables and changed to explore different trade-offs. Better simulators might allow for more-complex events to be done in simulators that could change the training program. More pilot retention (and thus higher levels of pilot experience) could reduce initial training costs and reduce the need for flying hours in units. Fewer, but more operationally available, aircraft could change the mix of aircraft and simulator events.

All of the constants that we think should be explicitly included in a trade-off act as constraints in the short-term trade-off most often discussed. Those constants (and there are likely many others) can be found in Table 3.2. Next, we construct a model of how these longer-term variables constrain (or cause unintended consequences) if not considered simultaneously with the simulator versus flying hour trade-off.

STRUCTURE OF A MODEL TO ANALYZE TRADE-OFFS

Figure 3.3 is a representation of the typical view of the simulator hours for flight hours trade-off.

In this view, the training matrix allows for an event to be done either in an aircraft or in a simulator. The event must be done 12 times a year to achieve qualification. This representation assumes one-for-one equivalency in performing the event live or with a simulator, so eight aircraft repetitions and four simulator repetitions would meet the standard.[13] Each point on the line has a

[13]We use the one-for-one ratio is for illustrative purposes only.

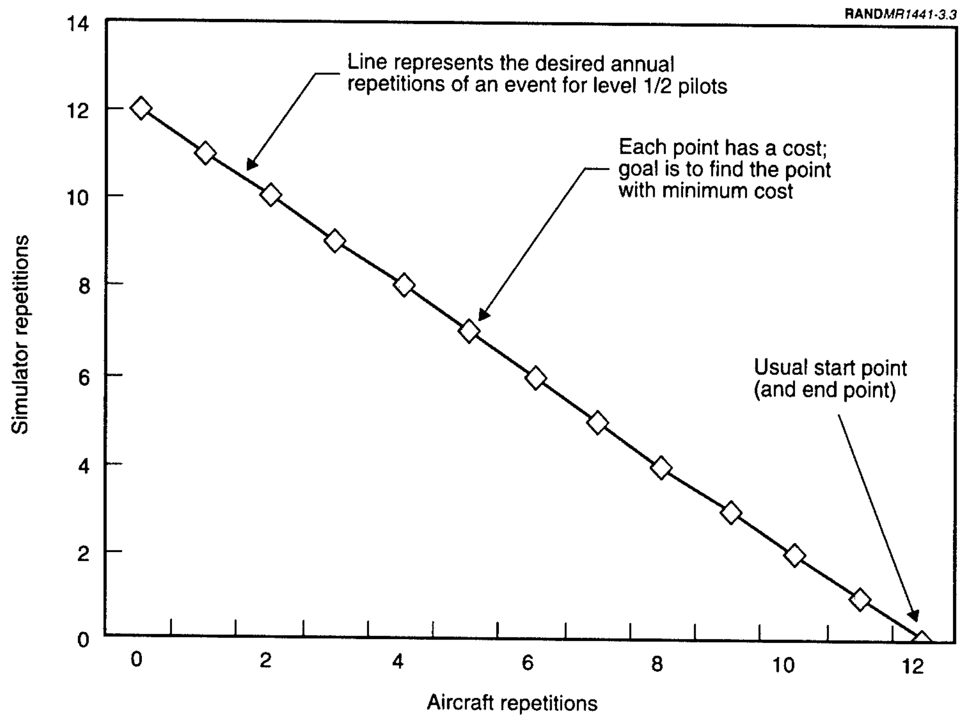

Figure 3.3—Simplified View of a Trade-Off Analysis

cost, and the goal is to find the point with minimum cost. In this view, one would move along the line toward the less expensive means to perform the event. The status quo is to perform the event with aircraft repetitions, the way the event has always been done. Assuming that simulator repetitions cost less than aircraft repetitions, why have training programs not moved toward all simulator repetitions? Obviously, constraints must be at work.

Figure 3.4 shows some of these constraints. (As stated above, the aviation cultural metric of the flying hour may dominate all of the other constraints.) We use this simple representation to illustrate how other variables limit the trade-off in ways not readily understood. Such variables as pilot time or aircraft availability are treated as constants in the short term and limit either simulator repetitions or aircraft repetitions. The constraints on simulator repetitions include simulator availability and pilot time. The constraints on aircraft repetitions include aircraft availability and pilot time. These constraints bound the trade-off to some combination of eight simulator repetitions or six aircraft repetitions.

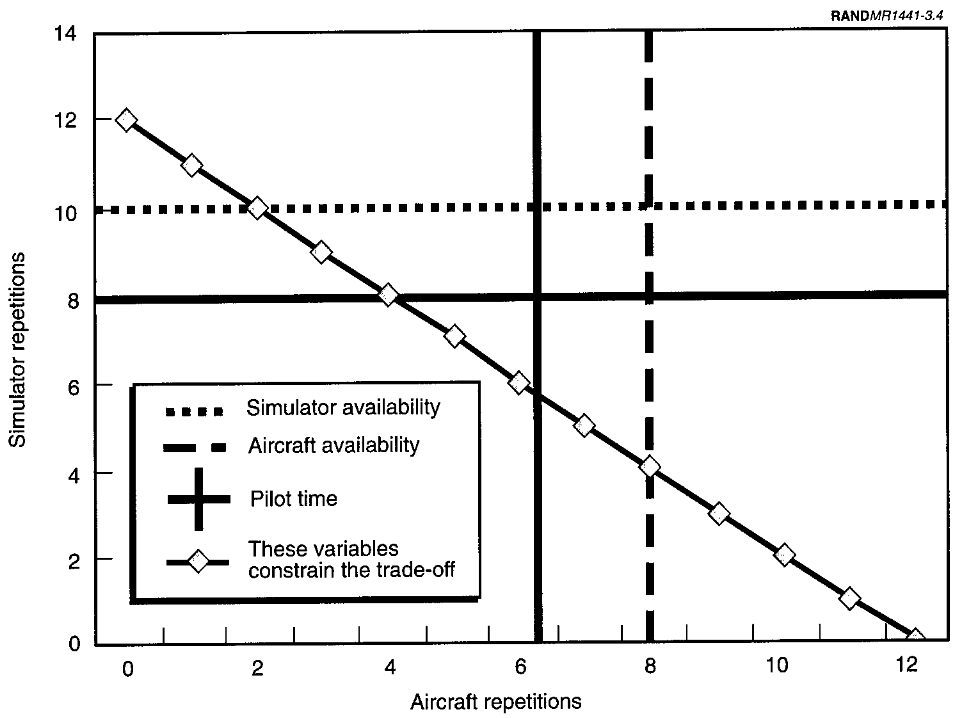

Figure 3.4—Constraints Must Be Considered

This simple model can also be used to demonstrate visually the effects of improving simulator fidelity. Figure 3.5 shows the effect of introducing a better simulator. Simulator repetitions can now be done in half the time or with twice the effectiveness as previously. Even with the other constraints remaining in place, more of the trade-off is now available to the decisionmaker.

More work is needed on framing the trade-offs properly. Our observation is that as it is currently framed, many debates but few trades will occur. Moreover, if the simulator hour vis-à-vis flight hour trade-off does proceed, it is likely that unintended consequences (e.g., resources will not be saved or readiness will not increase) will emerge because systems of this complexity generally have hidden constraints. In essence, the trade-off "space" is smaller than recognized.

DIFFICULTIES IN ANALYZING A MORE COMPLEX TRADE-OFF

We have used these simple figures to begin to illustrate complexities inherent in the trade-off. The investment in a means to achieve an objective needs to be

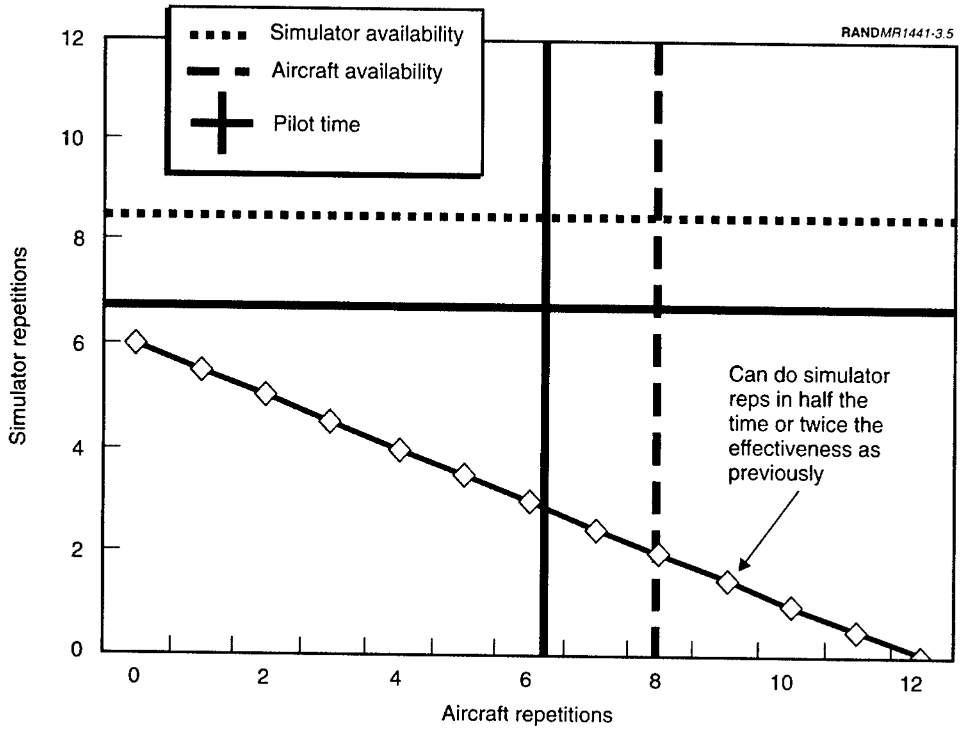

Figure 3.5—Increasing Simulator Fidelity Can Affect Trade-Offs

analyzed in a more complex environment. Complexity results from the number of variables and the relationships among them. Spending the money to increase simulator availability or fidelity may not improve squadron readiness if other variables constrain the improvement. Figure 3.6 and the discussion of it introduces the concept of a larger number of variables. Figure 3.7 shows a more complex representation of the interactions of many of the variables that need to be considered.

Large Number of Variables

Many variables affect individual performance and unit performance, including personnel characteristics, task and unit design, and individual and collective training. It may be that the extent to which an individual is trained prior to joining a crew or the extent to which multiple crews participate in collective training or training exercises has greater effect on performance than the training of crews, which is the focus of this project. Moreover, in examining unit training we tend to treat many of these variables as constants because we take a short-term view of the possible trade-offs.

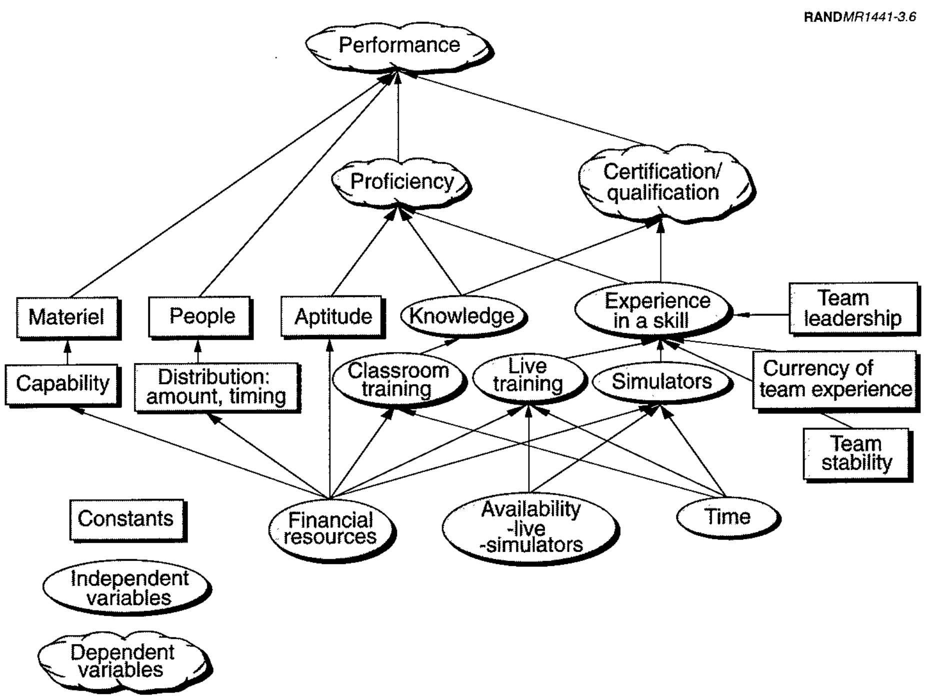

Figure 3.6—Variables in the Trade-Off Analysis

Figure 3.6 is a picture of the relationships among variables that could be part of the trade-off analysis.

We define each of the terms as follows:

Performance is completing a task according to a standard for a certain environmental condition. The standard might be time, distance, quantity, rate, percent, accuracy, or an objective evaluations score.

Proficiency is the state of being skilled in performing a task—i.e., expertise (Linder and McDevitt, 1998). The degree of expertise is measurable as higher or lower against standards of performance for a task. Proficiency as a measure of performance increases with practice on a scale without an upper bound although, in practice, increases in proficiency per practice repetition diminish as one reaches higher levels of proficiency.

Certification/Qualification is also a measure of performance but has a lower and upper bound. It is the accomplishment of minimum standards of performance for a task. It is also a certification of proficiency at that performance level. Qualification is time limited (has a periodicity) and varies by task difficulty and complexity. For example, the Kapos analysis of ASW for surface ships suggests 60 days of currency (after initial qualification) is optimal although fleet standards tend to 90–180 days.

Ability or aptitude is an enduring characteristic of people. It is mainly unchangeable in the short term.

Knowledge and Skill are developed attributes in people. Each can be changed through education and training. Classroom training is usually focused on increasing the knowledge base of an individual. Live and simulator training is usually focused on increasing skill by giving more practice in that skill. Individual experience in a skill is affected as well by the leadership of the team surrounding the individual, by the currency of group experience, and by the stability of the team (cohesiveness).

Amount of Materiel and its Capability have a direct effect on performance. More materiel tends to be better than less in all cases, given the people available to use it. Highly capable materiel can overcome deficiencies in aptitude, knowledge, skill, and experience. Conversely, more aptitude, knowledge, skill, and experience can overcome the shortcoming of materiel capability. Doctrine or how best to use the materiel in certain situations also plays a role.

The number of **People** available has a direct effect on performance. If a position is not filled, performance is degraded to a greater or lesser degree depending on the value (occupation, rate, experience) of the unfilled position. More people tend to be better than fewer in all cases, given the amount of materiel, casualties, etc. The number of people is affected by the overall level of authorizations funded by the Navy, by retention patterns that affect inventory, and by their movement through the training and detailing system (distribution). The timing of arrival of people into units can affect performance. For example, a recent DoD Quarterly Readiness Report to Congress (DoD, 2000) states that "personnel continue to report to units late in the Interdeployment Training Cycle, hampering the effectiveness of unit training, especially in aviation squadrons." As a general rule, training has a strong dependence on personnel resources.

Financial Resources, Time, and Availability of training methods (either live or simulators) are essential lubricants for this closed system. More of each increases performance, but the amount of the increase is limited by the intervening variables. These trade-offs are discussed in greater detail below.

Not all variables have to be included in a trade-off analysis. Some variables can be treated as constants to simplify the analysis. In essence, the boundaries around the trade-offs can be tightened to get at only the effect of training on performance. However, excluding variables in this fashion may lead in the wrong direction. Changes in the materiel or people systems could yield greater payoffs than changes the training system would. All systems need to be considered simultaneously. For example, in the Kapos proficiency model for Navy STW in its figher/attack squadrons (VFAs), the materiel and people factors account for 64 percent of relative proficiency while knowledge and experience (training) account for 36 percent.

For some variables, minimum levels are sufficient while for other variables, increasing levels have greater returns to performance. For example, minimum levels of knowledge are useful in increasing proficiency, but, beyond the minimum level, proficiency is increased faster through practicing of the skill embedded in the practical application of the knowledge.

We do not account for the many feedback loops in this conceptual model. For example, live training is widely perceived as having a retention effect (the "whoosh" factor) for individuals, teams, and crews participating in it, even if tangentially. If true, this effect could increase team experience and stability and reduce the need for training of new entrants to the system.

Interactions of the Variables

It is not just the number of variables that creates complexity for the trade-off analysis but also the interactions among the variables. Figure 3.7 introduces interactions to the variable mix using a system dynamics portrayal.

In this portrayal, an intermediate effectiveness objective is pilot proficiency (maximum proficiency in an event), which could also be stated as pilot readiness (minimum qualification in an event). As noted earlier, how this intermediate objective is stated can govern results. Time in a pilot's day, simulator fidelity and availability, the availability of aircraft, pilot experience, and the flying hour performance metric can be varied along with the training program and the number of flying and simulator hours per month. Do better simulators allow for more-complex events to take place in simulators (greater proficiency)?

It is the costs of all of these variables that matter, not just the cost of a simulator hour versus a flight hour. For example, does more pilot retention reduce initial training costs and the number of flying hours in units? Can fewer but more frequent fully mission capable planes mean better simulators that changes the mix of flight and simulator events?

What is needed is more analysis (and mathematical representation) of the constraints such that one could answer questions about the costs and benefits of removing an individual constraint and especially of removing one or more simultaneously.

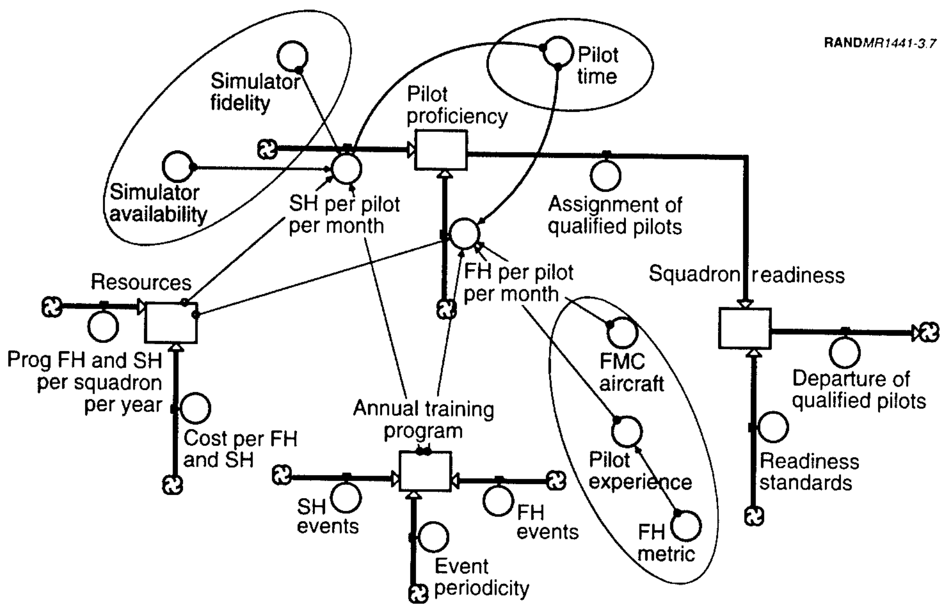

Figure 3.7—Multivariable Long-Term View of Trade-Offs

Different answers could emerge based on what the desired objective is. The goal must be determined. Is it to reduce cost in achieving maximum proficiency, or it to reduce the cost of achieving a given proficiency threshold?

Chapter Four

OBSERVATIONS AND RECOMMENDATIONS

This chapter presents our summary observations about simulator use, live training, and potential trade-offs between them. We also offer some suggestions about how the Navy might proceed.

OVERALL

Our research shows that simulations are used most frequently for events that involve the analysis of input data, such as occurs in ASW training. They are used least often for events that attempt to replicate situational or environmental conditions, such as occurs in strike warfare training.

FIGHTER TRAINING

Simulators do not play a large role in the training of fleet F/A-18 pilots, who average only about one hour a month in simulators. A number of factors contribute to this low use. Some are simply physical or temporal constraints. There are not very many simulators, and the FRP has priority for them. The fleet pilots have limited opportunity to use them. However, the quality of the simulators in some locations appears to act as an additional constraint. Past F/A-18 simulators have not provided the type of environmental response and mission realism pilots want. Furthermore, the OFP of the simulators has not kept pace with those of the aircraft, and pilots do not regard the simulator as suitable to support their training. These factors may have contributed to cultural issues that also require resolution. Simulator training may not be viewed as being as valuable or effective as actual flying. Indeed, simulators cannot substitute for flying, but they can provide complementary and supplementary training to reduce deficiencies.

The situation in the other services (Air Force and Marines) and among our allies (British and French) does not differ much from that in the Navy. These other organizations use simulators, but they do not play a large role in the training.

The reasons are the same as they are for the Navy: availability, fidelity, and culture. However, driven by the high cost of live training and the limited operational life of aircraft, the Marines and the British are exploring expanded use of simulators.

Assessing the effect of simulator training on pilot proficiency poses a difficult task. Controlled studies are few, and the ones that do exist are dated and frequently raise methodological concerns. Also missing are good baseline data about the increase in proficiency that occurs with repetition. Furthermore, the constraints on the simulators remain unclear. These include the degree to which the pilot community will accept simulator training as being effective, the availability of the simulators, and those that will emerge as a result of the complexity of the simulated environment.

Without a clear understanding of the effect of simulators on proficiency and the constraints of simulator training, the Navy cannot make reasoned judgments about the balance between live and simulated training.

ASW

In contrast to the fighter community, the ASW community uses simulators extensively. Simulation is valuable for this community because of the difficulty in finding suitable targets. For the P-3C crews, simulators benefit both the flight crew and the "back of the airplane" crew. The flight simulators replicate the flight environment of the P-3C pilots better than do those used by the F/A-18 pilots and thus enjoy wider acceptance. This wider acceptance reflects in the greater use of simulators by the P-3C crews. During IDTC, the P-3C crews average more than 14 hours of mobility simulation per month and more than six hours of tactical simulation. However, the P-3C lacks a deployable simulator.

The British and French antisubmarine crews also use simulators far more than their fighter counterparts, although there are some differences from the P-3C crews. Both use far less simulator time for the flight crews, but the French put in about the same amount of time on tactical training as the U.S. crews do. The British log about three more hours of tactical simulation a month than do U.S. crews. However, the pattern of greater simulator use for the ASW crews than for the fighter crews is consistent.

Turning to the surface ASW crews, almost all training involves some level of simulation. The ships typically have on-board simulators that allow the sonar technicians to train on their own equipment, and they can do this at sea or tied up to a dock. They also have drones that can be launched when they are at sea, and these can emulate various types of targets. An extensively instrumented range off the coast of southern California also offers a range of simulation-supported training activity.

While some differences exist between the surface ASW of the U.S. Navy and our allies, they are similar in that all three navies extensively use simulators in their training. The United States and the British tend to use or replicate operational equipment, while the French use computers whose displays mimic the screens and controls of operational gear. However, simulators play a major role for all.

RECOMMENDATIONS

Of the three Navy communities we examined, the fighter community uses simulators the least, and some research suggests that aviation simulators offer the most potential for cost avoidance. However, before the Navy pursues any expanded use of simulators, a number of things should happen. First, the Navy must decide how it wants to measure readiness. Currently, it measures it by ensuring a given level of proficiency across a range of tasks. Put another way, it establishes a minimum level of proficiency, and once a unit meets that minimum level, it is declared ready. The unit could improve its proficiency through additional training, but the current system accords no benefit to being "more ready." More repetitions of a task (up to some number) might make a pilot more proficient in the task, and thus he would be better trained. Also, more repetitions exploit the cost advantage of the simulators. But the current system offers no incentives for this additional training and has no way to even recognize it.

Second, the Navy should identify the goal of the future balance of training. For example, the goal might be keeping the current level of proficiency but at less cost. Or it might be more-proficient crews within the current cost ceiling. At one level, this means striking a balance among dollars, resources (e.g., flight hours), training programs (e.g., frequency), and pilot proficiency.

Third, the Navy should determine the relationship between simulators and proficiency for different levels of fidelity and availability and ascertain if the needed levels are technologically and economically feasible.

Fourth, identify the constraints—physical and psychological—that limit both live and simulated training. This process would include identifying events that cannot be simulated. In a system of this complexity, it is unlikely that all constraints can be identified, so it will require a judgment about when the system has been characterized well enough to proceed.

Fifth, if the analysis shows that increased simulator use would benefit the training, the Navy needs better simulators and more of them. The current quality and availability are impediments that need to be overcome. Better does not necessarily imply more sophisticated and expensive. It may be that relatively inexpensive simulators can train a subset of tasks quite well.

Finally, even if more and better simulators appear to be the best path to follow, cultural issues may need to be overcome for them to gain wide acceptance in all cases. The Navy can help this process by reexamining its readiness measurement criteria and conducting a complete and objective trade-off analysis.

Appendix A

U.S. NAVY F/A-18 FIGHTER TRAINING FOR STRIKE MISSIONS

This appendix describes the tactical training of U.S. Navy F/A-18 squadrons focusing on strike missions. It outlines the Navy's training philosophy, how the Navy structures and bases its F/A-18 squadrons, the planning and conduct of tactical training, the mission-related events in the training and readiness (T&R) matrix, and the employment of live and simulated events in tactical unit training.

NAVY TRAINING PHILOSOPHY

The Navy employs a progressive and repetitive training philosophy for its fighter pilots. It is progressive in the sense that the pilots train on increasingly complex skill sets, with the more basic ones providing a foundation for the more complex ones. It is repetitive in that once a squadron completes a deployment, it returns to the basic tasks and then builds to the more complex ones over an 18-month cycle. It adopting this philosophy, the Navy accepts cyclical readiness. The units completing deployment receive a lower priority for personnel and equipment and are not viewed as being as ready as those later in the deployment cycle.

HOW NAVY F/A-18 SQUADRONS ARE ORGANIZED AND BASED

The F/A-18C is a single-seat version of the Hornet strike fighter. It is capable of air-to-air and air-to-ground combat. The Navy has 24 F/A-18 Strike Fighter Squadrons (VFA), each with 12 F/A-18C aircraft and 16 to 18 pilots. Squadrons deploy aboard the Navy's 12 aircraft carriers as part of a carrier air wing, of which there are 10. The typical carrier air wing aboard a carrier has three F/A-18 squadrons, one F-14 squadron, one S-3 squadron, one EA-6B squadron, one E-2C squadron, and one SH-60F/HH-60H squadron. Eight of the 10 carrier air wings have three F/A-18 squadrons; two[1] have two F/A-18 squadrons, and four[2] have two Navy and one Marine Corps F/A-18 squadron.

The F/A-18 basing reflects the Navy's organization into an Atlantic and a Pacific fleet: 11 squadrons are assigned to the Atlantic Fleet (nine at NAS Oceana, Virginia, and two at MCAS Beaufort) and 13 assigned to the Pacific Fleet. Ten of 13 Pacific Fleet squadrons are based at NAS Lemoore, California, and the remaining three are forward deployed and based at NAF Atsugi, Japan. The commanders and staffs of East and West Coast Carrier Air Wings, when not deployed aboard the carrier, are based at NAS Oceana and NAS Lemoore, respectively. Also based at NAS Oceana and Lemoore are the Atlantic and Pacific Fleet F/A-18 Type Wing Commanders, F/A-18 Fleet Replacement Squadrons (FRSs), and Strike Fighter Weapons Schools.

Table A.1 displays Navy F/A-18 squadron assignments to carrier air wings, home bases, and aircraft carriers.

HOW TRAINING IS PLANNED

Navy F/A-18 planning for training is hierarchical, beginning at the highest level with the F/A-18 Universal Task List. Below these are Primary Mission Areas (PMAs), which are specified in the Required Operational Capabilities[3] and Projected Operational Environment (ROC/POE). A unit must be fully capable of carrying out a PMA.

F/A-18 Primary Mission Areas

The following lists the seven PMAs for the F/A-18 in training priority order with a brief description of the desired mission outcomes:

- **Mobility** (MOB)—safely operate aircraft in all weather conditions, take off and land aboard the carrier, and aerial refuel.
- **Strike Warfare** (STW)—attack and destroy enemy targets employing a wide variety of air-to-ground munitions, conduct combat search and rescue (CSAR).

[1]CVW-7 and CVW-8 each have two F-14 squadrons; all other CVWs have one F-14 squadron.

[2]CVWs -1, -2, -3, and -9 have VMFAs -251, -323, -312, and -314, respectively. VMFAs -251 and -312 are based at MCAS Beaufort, South Carolina, and VMFAs -323 and -314 are based at MCAS Miramar, California.

[3]For aviation squadrons, the ROC assigns primary and secondary naval mission areas; the POE establishes the operational conditions, including the numbers of aircraft and flight hours, under which the squadron will execute the assigned missions.

Table A.1

Navy F/A-18 Squadron CVWs, Home Bases, and Aircraft Carriers

Air Wing	Squadrons	Home Base	Aircraft Carrier
	Atlantic Fleet/East Coast		
CVW-1	VFA-82 VFA-86	MCAS Beaufort	USS *Theodore Roosevelt*
CVW-3	VFA-37 VFA-105	NAS Oceana	USS *Harry S. Truman*
CVW-7	VFA-131 VFA-136	NAS Oceana	USS *John F. Kennedy*
CVW-8	VFA-15 VFA-87	NAS Oceana	USS *Enterprise*
CVW-17	VFA-34 VFA-81 VFA-83	NAS Oceana	USS *George Washington*
	Pacific Fleet/West Coast		
CVW-2	VFA-137 VFA-151	NAS Lemoore	USS *Constellation*
CVW-5	VFA-27 VFA-192 VFA-195	NAF Atsugi	USS *Kitty Hawk*
CVW-9	VFA-146 VFA-147	NAS Lemoore	USS *John C. Stennis*
CVW-11	VFA-22 VFA-94 VFA-97	NAS Lemoore	USS *Carl Vinson*
CVW-14	VFA-25 VFA-113 VFA-115	NAS Lemoore	USS *Abraham Lincoln*

NOTE: Aircraft carrier assignment is as of December 2000.

- **Antiair Warfare** (AAW)—maintain local air superiority and destroy enemy aircraft using air-to-air missiles and guns.
- **Amphibious Warfare** (AMW)—conduct close air support (CAS) missions.
- **Antisurface Warfare** (ASUW)—attack and destroy enemy ships.
- **Mine Warfare** (MIW)—deploy mines.
- **Command, Control, Communications**[4] (CCC)—tactically communicate.

The AMW, ASUW, and MIW Primary Mission Areas are a refinement of the STW PMA; an inherent STW capability exists in each.

[4]Navy F/A-18 squadrons fly no training missions solely dedicated to the CCC mission.

Training and Readiness Matrices

For each aircraft type, the type commanders issue T&R matrices (U.S. Navy, 2000a) that establish the training priorities and requirements for the PMAs. Each matrix consists of a series of missions and actions organized by PMA. Typically, a mission comprises several training actions. For example, a given mission, e.g., Offensive Counterair, may require 15 actions (e.g., high fast intercept) to accomplish. Only one mission can be accomplished on a given sortie. However, several training actions can be completed. The T&R matrix provides the type commander what he needs to know to plan training. In addition to the task number (linked to a PMA) and title, it specifies the following:

- Whether the task must be flown, must be done in a simulator, or can be done either way.
- The emphasis level, essentially the importance of the task, which enables a commander to make choices in times of reduced resources.
- The "periodicity," that is, how frequently the task must be performed.
- The points awarded for a task by PMA area, an accounting device that enables commanders to track readiness.

The matrix also specifies required ordnance and support. A commander knows which actions his crews must accomplish, how they can be accomplished, how often they must be done, and the resources required to do them. Planning training is simply a matter of comparing the missions and actions that a pilot must accomplish with those that he has done within periodicity limits, and then schedule accordingly.

HOW TRAINING IS CONDUCTED

F/A-18 squadron training has three components. One is conducted through simulator and flight operations specified in the T&R matrices that raise the training readiness levels of squadron pilots. A second facet of squadron training is the Strike Fighter Weapons and Tactics (SFWT) program (U.S. Navy, undated 1), which increases the tactical experience of squadron pilots as well as ensuring tactical standardization. The SFWT program overlays the training specified in the T&R matrices and does not drive flight hour requirements. The last component of squadron training is participation in increasingly complex exercises geared to improve readiness and interoperability at the unit, battle group, and joint task force levels.

The management of squadron training during the various phases of the deployment cycle rests in a variety of offices. The squadron commanding officer and carrier air wing commander are always directly involved in all aspects of training regardless of phase. The battle group commander is directly involved during all embarked phases of training especially during the Advanced phase and during deployment. The type commanders equip and support squadrons throughout the employment cycle; establish the T&R reporting requirements used, regardless of training or deployment phase; and allocate flying hours on a quarterly basis to the squadrons (usually through the air wing commander) throughout the employment cycle. The type wing commanders develop and maintain the Wing Training Manual (WTM) (U.S. Navy, undated 2), manage aircraft assignment and depot-level maintenance scheduling, monitor squadron training throughout the Interdeployment Training Cycle (IDTC) and deployment. Commanders of Carrier Groups One and Four are responsible for battle group training on their respective coasts during the Intermediate phase of the IDTC. The commanders of Second and Third Fleet, in addition to operational responsibility during the IDTC, are responsible for the Advanced phase of embarked training. The commander of Naval Strike and Air Warfare Center (NSAWC) is responsible for the content and standardization of all tactical training and for training conducted at NAS Fallon, Nevada.

Carrier-based squadrons follow a notional 24-month employment schedule; six months aboard a carrier, operationally deployed to the Sixth or Seventh Fleet[5] (which may include assignment or deployment to the Fifth Fleet) and an 18-month cycle of preparing and training for the next deployment. This 18-month IDTC is the time during which unit training is principally conducted.

The Navy uses a form of tiered readiness that manages resources, particularly flight hours,[6] so that training readiness peaks at deployment. Units about to deploy are accorded the highest priority for resources; the next to deploy get the next-highest priority; and the most recently returned from deployment, the lowest priority for resources. Flying hours for squadrons are based on programmed flying hours, historically measured as the numbers of hours necessary to attain 83 percent[7] of Primary Mission Readiness (PMR). The IDTC is broken into three phases—Basic, Intermediate, and Advanced—of approximately six months each.

---

[5]The Fifth, Sixth, and Seventh Fleets are under CINCCENT, CINCEUR, and CINCPAC, respectively.

[6]While the emphasis is on flight hours, the resources prioritized and allocated over the IDTC include aircraft; personnel; aircraft parts and pods; military airspace and ranges; live and training ordnance, including captive training ordnance; and adversary services .

[7]Two percent of PMR represents the simulator contribution. *Highlights of the Department of the Navy FY 2001 Budget*, Office of Budget, Department of the Navy, February 2000, pp. 2-11 to 2-12.

IDTC

Until about 1995, carriers and air wings were on an 18-month employment cycle; six months deployed to the Sixth or Seventh[8] Fleet and 12 months conducting turnaround training. During the first six months of the turnaround, the carrier was usually undergoing pier-side or shipyard maintenance, and the squadrons conducted shore-based training. The final six months before deployment was spent in a series of at-sea training periods of increasing complexity. Of the 78 days nominally scheduled for at-sea training, squadrons were embarked for 71. Flight hour funding was typically at 65 percent of PMR for the first half of the turnaround period, 95 percent for the second half, and 115 percent for the deployment (U.S. Navy, 1994).

After Desert Storm, the Navy gradually increased the nominal length of the IDTC from 12 to 18 months. Figure A.1 shows how the number of months in the IDTC increased between 1991 and approximately 1996 and has stabilized since then. The peak in the IDTC length in 1995 is attributable to squadrons making the transition from the F/A-18A to the F/A-18C.

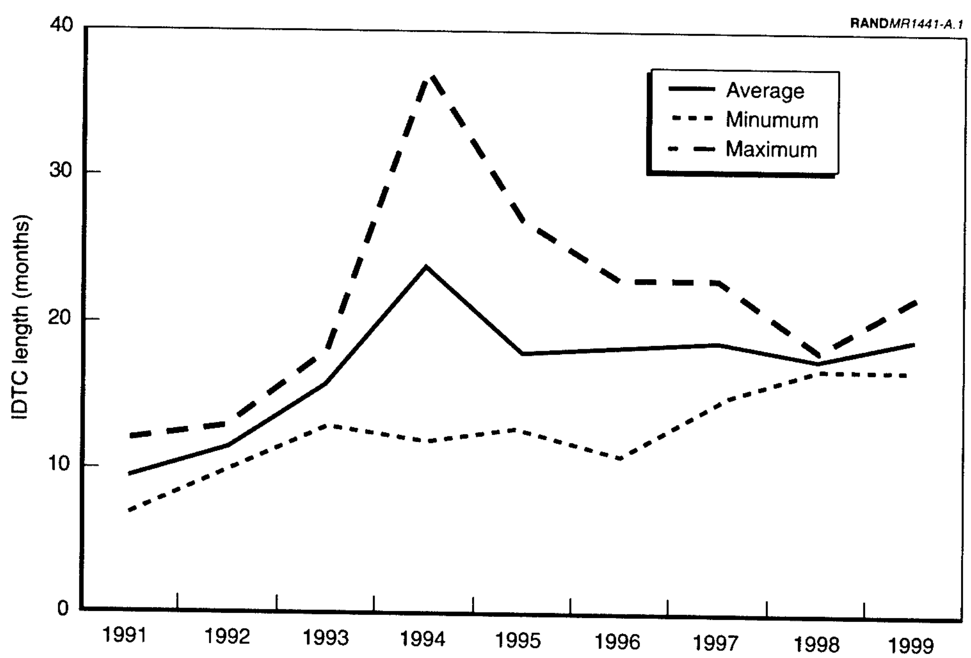

Figure A.1—Length of IDTC for F/A-18 Squadrons

---

[8]Fifth Fleet was established in 1995.

The current IDTC is nominally 18 months; the first and last months of the IDTC do not have training scheduled. The first month is used for crew turnover and leave, and the last month is used to prepare for deployment. During the middle 16 months of the IDTC, the typical F/A-18 squadron is embarked in the aircraft carrier for at-sea training periods, deployed to bases for unit and air wing training, and operating at its home base. Figure A.2 shows the major embarked and ashore training opportunities during the IDTC.

Embarked Phases of Training

Squadron unit training is tied to the carrier's schedule during the IDTC. Like the squadrons, the carrier has three phases of training—Basic, Intermediate, and Advanced. The *Basic Phase* includes any postdeployment ship repair, subsequent sea trials, and at least three Tailored Ships Training Availabilities (TSTAs), designed to bring the ship and air wing as a team to a readiness level that enables them to operate as a unit within the battle group. Throughout TSTAs I–III, the crew not only performs basic missions but also trains in fire fighting, damage control, flooding, etc. Normally TSTA I and II are scheduled back-to-back; TSTA I affords air wing pilots the opportunity to regain carrier

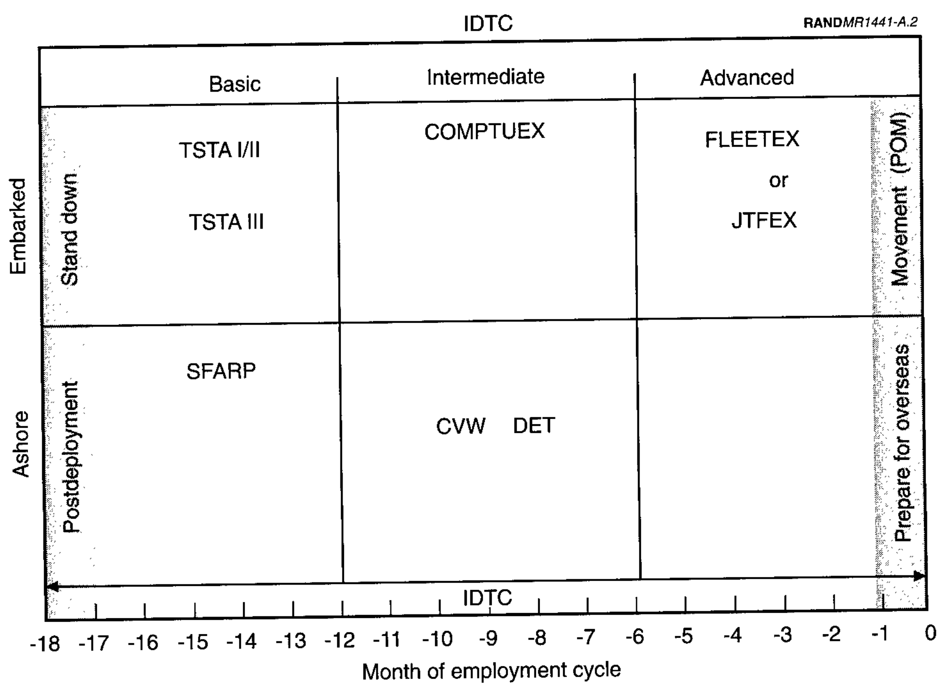

Figure A.2—Major Training Opportunities in IDTC

qualification, and TSTA II introduces cyclic flight operations. TSTA III culminates in a three-day Final Evaluation Period, during which observers from the Afloat Training Group are embarked as evaluators. Successful performance during the Final Evaluation Period leads to type commander certification to proceed to intermediate-phase training. TSTAs I–III[9] typically encompass 25 days under way, of which three are dedicated to carrier qualifications and 14 to cyclic flight operations.

The *Intermediate Phase* emphasizes multiunit or battle group training. A Composite Training Unit Exercise (COMPTUEX) of roughly three weeks is conducted under the control of Commander Carrier Group (CARGRU) One or Four—the Training CARGRUs for each coast. For F/A-18 squadrons, this embarked period affords the opportunity both to integrate with other units in the battle group while continuing to increase training readiness in all PMAs. The final three days of a COMPTUEX include a demanding final battle problem, which is normally conducted out of range of divert airfields. The Training CARGRU evaluates the final battle problem, and the battle group, if successful, is certified for operations with numbered fleet commanders, and the air wing is certified for blue-water operations.

During the *Advanced Phase*, the battle group is joined with the Amphibious Ready Group that will deploy at a similar time, and a Joint Task Force or Fleet Exercise of about three weeks' duration is conducted. While the objective is to exercise the battle group in joint or multitask force operations, the advanced phase normally affords F/A-18 squadrons the opportunity to complete live ordnance training requirements.

During the embarked portions of the IDTC, F/A-18 squadrons fly at increased rates as they progress through each of the phases—in part to exercise the aircraft carrier itself and in part to exercise the squadron in sortie generation. Additionally, the intermediate and advanced phases afford the F/A-18 squadrons the opportunity to expend live ordnance and to use target complexes not normally available at their home bases. The carrier is nominally scheduled to be at sea for 86 days during the IDTC, and the air wing is embarked for 67 days.

---

[9]TSTA IV is a seven-day at-sea period during which carrier qualifications (CQs) are conducted for Training Command and Fleet Replacement Squadron students; during TSTA IV, the air wing is not embarked. It is not unusual for the carrier to conduct two TSTA IV/CQ periods over the IDTC; TSTA IV/CQ may be conducted during any phase of the IDTC.

Ashore Phases of Training

Two major ashore training exercises occur during the IDTC—the Strike Fighter Advanced Readiness Program (SFARP) and the CVW Detachment to NAS Fallon. The ashore phase has only basic and intermediate elements.

SFARP is broken into two parts—air-to-air and strike—each roughly three weeks long. Each may be conducted at different times and at different sites.[10] SFARP is the first structured training the squadron undergoes in the IDTC. It is the first time since returning from deployment that resources are prioritized and dedicated to the squadron. Recently, squadrons have been participating in SFARP about eight months[11] after returning from deployment.

The three weeks of air-to-air and strike SFARP start with one week of lectures and two weeks of flying. Strike fighter tactics instructors (SFTIs) teach the SFARP syllabus from both the Strike Fighter Weapons Schools and the squadron.[12] Ten strike sorties and eight air-to-air sorties are flown during SFARP. F/A-18 tactics require that missions be composed of two- or four-plane formations. Rarely are missions flown as a single-aircraft sortie. All of SFARP flight sorties[13] count toward meeting T&R matrix PMA requirements. One strike and two air-to-air simulations take place during SFARP. The simulators are in addition to T&R matrix requirements and are primarily rehearsals for SFARP missions. During SFARP, the intent is to have every pilot fly every sortie. However, emphasis is on ensuring that less experienced pilots are afforded a higher priority to fly. One weapons expenditure mission is offered to three[14] squadron pilots. The primary objectives of SFARP are to initiate unit-level training in the two primary mission areas, evaluate individual pilot and squadron proficiency in strike fighter tactics, integrate the SFTIs into the squadron training organization, and ensure tactical standardization.

The CVW Detachment is a four-week program conducted for all of an air wing's squadrons at NAS Fallon by NSAWC. The first week predominantly consists of academics directed toward mission leaders. The three weeks of flying progress from unit-level tactics through air wing integration and into advanced training simulating and air warfare campaign. Training is conducted on Fallon's exten-

---

[10]East Coast squadrons routinely deploy to NAS Key West for air-to-air SFARP and to NAS Fallon for strike SFARP. Few if any East Coast target complexes provide the instrumentation desired during SFARP.

[11]F/A-18 training managers indicated that limited numbers of aircraft and aircraft parts precluded conducting SFARP training earlier in the IDTC.

[12]The squadron SFTI is a graduate of the Top Gun SFTI curricula conducted by NSAWC at Fallon.

[13]While the sorties count toward readiness for squadron pilots, SFTI sorties are overhead.

[14]Constrained by ordnance resources.

sive complex of ranges, which have the capability for digital recording and replay (for debrief purposes) of mission profiles. During our discussions with F/A-18 pilots, we consistently were told that training readiness peaked at Fallon. The air wing deployment to Fallon usually occurs during the intermediate phase of the IDTC.

Real-World Example

VFA-83 returned from deployment in USS *Dwight D. Eisenhower* in December 1998. Air-to-air SFARP was conducted in Key West October 2–14; 10 months into the IDTC. Strike SFARP was conducted at NAS Fallon from October 30 to November 6. The squadron embarked in USS *George Washington* for TSTA I/II December 1–16. The air wing deployment to Fallon took place from January 14 to February 7, 2000. TSTA III and COMPTUEX were conducted aboard USS *George Washington* February 28 to April 7; and Joint Task Force Exercise (JTFEX), in the Gulf of Mexico was May 9–22. The squadron deployed in June—18 months after returning from its last deployment.

We did not analyze why most of the major training opportunities occurred late in this particular IDTC. It would appear that prioritization of constrained resources and a desire to provide high-quality training opportunities near the deployment date create this type of situation. Figure A.3 incorporates the actual schedule of VFA-83's IDTC into the notional schedule.

HOW TRAINING IS MANAGED

Squadron training is specified in the T&R matrices contained in the F/A-18 Wing Training Manual (WTM).[15] Pilot training readiness in each PMA is attained by successfully completing training missions and training actions. Point awards track successful completion. Readiness is maintained by successfully repeating the appropriate training mission or action periodically as a function of SFWT pilot experience. A maximum score of 100 points is possible in each PMA, though the numbers of points awarded for each vary. Flying more missions than those required does not garner additional points. Pilots cannot accumulate more than 100 points in any PMA. The number of points in each PMA, the number and experience level of assigned pilots, and the number of

[15]The T&R Matrices are approved by the type commander and promulgated in the T&R manual (U.S. Navy, 2000a). The type wing commander issues the WTM (U.S. Navy, undated 2), which amplifies the basic T&R matrices.

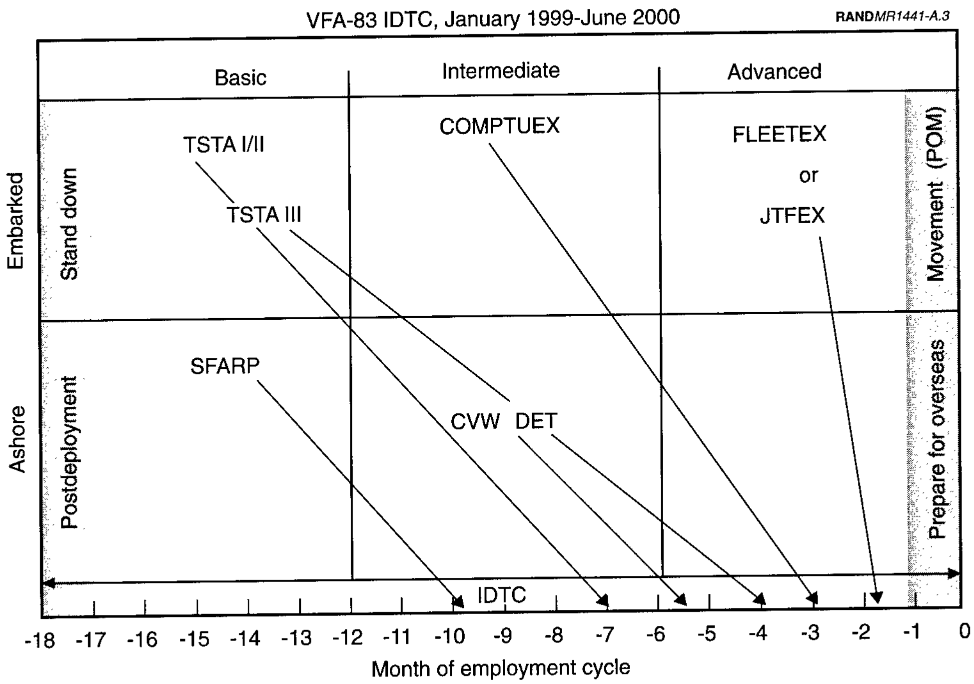

Figure A.3—Real-World Example of IDTC

on-board pilots who have expended certain weapons determine training readiness.

There are four training levels, T1 to T4, with T1 being the highest level. T&R matrices prioritize the number of pilots (as a percentage) who should be current at each T-readiness level, which, in turn, relates to phases of the IDTC. This prioritization or emphasis is designed to assist squadron commanders in determining which missions should be flown during various phases of the IDTC.

The T&R matrices list the resources required to support squadron training. Specifically, flight hours per pilot for each T-readiness level are given, as is ordnance and simulator requirements. The T&R matrices specify when training missions and actions may be flown in the aircraft or in a simulator.

Training Missions and Actions

Until 1998, training readiness was measured by counting the number of points awarded for completing events. On any given sortie, a number of events, out of the 101 required, could be flown and associated numbers of points would be credited. Some events must last a specified number of hours to count. These are said to have "event hours" associated with them. Others are task-specific and can be completed as part of other events. Event hours[16] were associated with many of the events but not all; those not having event hours were to be completed during other events. The requirements to maintain currency (repetition rate) were the same for all pilots regardless of experience. There were no standards for measuring success or failure, nor were there guidelines for partial success.

In 1998, a significant change to the way squadrons conducted unit training was promulgated in the *Type Commander Training and Readiness Manual* (U.S. Navy, 2000a).[17] Training events were separated into *missions* and *actions*. The previous training events were broken down into pilot tasks and were either grouped into logical training missions or were identified as actions that could be accomplished during certain missions. These missions and actions were tied with a PMA through the assignment of event numbers,[18] such as STW-1. Points were still used to indicate qualification and currency in the various missions and actions. Training missions have specific training objectives assigned. Only missions require flight hours,[19] and only one mission per sortie can normally be flown. The WTM establishes which actions are allowed to be flown during which missions. Not all training actions are conducted during a sortie. A few actions are significant experiences that reflect on training readiness. Three such actions are SFARP, the CVW Fallon Detachment, and the attainment of T3 status in STW (which contributes to readiness in AMW, ASUW, and MIW[20]). Some training missions and actions accumulate points in more than one PMA. Conversely, the CCC PMA has no training missions or actions. CCC PMA points are attained during missions and actions associated with other PMAs.

To qualify in any mission or action, the pilot must meet the standards prescribed in the associated Measures of Performance (MOPs) and Measures of Effectiveness (MOEs).[21] To maintain qualification, pilots must refly the event

[16]Flight hours required to complete the event.

[17]The manual was updated by the current manual, in March 2000. The update made minor changes, primarily to aircraft T&R matrices, and is an extension of the changes introduced in 1998.

[18]Event numbers are assigned to both training missions and actions.

[19]Training missions equate to a training sortie and a sortie is estimated to average 1.45 flight hours (0.80 hours of training and 0.65 of transit). A few training missions, primarily those relating to carrier landing practice and qualification, estimate flight hours on an annual instead of sortie basis.

[20]The WTM specifies that 25, 30, and 50 points will be credited toward AMW, ASUW, and MIW on attaining a T3 training readiness qualification level in STW.

[21]MOPs identify knowledge, skills, and abilities of the pilot and relate to the process. MOEs identify quantifiable mission outcomes.

within a time frame predicated on their SFWT experience level. There are four SFWT experience levels, L1–L4, reflecting progression through the SFWT program:

- from recent FRS graduate (L1),
- to qualified wingman (L2),
- to qualified section leader (L3), and
- to qualified division leader (L4).

Last, each mission has a list of "Measures of External Mission Degrade" that specifies applicable degradations beyond the control of the pilot the percentage mission and action PMA points will be reduced. This approach allows for partial completion, but full currency, when external factors preclude completing all of the mission's training objectives. The mission degrading categories include[22]

- mission requirements,
- lack of prescribed ordnance,
- range restrictions,
- reduced support asset(s),
- aircraft equipment constraints,
- performance constraints, and
- weather restrictions.

Annual Training Requirements

Table A.2 displays the annual training requirements for a squadron to be at the T1 level.

As displayed in Table A.3, to achieve the T1 level, the squadron would have at least 17 pilots on board, and those 17 would have an SFWT experience distribution as indicated. The *Type Commander Training and Readiness Manual* further specifies that for each PMA, at least 12 pilots have PMA points at the T1 level.

[22]Each of the briefing guides for training missions and actions in the WTM contains appropriate modifiers for these categories.

Table A.2

Approximate Annual PMA Training Requirements

PMA	Missions (Flight/Simulator)	Annual Sorties (Flight/ Simulator)	Annual Training Flight Hours	Annual Simulator Hours
AAW	9 (8/1)	81/17	114	17
STW	10 (8/2)	88/21	125	20
MIW	2 (1/1)	2/1	3	1
AMW	2 (2/0)	12/0	17	0
ASUW	1 (1/0)	2/0	3	0
MOB	6 (3/3)	25/12	43	9
CCC	0 (0/0)	0/0	0	0
Total	30 (23/7)	210/51	305	47

NOTE: Based on a squadron with a T1 training readiness rating and 17 pilots whose SFWT experience levels are at the minimum required for T1.

Table A.3

SFWT Pilot Experience Level Versus T-Rating Level

	L1	L2	L3	L4	Total
T1	2	5	5	5	17
T2	3	4	5	4	16
T3	3	4	4	4	15

Source: WTM.

The readiness rating system takes the experience of the pilots into account. The WTM specifies added requirements for each level, to ensure that there are pilots with specific experience. For example, at the T1 level, at least four pilots must be qualified as strike leaders, 14 qualified in night vision goggles, one graduate of mining school, at least two who have dropped a Walleye glide bomb, etc.

STW Training Missions and Actions

There are 10 STW missions: nine flight and one simulator. Of the 10 missions, seven must be flown, one must be done in a simulator, and two can be either in flight or in a simulator. Table A.4 lists STW missions in the order recommended for maintaining qualification. The number of sorties per period indicates how many times the mission can be flown for PMA points within the periodicity for the experience level of the pilot. For ease in reading, we show only L1 and L4 periodicity in the table.

As an example, the mission "High-Speed Antiradiation Missile (HARM) Training" (shaded cell in table) can be completed in either the aircraft or simulator, is

Table A.4

STW Training Missions

Event Title	Flight, Simulator, or Either	Qualification Phase (T-Level)	Sorties per Period	L1 Periodicity	L4 Periodicity	PMA Points per Mission
STW Simulator	Simulator	T4	3	62 days	120 days	1 STW 3 ASUW
Target Attack	Flight	T4	2	62 days	120 days	2 STW
Target Acquisition	Flight	T3	1	92 days	120 days	2 STW
High-Speed Antiradiation Missile (HARM) Training	Either	T3	1	92 days	120 days	2 STW 7 ASUW (6 ASUW if Sim)
Low-Altitude Tactical Training	Either	T3	1	180 days	180 days	2 STW
Four-Plane Self-Escort Strike	Flight	T2	2	31 days	62 days	6 STW 2 AAW 3 CCC
Day Four-Plane Strike	Flight	T2	1	31 days	62 days	4 STW
Two-Plane Strike	Flight	T2	2	31 days	62 days	4 STW
Night Four-Plane Strike	Flight	T2	2	62 days	92 days	4 STW
CSAR	Flight	T1	1	120 days	120 days	3 STW 2 AMW 5 CCC

Source: WTM.

normally initially undertaken as the squadron moves from T4 to T3 during the IDTC—probably during SFARP, and can only be flown semiannually regardless of the pilot's experience level. On successful completion of the mission, the pilot would receive two STW and at least six ASUW points. If the mission was flown in an aircraft, then seven ASUW points could be counted.

There are 36 training actions; 19 are STW actions. STW points can be gained for all of the STW actions and also for two AAW actions—the employment of chaff or flares for self-defense. Not all actions can be performed during any mission. The WTM specifies what actions can be completed, if needed and as appropriate, for each mission.

Table A.5 lists the STW training actions. Because actions supplement missions, the timing of their qualification is less important. STW training actions reflect the increased use of precision-guided munitions. One of the changes incorporated in the update to the 1998 T&R matrices was to double the requirement for

Table A.5

STW Training Actions

Event Title	Flight, Simulator, or Either	Qualification Phase (T-Level)	Sorties per Period	L1 Periodicity	L4 Periodicity	PMA Points per Action
Tactical Employment of Specialized Equipment						
Night Vision Device Low Level	Flight	T2	1	62 days	92 days	2 STW
Laser Spot Tracker	Either	T2	1	120 days	180 days	2 STW 2 AMW
Tactics						
Day Low-Level	Flight	T4	1	62 days	120 days	1 STW
Surface-to-Air Electronic Warfare Threat	Either	T2	1	62 days	92 days	2 STW 2 AAW 2 AMW
Coordinated Strike	Flight	T2	1	180 days	180 days	3 STW 3 AAW 10 CCC
SFARP		T2		Turn-around	Career	5 STW 8 AAW 4 AMW 4 CCC
CVW Fallon		T2		Turn-around	Career	7 STW 7 AAW 8 AMW 5 CCC
"Dumb" Weapons Tactics/Expenditure						
Paraflare Bombing	Flight	T2	1	270 days	360 days	1 STW 3 AMW
Air-to-Ground Strafe	Flight	T2	1	62 days	92 days	1 STW 4 AMW
Mk. 80 Series Weapons Expenditure	Flight	T3	1	120 days	180 days	2 STW 6 AMW 5 MIW
Rockets Expenditure	Flight	T2	1	548 days	N/A	1 STW 1 AMW
Cluster Weapons Expenditure	Flight	T2	1	548 days	N/A	2 STW

Table A.5—continued

Event Title	Flight, Simulator, or Either	Qualification Phase (T-Level)	Sorties per Period	L1 Periodicity	L4 Periodicity	PMA Points per Action
Precision Weapons Tactics/Expenditure						
Precision-Guided Munitions Expenditure	Flight	T2	1	1,095 days	1,095 days	3 STW
Laser-Guided Training Round Expenditure	Flight	T2	1	31 days	62 days	3 STW
Laser Maverick Profile	Either	T3	1	92 days	120 days	1 STW 8 ASUW
IR Maverick Profile	Either	T3	1	92 days	120 days	1 STW 8 ASUW
Walleye Profile	Either	T2	1	92 days	120 days	2 STW
Standoff Land-Attack Missile (SLAM/SLAM ER) Profile	Either	T2	1	180 days	180 days	2 STW
Laser-Guided Bomb Expenditure	Flight	T2	1	365 days	N/A	3 STW

SOURCE: WTM.

laser-guided training rounds for L1/L2 pilots. Completion of SFARP and the CVW Detachment Fallon adds PMA points in four PMAs. During SFARP and the Fallon Detachment, the squadron flies at a higher-than-normal rate and completes training missions and actions. The syllabi during both SFARP and the Fallon Detachment are built on the training missions and actions in the T&R matrices.

Again using the HARM mission as an example, authorized actions that gain STW points on this particular mission include:

- chaff expenditure (AAW action),
- flares expenditure (AAW action),
- day low-level navigation,
- surface-to-air electronic warfare threat, and
- coordinated strike.

Some training actions that gain points in categories other than the PMA can be conducted on a mission. For example, on the HARM mission, the pilot might be refueled or might conduct the mission in an electronic emission controlled environment—both of which are MOB actions.

MOPs and MOEs

MOPs and MOEs are established for each training action and mission and in conjunction with the training objectives, and measures of mission degradation are used (by the flight leader) to assess the success of the event. In our discussions with F/A-18 training managers, the relatively new MOPs and MOEs are being used more to brief and debrief the particular training event than to asses whether (or how many) PMA points should be counted. When the MOPs and MOEs are aggregated by PMA, the criterion for performance in each PMA is outlined. Said another way, the MOPs and MOEs define the PMA capabilities the squadron training aims to achieve.

Tables A.6 and A.7 list every MOP and MOE for every STW training mission and action. The MOPs and MOEs are aggregated under broad skill categories—

Table A.6

Measures of Performance for All STW Missions and Actions

Measure of Performance	Missions	Actions
Navigation		
Adherence to 50% rule, 10-degree rule, and MCTs	1	0
Situational Awareness		0
Formation in target area	6	0
Formation in recovery area	1	2
Mutual support	2	0
Sanitization of area of responsibility	2	0
Management of on-board sensors	1	0
Surface-to-air and air-to-air threat survival	1	0
Effective defensive maneuvering in low-altitude environment	1	0
Communications conducive to situational awareness	2	0
Timely threat recognition/evaluation	0	1
Timely defensive maneuvers	0	1
As per mission module	0	10
Target Acquisition-Detection		
First-pass weapons expenditure	5	1
First-pass acquisition of briefed targets	1	0
Weapons release an timeline or detection	1	0
Weapon Delivery		
Valid weapons release parameters	8	1
Simulated weapons release parameters	1	0
Valid shot percentage	1	0
Employ gun within briefed parameters	0	1
Two SLAM-delivery profiles in weapon aircraft or pod control aircraft	0	1
Rules of Engagement		
No training rule violations	1	0

NOTE: The MOP "As per mission module" indicates that the training action is to be integrated into the training mission seamlessly.

Navigation, Situational Awareness, Target Acquisition and Detection, Weapon Delivery, and Rules of Engagement. MOPs and MOEs are listed in no particular order. The numbers of times the specific MOP or MOE is applied to a mission or action is aggregated in the right two columns.

Several MOPs occur frequently, including formation in the target area, first-pass weapon expenditure, and valid weapons release parameters.

Table A.7

Measures of Effectiveness for All STW Missions and Actions

Measure of Effectiveness	Missions	Actions
Navigation		
Briefed TOT +/–15 seconds	5	0
Accurate navigation and route timing	0	2
Ability to maneuver in low-altitude tactical regime	1	0
Situational Awareness		
Zero blue losses	1	0
Zero blue losses to surface (ground) threat	4	0
Effectively target/influence/neutralize all airborne or ground enemy forces	2	0
Kill ratio 4:1	1	0
Mission accomplishment	1	0
Mission accomplishment, i.e., successful rescue of survivor	1	0
As per mission module[a]	0	4
As determined by EW operator (objective observer)	0	1
Target Acquisition-Detection		
Bomb impact within +15/–45 seconds of briefed TOT	1	0
Weapon Delivery		
Freefall ordnance—CEP within 10 mils for Dash 1/3, 15 mils for Dash 2/4[b]	4	0
Precision ordnance—CEP within 2 mils	4	0
BIA (if applicable)	5	0
BIA (simulated)	1	5
Freefall ordnance—CEP within 7 mils	1	0
Precision ordnance—CEP within 2 mils	1	0
Perform Low-Altitude Tactical Training maneuvers as briefed	1	0
Valid shot versus surface-to-air threat	1	0
Deliveries within 5 degrees of preplanned dive angle	1	0
10% of rounds on target	0	1
Fuzed ordnance on target	0	3
Fuzed ordnance on target	0	1
Rules of Engagement		
No violations of prebriefed minimum altitudes	1	0

[a]The MOE "As per mission module" indicates that the particular training action was to be conducted so as not to disrupt the training mission.

[b]CEP (circular error probable) within 10 mils is an accuracy measurement pertaining to the delivery of ordnance with respect to the aim point. In practice, this is reported as feet from the target.

Several MOEs also have a high incidence: briefed TOT +/–15 seconds, zero blue losses to ground threat, ordnance accuracies for freefall and precision ordnance, and BIA (Battle Impact Assessment). These MOPS and MOEs define the capabilities and standards of an F/A-18 squadron and could potentially be used by senior operational commanders and planners.

HOW TRAINING IS RESOURCED

F/A-18 Squadron Flight Hours

The T&R matrices include resource summaries that show the flight hours required to attain the various T-levels. Included in these summaries are the various "overhead" factors, which add to the total flight time required to complete mission training. In these calculations, an average F/A-18 sortie lasts about 1.75 hours,[23] representing 0.80 hours of mission time and 0.65 hours of transit time. Overhead times include weather and maintenance aborts, performance failures and scheduling conflicts, transit time, and functional check flights. Table A.8 displays flight hour information for the various T-levels and for individual pilots as well as for the squadron as a whole.

The T&R matrix flight hours represent a planning factor and establish a requirement. Programmed flight hours have historically been based on Primary Mission Readiness (PMR), and budgeted flight hours have represented 83 percent of PMR. Again, historically PMR for F/A-18 pilots has been 25 hours per month.

Figures A.4 and A.5 display the historical execution of flight hours by F/A-18 squadrons. With the exception of 1996, F/A-18 squadrons, in the aggregate, flew fewer than the budgeted flight hours.

Table A.8

T&R Matrix Flight Hour Profiles

Flight Hours Per Month	T4	T3	T2	T1	100%
Training Mission Hours per Pilot	14.9	18.3	21.6	25.4	27.7
Total Hours per Pilot	17.6	21.5	25.2	29.6	31.2
Squadron Mission Hours	253.0	311.0	367.0	432.0	471.0
Squadron Total Hours	299.0	366.0	428.0	503.0	547.0

NOTE: Derived from the WTM. T&R matrices use 17 pilots for a squadron in these calculations.

[23]In the 1995 and 1998 T&R matrices, the sortie duration was 1.40 hours.

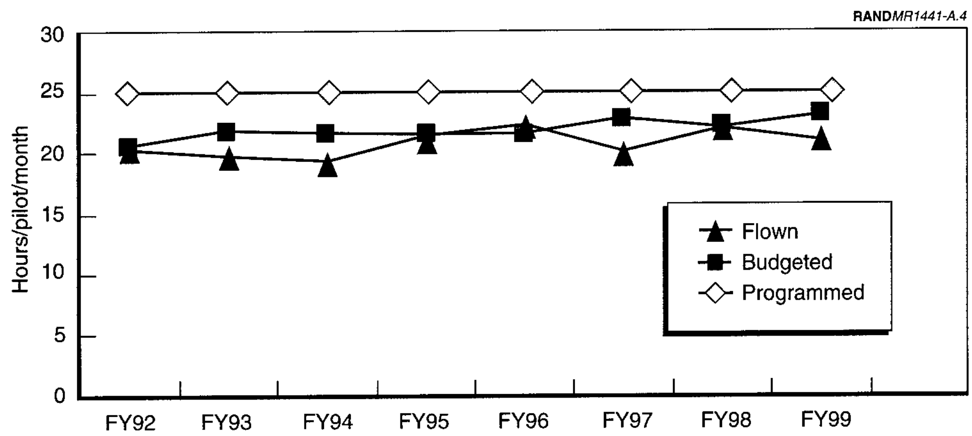

Figure A.4—Flight Hours Performance Versus PMR Hours

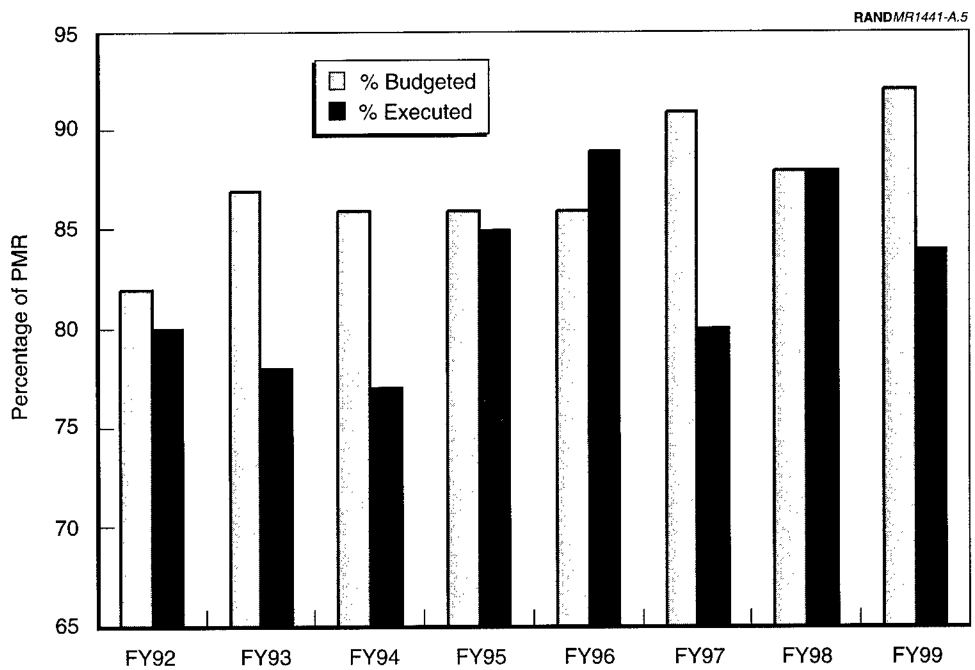

Figure A.5—Historical Budgeted and Executed Flight Hour Performance

At the individual squadron level, flight hours are allocated consistent with the Navy's tiered (or phased) readiness training philosophy across the employment cycle. Squadrons on deployment are allocated flight hours in excess of PMR. Squadrons newly returned from deployment receive flight hours well below

PMR. As the squadrons progress through the IDTC, flight hour allocations increase consistent with the intent to peak readiness at deployment. This is not a building block approach whereby the squadron completes one level of training and moves to a different area. Rather, the building blocks are accretive. As the squadron attempts to attain the next training level, it continues to expend flight hours maintaining currency and the existing level.

Figure A.6 depicts the flight hour allocation scheme for the employment cycle.

This allocation scheme reflects in the historical performance as displayed in Figure A.7. The dips during the first and last month of deployment reflect the time the carrier transits to and from deployment. Strike flight hour performance is also displayed in Figure A.7 to show what portion of total flight hours is flown during each month of the cycle. STW flight hours progress consistent with total flight hours over the IDTC, peaking during the final months before deployment. However, during deployment, though total flight hours peak dramatically, STW flying falls to lower levels than during the IDTC. In part, this is a reflection of the lack of training ranges and opportunities while deployed. Also, the strike flight hours reflect only hours for STW training; squadrons may well be flying operational strike missions that are not depicted.

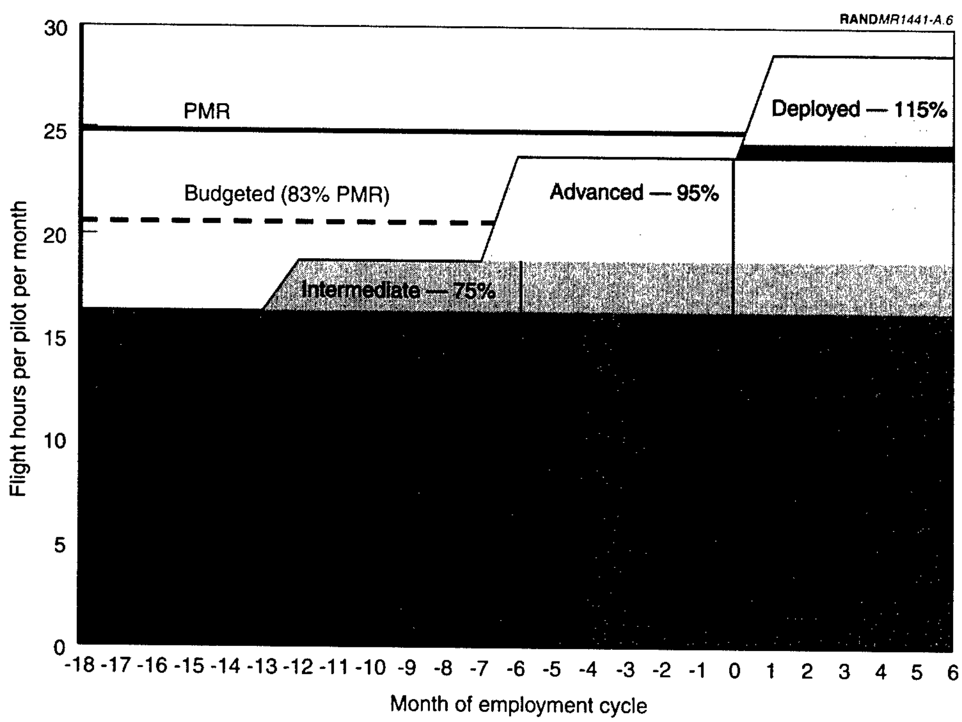

Figure A.6—Flight Hour Allocation and Employment Cycle

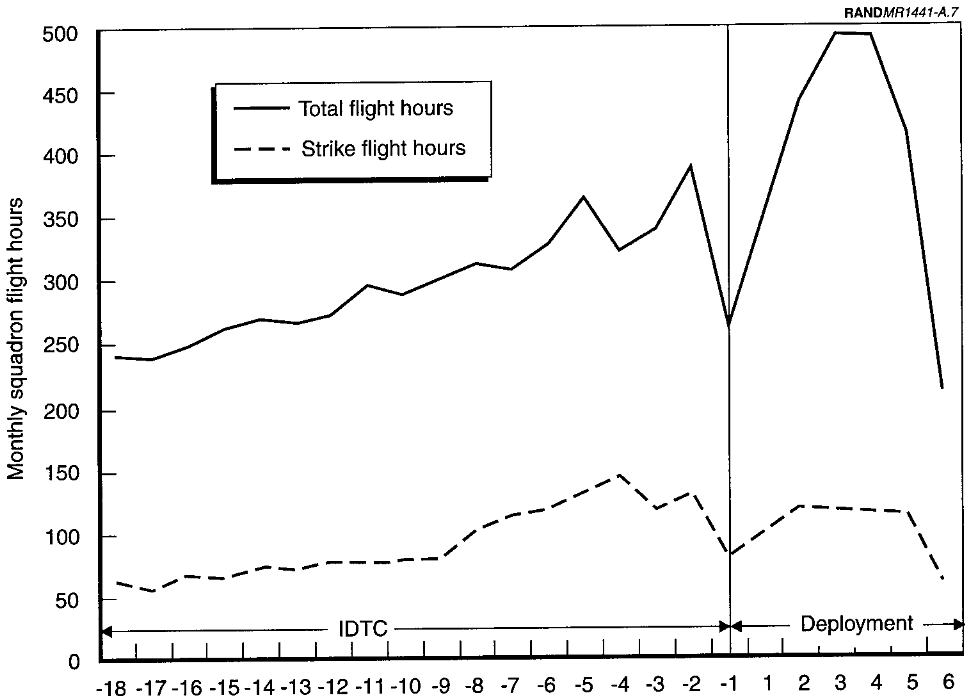

Figure A.7—Historical Flight Hour and STW Flight Hour Performance and the Employment Cycle

The trends for total squadron flight hours and STW flight hours are displayed in Figure A.8. On average, squadrons have been flying more during the years since Desert Storm, but STW flight hours have been trending downward.

This downward trend in STW flight hours is better depicted as a percentage of total flight hours in Figure A.9.

This downward trend in STW hours does not imply a decreased emphasis in STW training requirements. Table A.9 shows how the two previous T&R matrices (1995 and 1998) altered the flight hours and mix of training across the seven PMAs.

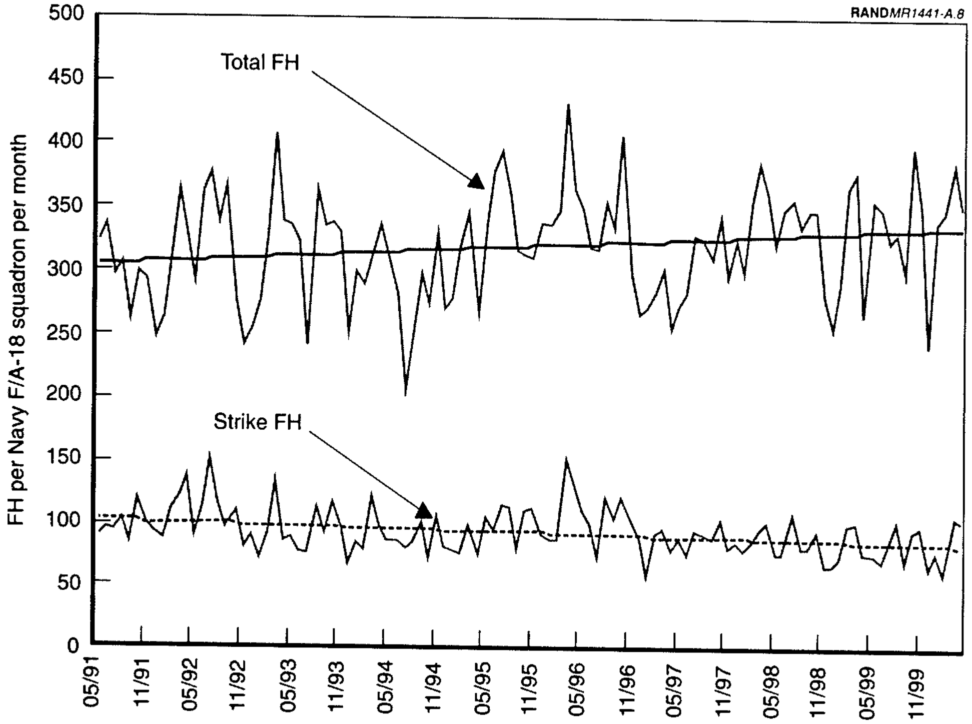

Figure A.8—Average Squadron Flight Hours and STW Trends

Table A.9

F/A-18 T&R Matrix Comparison, 1995–2000

	1995	1998	2000
	Hours per Month per Pilot		
Total Flight Hours	32.1	29.1	32.5
Training Event (Flight) Hours	30.6	25.1	27.7
Simulator Hours	0.8	4.1	4.1
	Percentage of Flight Hours Allocated to PMA		
MOB	14	13	13
STW	38	36	41
AAW	40	44	39
AMW	1	5	5
ASUW	6	1	1
MIW	1	1	1
CCC	0	0	0

NOTE: Based on attaining 100 percent training readiness in each PMA for an L-1 pilot.

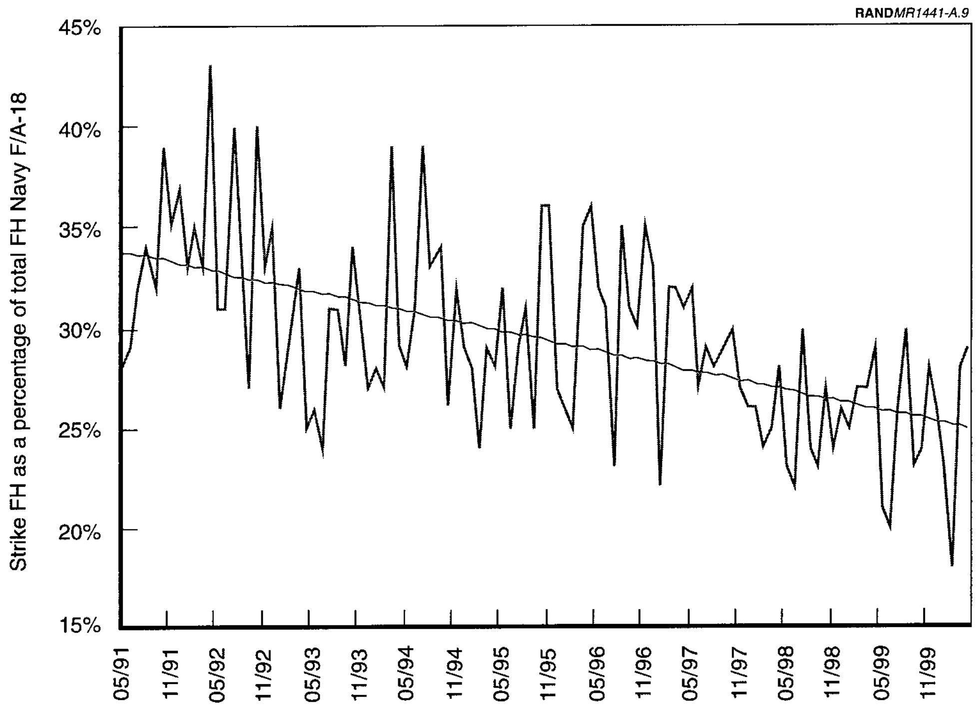

Figure A.9—STW Flight Hours as a Percentage of Total Flight Hours

The slight decrease in STW emphasis in the 1998 T&R matrices may have influenced the downward trend displayed in Figure A.9. Other contributing factors might include decreasing quality and accessibility of ranges, especially on the East Coast; limited training ordnance resources; and the aforementioned lack of training ranges and opportunities during deployment.

F/A-18 Pilot Flight Hours

The number of pilots assigned and the pilots' experience level affect the numbers of flight hours the squadron needs to fly. F/A-18 squadrons are generally manned to at least 16 pilots for deployment. The T&R matrices require 17 pilots to attain an overall T1 readiness level. As depicted in Figure A.10, the number of pilots assigned to squadrons has increased steadily. We were repeatedly told that though the situation is improving,[24] most squadrons have new pilots who

[24]The Navy has addressed the issue of the time it takes to train new pilots for fleet squadrons in the Naval Aviation Production Process Improvement program.

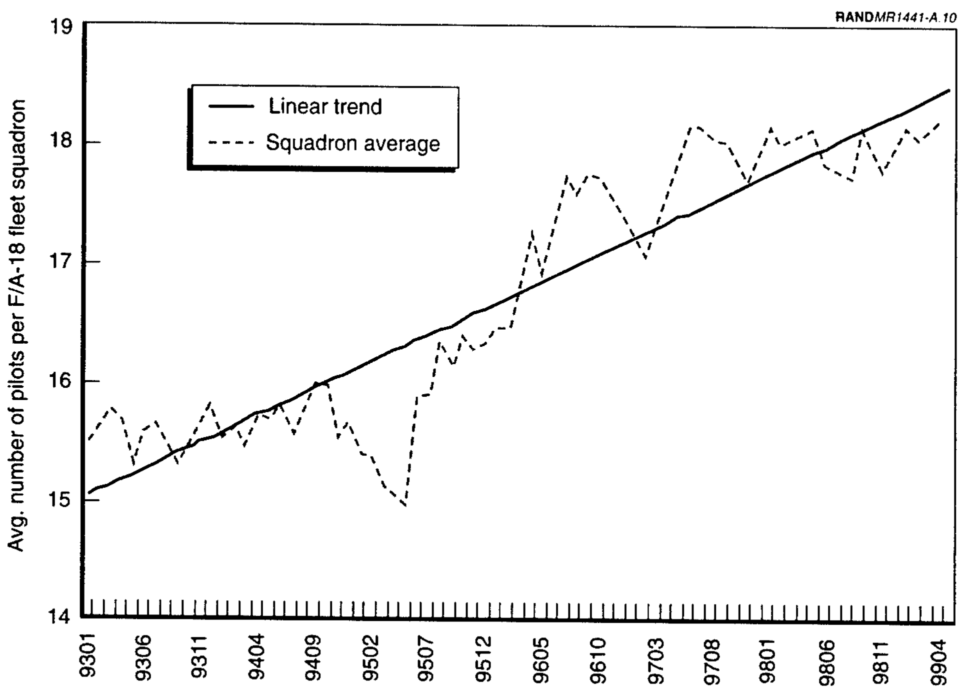

Figure A.10—Average Number of Pilots Assigned to F/A-18 Squadrons

report late in the IDTC and miss the opportunity to participate in SFARP and, less frequently, the CVW Fallon Detachment.

One of the most significant changes introduced in the 1998 T&R manual was incorporation of the SFWT into the T&R matrices. The various experience levels (L1–L4) have varying flight hour requirements to attain and maintain T-levels of readiness. L1/2 pilots require more flight hours at each T-level than do L3/4 pilots. For example, an L1/2 pilot requires approximately 10 STW hours monthly at the T1 level and an L3/4 pilot requires approximately six hours per month. F/A-18 tactics require two or more aircraft formations for most sorties. Thus for most missions flown by an inexperienced pilot, an experienced pilot is also required independent of the experienced pilot's need to meet a PMA training requirement. Given that all squadrons have a mix of inexperienced and experienced pilots, those squadrons having a more experienced mix require marginally fewer flight hours.

The experience level of F/A-18 squadron pilots, as measured in terms of years of service, has also increased. Figure A.11 displays this gradual trend.

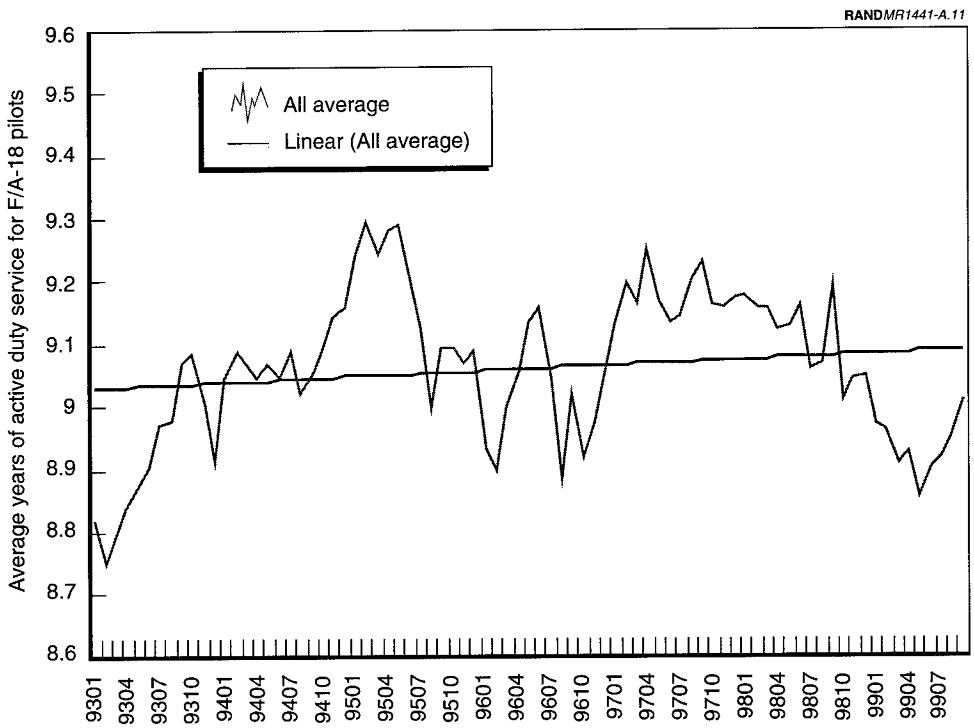

Figure A.11—F/A-18 Fleet Squadron Pilot Experience

As the average number of pilots per squadron has increased to approximately 18 and as the experience of pilots has also trended upward, flight hours per pilot have decreased, as depicted in Figure A.12. Strike flight hours per pilot also decreased.

As pilot manning and experience improved and as the number of squadron flight hours increased, the rates of increase in flight hours did not keep pace with the increases in pilots, and a downward trend in individual pilot flight hours ensued.

F/A-18 Simulators and Squadron Training[25]

The T&R matrices require approximately four simulator hours per month per L1/L2 pilot at almost all T-levels; L3/4 pilots require approximately two hours

[25]Most of the configuration, utilization, and cost data used in this section were provided by the Naval Aviation Training and Manpower Office (N789).

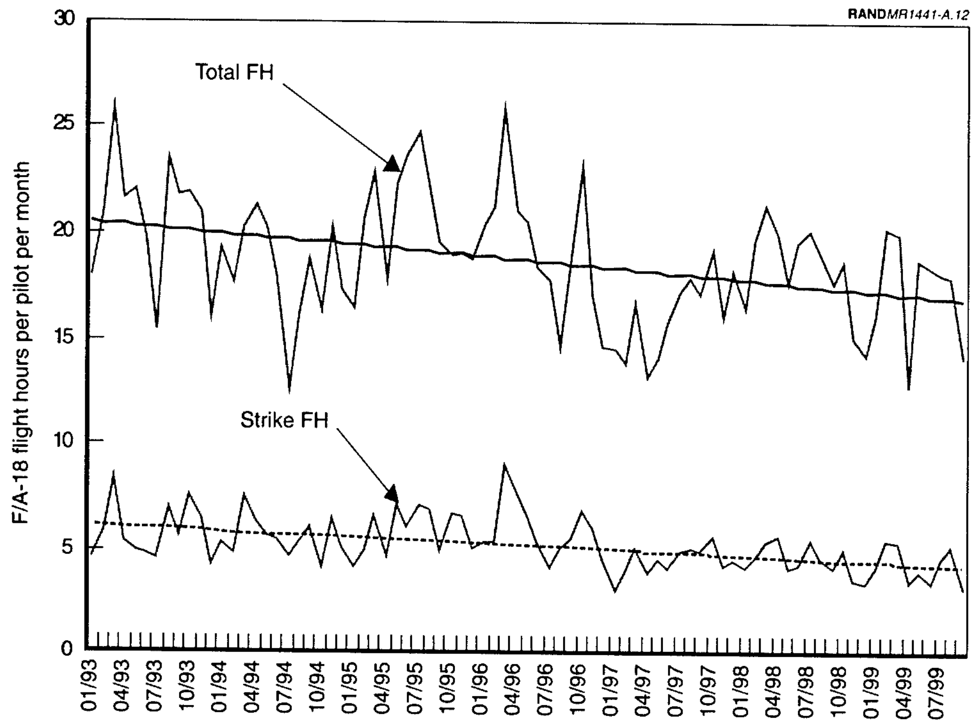

Figure A.12—Monthly Flight Hours per F/A-18 Fleet Squadron Pilot

per month at the T4 level and three hours at the T1 level. When simulators are not available, the T&R manual allows squadron commanding officers to substitute flight missions/actions. Thus while some flights cannot be simulated, there are no simulation events that cannot be flown. Given that no simulators are available to forward-deployed or carrier-embarked squadrons, such a policy is needed.

There are four F/A-18 simulator models, three of which are currently used by Navy fleet F/A-18 squadron pilots. The simulators range in capability and cost from the Partial Task Trainer (PTT), to the relatively sophisticated Operational Flight Trainer (OFT), to the ultrasophisticated, full-motion, and full-visuals Weapons Tactics Trainer (WTT). NAS Oceana and NAS Lemoore each have one PTT, two OFTs, and two WTTs. The two Navy squadrons at MCAS Beaufort have one PTT and one WTT. The Navy squadrons stationed in Japan have no simulators. Only the WTT and OFT are specified in the F/A-18 T&R matrices.

The PTT is used to familiarize new pilots with the operation of specific systems. The PTT does not simulate the flight characteristics of the aircraft, and it costs $2 million to $3 million.

The OFT can accommodate one pilot at a time, was designed to familiarize pilots in the flight characteristics of the aircraft, and also has a carrier landing simulation capability. The OFT costs $8 million to $15 million.

Each WTT has two full cockpits (one in each "dome") and uses actual aircraft components to provide realism. This simulator is considered state-of-the-art and was designed to provide a full range of the tactical capabilities of the aircraft to the pilot. The simulator is programmed with the Operational Flight Program (OFP) used in the aircraft. However, the most recent OFP updates have not been implemented, especially at NAS Oceana.[26] The acquisition cost of the WTT simulator is in the $30 million to $50 million range.

Reserve squadrons currently use a fourth F/A-18 simulator, the Tactical Operational Flight Trainer (TOFT). Essentially, it is a blend of the OFT and WTT and provides all of the normal and emergency procedures capability of the OFT with the additional capability to provide tactical training. The TOFT appears to be the simulator of the future[27] both for F/A-18C/D and F/A-18E/F. The cost for the TOFTs in use by the Naval Reserve was $4.2 million.

Table A.10 lists the various simulators used by Fleet F/A-18 pilots along with their current configuration (OFP). The F/A-18 has been in service for almost 20 years. Numerous production lots of aircraft have been delivered, and numerous upgrades to the computer software—the OFP—that affects virtually every

Table A.10

Location and Configuration of F/A-18 Simulators

Air Station	Simulator	Cockpit #1 OFP	Cockpit #2 OFP
NAS Lemoore	WTT 1	OFP 13C	OFP 11C
	WTT 4	(F/A-18F mod)	OFP 91C
	OFT 1	OFP 92A	N/A
	OFT 3	OFP 11C	N/A
NAS Oceana	WTT 3	OFP 11C	OFP11C
	WTT 5	OFP 91C	OFP 91C
	OFT 2	OFP 11C	N/A
	OFT 5	OFP 10A	N/A
MCAS Beaufort	WTT 7	OFP 11C	OFP 13C
	OFT 4	OFP 92A	N/A

[26]The move of simulators not only interrupted the use of simulators but also precluded updates in a timely manner. The current cost of updating the WTTs to current/future OFP configuration was estimated to us on several occasions to be more than $24 million.

[27]See http://pma265.navair.navy.mil/crew/fs/trainers/trainers.html.

aspect of flight and tactical employment[28] have been incorporated. The current OFP is OFP 13C, and OFP 15C is on the verge of being incorporated[29] into the aircraft. OFP 13C is the most recent OFP configured in any of the simulators used by Navy F/A-18 pilots.

The FRS controls the scheduling and has priority for using the simulators. Fleet squadrons have to schedule simulator time around the needs of the FRS. Annually, approximately 15,000 hours of F/A-18 simulator time are available. Figure A.13 shows the percentage utilization of F/A-18 simulators by the FRS and fleet squadrons. FRSs use 50–60 percent of the available time; fleet squadrons use roughly 15–22 percent; and the simulators are also unused approximately 15–22 percent of total available time. The overall decrease of use in FY 1999 is attributable to the move of the simulators from NAS Cecil Field, Florida, to Oceana.

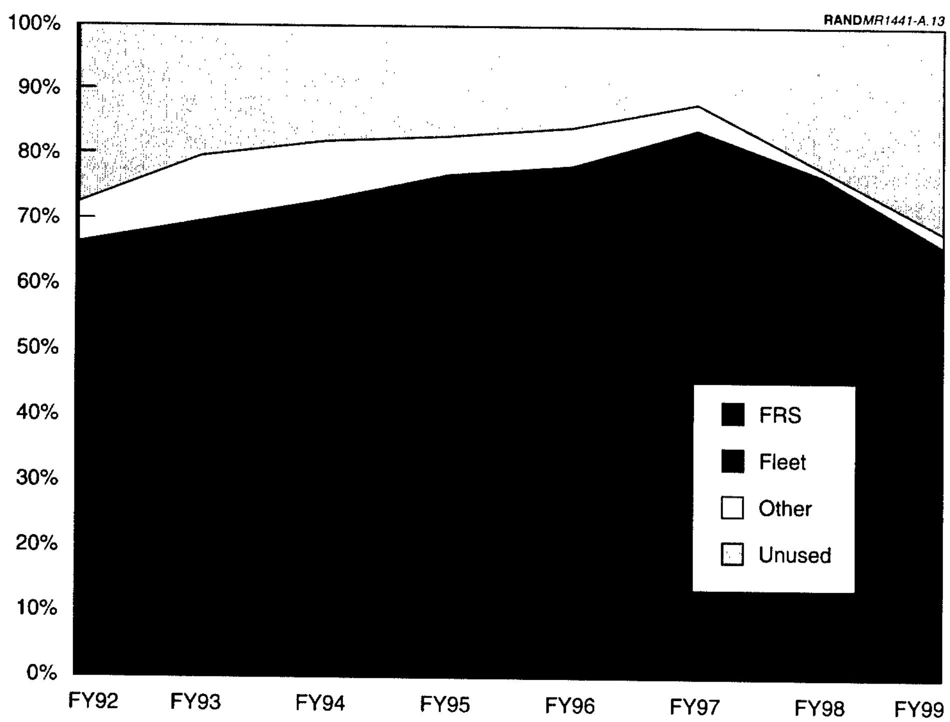

Figure A.13—F/A-18 Simulator Usage

[28]For example, OFP 13C integrates the capabilities to employ the latest weapons—SLAM/SLAM ER, JSOW, and JDAM.

[29]OFP 17C is on the horizon and simulator managers are concerned about the costs of upgrading current WTTs to these configurations.

We encountered complaints about the simulators. Fleet pilots cited the configuration of Oceana's WTTs in particular as a major drawback to using them. Although OFP 13C is available in the WTTs at both Lemoore and Beaufort, Oceana's most current OFP is OFP 11C. Oceana F/A-18 pilots consistently remarked on the unsuitability of the WTTs to support their tactical training.

The second most often heard dissatisfaction with simulators concerned availability and the timing of the availability. With the FRS using more than half of the available time, fleet pilots felt they were frequently given the less desirable times. The combination of being scheduled at less-desirable times in the day and the feeling that their day was already filled with flying and squadron duties made for a less-than-positive impression about simulator training.

CONCLUSION

F/A-18 squadron training is focused on attaining and maintaining PMA qualifications and currency so as to have sufficient PMA points to attain desired T-ratings. Overlaying the missions/actions comprising the training requirements is the Strike Fighter Weapons and Tactics program, which ensures tactical standardization and provides a structured program to increase the tactical experience levels of F/A-18 pilots. The SFWT program includes a significant number of evaluation flights during SFARP.

Table A.11 shows all of the PMA points a squadron can attain by flight or simulation missions and actions. STW and AAW, the two dominant warfighting PMAs, which take the most flight hour resources, can reach the T1 level (90 and 86 points, respectively) without conducting any simulator events. The MOB

Table A.11

PMA Points by Training Event and Media

	PMA Points			
Primary Mission Area	Flight Missions	Simulator Missions	Flight Actions	Simulator Actions
AAW	41	6	45	8
STW	43	5	47	5
MIW	28	18	50	4
AMW	37	0	59	4
ASUW	20	13	51	16
MOB	50	30	20	0
CCC	45	20	35	0
Percentage of Total PMA Points	38	13	44	5

NOTE: A pilot could attain a maximum of 700 total PMA points (100 points for each of the seven PMAs).

PMA, conversely, uses the OFT simulator for 30 percent of its maximum. There are not that many MOB training events, and the simulator is used for Naval Aviation Training Operations (NATOPS) and instrument check flights and for carrier landing rehearsal, relatively unsophisticated missions. Despite the sophistication of the WTT simulator, it has not yet fulfilled its promise to enhance tactical training.

In addition to the poor fidelity of (in particular) the WTT, there is the question of simulator versus pilot availability. While attention is being paid to whether the simulator's available time is utilized, fleet pilots expressed the concern that making the simulator more available to them was of greater importance.

Although more pilots with greater experience are reporting to F/A-18 squadrons, there is still a time lag between the time the squadron commences the significant portion of the IDTC (specifically, SFARP) and the arrival of all new pilots. Performance during all phases of the IDTC and during deployment depends on previous training opportunities. Pilots who miss SFARP require more attention during the Fallon Detachment. New pilots who miss Fallon (and SFARP) are essentially poorly trained at deployment.

Pilots reporting late in the IDTC might be considered a form of late or inadequate resourcing. When aircraft undergo extensive maintenance upgrades and then are not returned for fleet use on time, a problem similar to training readiness crops up. The flight hours lost because an aircraft was not available cannot readily be made up later in the cycle. The opportunity to fly the full SFARP or Fallon syllabus requires the right number of aircraft in a Fully Mission Capable (FMC) status.

The Navy's tiered/phased readiness philosophy delays resourcing because the next deployer needs the resources more. But we continually were told about problems that indicated resource shortfalls. IDTC training is being hindered because insufficient numbers of FMC aircraft; insufficient numbers of pods; limited suitable ranges, especially on the East Coast; and limited quantities of training ordnance, especially "smart" weapons. To successfully accomplish F/A-18 squadron training, a diversity of resources, in balance, and provided at the right time is required.

Appendix B

U.S. MARINE CORPS F/A-18 UNIT TRAINING

The U.S. Marine Corps flies F/A-18s, so it makes a good comparison candidate. This appendix briefly describes the training philosophy, shows how the Marine Aircraft Wings (MAWs) are organized, and discusses the planning, management, conduct, and resourcing of the training.

TRAINING PHILOSOPHY

Most Marine Corps squadrons have a 30-month cycle involving a six-month deployment[1] followed by a 24-month turnaround. USMC squadrons employed on aircraft carriers follow the same 24-month cycle (six months of deployment followed by an 18-month IDTC) as U.S. Navy squadrons. Marine Corps F/A-18 squadrons do not use a tiered readiness or "bathtub" approach to unit readiness that the Navy follows. Marine Corps squadrons strive to maintain high readiness levels at all times, usually C-2 or higher.

HOW MARINE F/A-18 SQUADRONS ARE ORGANIZED AND BASED

Marine aviation is organized into three active-duty MAWs and one Reserve MAW. MAWs are designed to support of Marine Air-Ground Task Force (MAGTF) deployments or other operations.

Each MAW has a unique organizational structure. Figure B.1 shows a notional structure of a MAW. When the MAW deploys as the aviation combat element (ACE) for a Marine Expeditionary Force (MEF), the MAW headquarters functions as the ACE's command element. Marine Air Groups (MAGs), task-organized based on the assigned mission, are subordinate to the MAW. Typically, all F/A-18 units in the MAW will be grouped in a single fixed-wing MAG (MAG

[1]The Marine Corps manages deployments under the Unit Deployment Program (UDP).

[VF/VA]). The primary mission of the MAG (VF/VA) is to provide AAW and offensive air support for the task force.

The Marine Corps considers aviation an integral part of the MAGTF. The ACE is a versatile part of the MAGTF's combined-arms team, complementing the MAGTF's ground combat element and combat service support element. The ACE's primary contribution is the ability to conduct the deep fight. The ACE is not a formal command. It is a task-organized Marine aviation force under a single commander within a MAGTF. An ACE usually consists of an aviation unit headquarters and various aviation wings, squadrons, or their detachments.

The tasks of Marine aviation fall into six functional areas: offensive air support, AAW assault support, air reconnaissance, electronic warfare, and control of aircraft and missiles. Marines employ the F/A-18A/C/D models in Marine fighter/attack squadrons (VMFAs) and the F/A-18D in Marine fighter/attack (all weather) squadrons (VMFA[AW]s). Table B.1 shows the six tasks of Marine aviation that VMFA and VMFA(AW) aircraft fulfill.

There are 12 VMFA squadrons and six VMFA(AW) squadrons, each with 12 aircraft and 18 crews assigned. There is one Marine F/A-18 training squadron

RANDMR1441-B.1

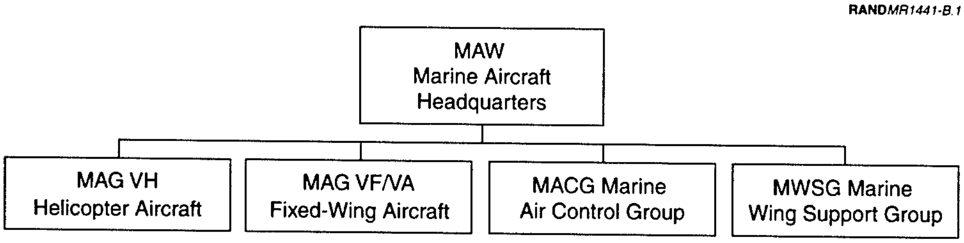

Figure B.1—Notional MAW

Table B.1

Marine F/A-18 Aviation Mission Allocation

	Offensive Air	AAW	Assault Support	Recon	Electronic Warfare	Control of Aircraft and Missiles
VMFA F-18A/C	x	x	Escort	x	Support	Support
VMFA(AW) F-18D	x	x	Escort	x	Support	FAC(A)/ TAC(A)

NOTE: x indicates primary mission.

(VMFAT)[2] with 12 F/A-18A/C and 17 F/A-18D aircraft assigned. All VMFA(AW) squadrons fly the two-seat F/A-18D model aircraft. Six active-duty squadrons fly the single-seat F/A-18C. Two active-duty and four Reserve squadrons fly the single-seat F/A-18A aircraft.[3] USMC F/A-18 squadrons are based as shown in Table B.2. Four VMFA squadrons are designated to deploy with U.S. Navy carrier air wings. The carrier air wing deploying USMC F/A-18 squadrons are VMFA-251 and VMFA-312 on the Atlantic coast and VMFA-314 and VMFA-323 on the Pacific coast.

HOW TRAINING IS PLANNED

Missions

A VMFA is tasked with intercepting and destroying enemy aircraft under all weather conditions and attacking and destroying surface targets. VMFA tasks include the following:

Table B.2

Marine F/A-18 Squadron Locations

		MAW Components		
MAW	HQ	MAG	MACG[a]	MWSG[b]
1st	Camp Butler, Japan	MAG-12, Iwakuni, Japan MAG-36, Futenma, Japan	MACG-18, Futenma, Japan	MWSG-17, Camp Butler, Japan
2nd	Cherry Point, N.C.	MAG-14, Cherry Point, N.C. MAG-26, New River, N.C. MAG-29, New River, N.C. MAG-31 Beaufort, S.C	MACG-28, Cherry Point, N.C.	MWSG-27, Cherry Point, N.C.
3rd	Miramar, Calif.	MAG-11, Miramar, Calif., MAG-13, Yuma, Ariz. MAG-16, Miramar, Calif. MAG-39 Camp Pendelton, Calif.	MACG-38, Miramar, Calif.	MWSG-37, Miramar, Calif.
4th	New Orleans, La.	MAG-46, Miramar, Calif. MAG-41, Fort Worth, Tex. MAG-42, Marietta, Ga. MAG-49, Willow Grove, Pa.	MACG-48, Fort Sheridan, Ill., and Great Lakes, Ill.	MWSG-47, Selfridge ANGB, Mount Clemens, Mich.

[a]MACG = Marine Air Control Group.

[b]MWSG = Marine Wing Support Group.

[2]The Marine Corps training squadron performs the same functions as the Navy's FRS.

[3]USMC squadrons fly 21 different lots of F/A-18 aircraft. Aircraft lots are not generally mixed within a single squadron.

- Intercepting and destroying enemy aircraft.
- Maintaining the capability to attack and destroy surface targets.
- Escorting friendly aircraft under all weather conditions.
- Maintaining the capability to deploy and operate from aircraft carriers and advance bases.
- Conducting day and night CAS under all types of weather.
- Maintaining the capability to deploy or conduct extended-range operations using aerial refueling.
- Maintain the capability to conduct Suppression of Enemy Air Defenses (SEAD) operations.

A VMFA(AW) is tasked with attacking and destroying surface targets under adverse weather conditions during both day and night operations, conducting multisensor imagery reconnaissance, providing supporting arms coordination, and intercepting and destroying enemy aircraft under all weather conditions. VMFA(AW) tasks include the following:

- Conducting day and night CAS under adverse weather conditions.
- Conducting day and night deep air support (DAS) under all weather conditions, including armed reconnaissance, radar search and attack, air interdiction, and strikes against enemy installations.
- Conducting multisensor imagery reconnaissance, including prestrike and poststrike visual reconnaissance and damage assessment.
- Conducting day and night supporting arms coordination, including forward air control airborne (FAC[A]), tactical air control airborne (TAC[A]), and artillery and/or naval gunfire spotting.
- Intercepting and destroying enemy aircraft.
- Maintaining the capability to operate from aircraft carriers, advance bases, and expeditionary airfields.
- Maintaining the capability to deploy or conduct extended-range operations using aerial refueling.
- Maintaining the capability to conduct SEAD operations.

To stay proficient in these tasks, aircrews must train in the following core skills:

- Air to Air
- Air to Surface

- Surface Specific Weapons Delivery (SSWD)
- Aerial Specific Weapons Delivery (ASWD)
- Low-Altitude Tactics (LAT)
- Night Systems
- Aerial Refueling
- Field Carrier Landing Practice/Expeditionary Qualifications (FCLP/EQ)
- DAS
- CAS
- FAC(A)
- TAC(A).

Unit Training

The Marine Corps Aviation Campaign Plan (MACP) details the overall Marine aviation operations and training strategy. The Marine Corps adopted a sortie-based training program over the past few years that centers on the combat readiness of the unit rather than individual readiness or a flying hour goal. A minimum goal of 12–15 sorties per aircrew per month is selected to maintain aviator currency and proficiency. The objective of the MACP is to train using shorter sortie lengths, thereby preserving limited assets, such as airframe life.

The campaign plan categorizes training requirements as "core" and "core plus." "Core" competencies are defined as those capabilities and skills that are realistically expected to be assigned in combat. "Core-plus" competencies and skills are defined as those that are high risk but low probability of execution or are theater/contingency-specific and are not needed by all individuals. The Marine Corps believes that training only a limited number of aircrews in core-plus skills provides acceptable training readiness based on the likelihood of employing the core-plus skills in assigned combat missions. Resources are assigned to such missions accordingly, with core missions receiving the most emphasis. Such a prioritization of training should help ensure more-efficient use of limited resources, in line with expected threats.

The purpose of the Marine Aviation T&R program is to provide standardized programs of instruction.[4] The goal is to develop unit war-fighting capabilities,

[4]Marine aviation training is governed by a series of T&R manuals. USMC (1999a) provides the foundation for all aviation training and USMC (1999b) provides more detailed guidance for Marine F/A-18 training.

not to measure the proficiency of individuals. Syllabi are based on specific performance standards designed to ensure proficiency in core competencies. Individual core skills support the achievement of a unit's core capabilities. Core and core-plus skills are related to Mission Essential Task Lists (METLs).[5]

HOW TRAINING IS CONDUCTED

The Marine Corps combat readiness cycle is a building block approach to training based on core competencies. The combat readiness cycle progresses from individual T&R syllabus core skills training to a unit's potential participation in a contingency or actual combat. The combat readiness cycle demonstrates the relationship of core competencies to unit combat readiness. Individual core skills training leads to unit proficiency and the ability to accomplish the unit's stated mission.

Unit training programs emphasize squadron qualifications and the overall combat readiness of the unit, facilitated by a standardized unit training progression model that depicts the logical progression of qualifications. Training involves four tiers. Crews progress from combat capable (when they leave the FRS) to combat ready to combat qualified. The last step in the progression is fully combat qualified, which involves the attainment of core-plus skills. Unit training programs are based on multitiered combat training phases for individual members.[6]

Tier One: Combat Capable Phase

The first tier (combat capable phase or 100 series events) concentrates on basic skills and is conducted in the training squadron (VMFAT). It includes day and night familiarization, instrument flights, formation flights, and initial exposure to core competencies. On completion of Tier One training, individuals have achieved 60 percent Combat Readiness Percentage (CRP) and are assigned to tactical units.

Tier Two: Combat Ready Phase

Second-tier (combat ready phase or 200 series events) training raises the skill level of aircrew and introduces them to all of their core competencies, developing proficiency in core skills. The second tier contains those skills and qualifi-

[5]The relationship between METL, core, and core-plus skills for VMFA and VMFA(AW) squadrons is shown on pages A-6 and A-8 of T&R Volume I (USMC, 1999a).

[6]Figure 3.1 on pp. 3-9 and 3-10 of T&R Volume II (USMC, 1999b) depicts the nominal core progression models for VMFA and VMFA(AW) crews.

cations normally obtainable within the first year of assignment to an aviation unit. Units normally train aircrews through this phase prior to overseas assignment. Each completed event increases CRP by 0.30 to 1.00. On completion of the combat ready phase, an individual is at 75 percent CRP. With successful completion of the second tier, unit personnel move to the combat qualifications phase. Table B.3 lists the F/A-18A/C/D flying hour and simulator requirements for Tier Two training.

Tier Three: Combat Qualification Phase

Tier Three (combat qualification phase or 300 series events) training includes advanced training in core competencies. The third tier training is focused on fairly experienced personnel and is designed to move individuals from proficiency to flight leadership, supervisory control, and field leadership positions. These skills reflect a shorter refly interval based on the perishability of the skill attained and their significance and relative impact on unit combat readiness. Each completed event increases CRP by 0.50 to 1.00. On completion of this phase, individuals are at 95 percent CRP. With successful completion of the combat qualification phase, unit personnel concentrate on full-combat qualifications. Table B.4 shows the F/A-18C flight and simulator requirements for Tier Three training.

Tier Four: Full Combat Qualification Phase

Tier Four (full-combat qualification phase or 400 series events) training focuses on a unit's most-experienced personnel, those capable of leading/directing flights of numerous aircraft in a complex wartime scenario. This tier contains mission commander qualifications. Full combat qualification training is reserved for large-scale, integrated missions; events having unique mission tasks; or those events having a low probability of execution in combat and containing relatively high risk, yet warrant maintaining a limited number of individuals trained in their execution. On completion, an individual will be at 100 percent CRP. Table B.5 shows the F/A-18C flight and simulator requirements for Tier Four training.

Three major training events take place during a squadron's turnaround cycle: a combined arms exercise (CAX), an air-to-air training detachment, and an air-to-ground training detachment. The combined arms exercise is conducted at Marine Corps Base Twentynine Palms, California, for squadrons from both coasts. This training exercise is somewhat similar to Navy air wing integrated predeployment training conducted at NAS Fallon, Nevada, and provides substantial experience dropping high-explosive ordnance. The air-to-air detach-

Table B.3

F/A-18A/C/D Tier Two Training Requirements

Core Skill	Number of Flights	Flying Hours	Simulator Periods	Simulator Hours
NAV	2	2.8	0	0.0
Aerial Refueling	2	3.0	0	0.0
FLCP/EQ	2	2.0	2	2.0
EW	1	1.5	1	1.0
LAT	2	2.0	1	1.0
Air to Air	14	15.5	1	1.0
ASUW	6	9.0	0	0.0
CAS	2	3.0	0	0.0
DAS	2	3.0	0	0.0
Total	33	41.8	5	5.0

Table B.4

F/A-18C Tier Three Training Requirements

Core Skill	Number of Flights	Flying Hours	Simulator Periods	Simulator Hours
LAT	2	2.0	0	0.0
Air to Air	12	15.6	1	1.0
ASUW	4	6.0	1	1.0
CAS	2	3.0	0	0.0
DAS	3	4.5	0	0.0
ASWD	3	3.5	1	1.0
SSWD	6/7	9/10.5	4	4.0
Night Systems	8	10.4	2	2.0
Total	40/41	54.0/55.5	9	9.0

Table B.5

F/A-18C Tier Four Training Requirements

Core Skill	Number of Flights	Flying Hours	Simulator Periods	Simulator Hours
Air to Air	2	2.6	0	0.0
Combat Qualification	2	3.0	0	0.0
SSWD	2/5	3.0/7.5	4	4.0
DAS	6	9.0	0	0.0
Total	12/15	17.6/22.1	4	4.0

ment focuses on air-to-air tactics and weapons training and is frequently accomplished at NAS Key West or as part of a U.S. Air Force Red Flag or Green Flag exercise. Air to air typically lasts two to three weeks. The air-to-ground training detachment is ideally completed prior to the CAX but may also be completed in conjunction with the CAX. It typically lasts two to three weeks and is usually completed on the West Coast for all squadrons because of greater range availability in the western continental United States. The air-to-ground detachment is not considered as critical for USMC squadrons deploying with Navy carrier air wings because of the extensive air-to-ground training conducted at NAS Fallon during integrated air wing predeployment training.

HOW TRAINING IS MANAGED

Initial qualification and annual requalification flight requirements for each training phase are shown in Table B.6. The increased combat capability and mission flexibility of newer, more-advanced models of the F/A-18 appear to require additional flight hours for both initial qualification and currency training required to maintain proficiency and readiness.

Table B.7 shows the minimum required number of qualified crews for a squadron to be considered "core competent." If a squadron has less than 100 percent of its required crews on board, these minimum numbers are scaled by the percentage of crews on board.

Table B.8 shows the number of sorties required to attain and maintain qualification in each mission area. Various training events are evaluated to determine whether an aircrew has mastered the skills for a particular training stage. Evaluations are typically completed in three circumstances: the first time an event is completed, when a crew returning to the fleet in refresher or transition training, or when the event is coded as an evaluated event (E-coded event). Certified instructors, flight leaders, or landing safety officers, as dictated in the T&R Manual Volume II, conduct evaluations. Evaluations are performed using T&R Mission Performance Standards (MPSs) for each T&R event. MPSs serve as training standards or guidelines for evaluation to determine satisfactory event completion.

Table B.6

Training Requirements for F/A-18A/C/D

		F-18A		F-18C		F-18D	
Stage	CRP Earned	Sorties	Hours	Sorties	Hours	Sorties	Hours
Combat Ready	15	33	41.8	33	41.8	33	41.8
Combat Qualified	20	32	43.6	41	55.5	51	70.5
Full Combat Qualified	5	10	14.6	15	22.,1	10	14.6
Total	40	75	100.0	89	119.4	94	126.9

Table B.7

Squadron Crew Requirements to Attain Core Competency

Core Skill	VMFA F-18A	VMFA F-18C	VMFA (AW) F-18D
Air to Air	12	12	12
ASUW	12	12	12
SSWD	8	8	8
ASWD	8	8	8
LAT	12	12	12
Night Systems	12[a]	12	12
Aerial Refueling	12	12	12
FCLP/EQ	12	12	12
DAS	12	12	12
CAS	12	12	12
FAC(A)			6
TAC(A)			2

[a]When NVD compatible.

Table B.8

Sorties Needed to Attain and Maintain PMA Qualifications

	VMFA				VMFA(AW)	
	F-18A		F-18C		F-18D	
Core skill	Attain	Maintain[a]	Attain	Maintain[a]	Attain	Maintain[a]
Air to Air	26	18	26	18	26	18
ASUW	10	7	10	7	10	7
SSWD	6	3	7	4	7	4
ASWD	3	N/A	3	N/A	3	N/A
LAT	4	1	4	1	4	1
CAS	4	4	4	4	4	4
Night Systems	0	N/A	4[b]/8	N/A	8	N/A
Aerial Refueling	2	1	2	1	2	1
FCLP/EQ	2	N/A	2	N/A	2	N/A
DAS	5	4	5	4	5	4
CACC					10	2
Total	662	38	67[b]/71	39	81	41

[a]On a semiannual basis.

[b]Sorties required for F/A-18C night systems modified aircraft.

The Marine Aviation Weapons and Tactics Squadron ONE (MAWTS-1) located at MCAS Yuma, Arizona, manages the Marine Corps Aviation Weapons and Tactics Training Program, conducts semiannual weapons and tactics instructor (WTI) courses, and provides supplementary courses of instruction. The six-week WTI course is the core curriculum of MAWTS-1. WTI is considered a graduate-level course of instruction and includes both academics and flight instruction following a building block approach to certify officers as WTIs. WTI instruction focuses on the integrated employment of tactical assets. WTIs return to Marine squadrons to serve as instructor pilots and to assist in implementing the squadron commander's training plan. WTIs are usually kept in a squadron for at least one year after WTI designation. MAWTS-1 also develops academic training lectures for use by squadron training officers. MAWTS-1 frequently employs air-to-air academic lectures from the Navy's Top Gun School.

MAWTS-1 also offers three courses via mobile training teams of MAWTS-1 instructors. Two mobile training courses are designed to augment predeployment training: the Marine Expeditionary Unit (MEU) ACE training course and the MAGTF Integration Course. The Marine Division Tactics Course was developed for F/A-18 aircrews who are unable to attend Navy Fighter Weapons School as a prerequisite to the WTI Course.

Squadrons must meet certain minimum standards and levels of proficiency to enable mission completion in some critical areas. Marine F/A-18 squadrons must maintain proficiency in carrier landing qualifications, fixed-wing expeditionary airfield/forward site operations, and missile or precision-guided munitions (PGMs) firing. F/A-18 squadrons maintain both day and night shipboard landing qualifications. When carrier decks are not available, these units maintain ship skills with field carrier landing practice. Squadrons qualify for fixed-wing expeditionary airfield operations on an available expeditionary airfield/forward site or on a runway configured for expeditionary airfield/forward site operations. Aircrews participating in live-fire exercises must demonstrate proficiency in the employment of their weapon systems. Subject to the availability of missiles, PGMs, drones, and targets, all aircrews should fire at least one of each applicable missile/PGM during a three-year period.

Skill Retention and Proficiency

Aircrews must repeat specific events and stages of training to ensure skill retention. Refly factors listed in the T&R Manual Volume II are expressed in months. Personnel retain proficiency through "chaining" or repetition of events before the end of the refly factor expiration month. Should a pilot become delinquent in a given event, it will not be updated through chaining and the associated CRP will be subtracted from the individual's total CRP. There is no requirement to repeat every event in a syllabus to maintain proficiency. Syllabi are structured such that lower-stage events "chain" to higher-stage events. This structuring allows for the completion of more-complex or advanced events using the same skills to "update" proficiency in the prerequisite events. Established refly factors ensure proficiency in those skills. Units may reduce the time between reflight of events (reduced refly factors) based on an individual's learning curve, retention capabilities, tactical currency, or local policies.

Syllabus Training Exceptions

The completion of a specific number of flights or training periods may not necessarily qualify an individual in a particular area of training. Commanders evaluate the performance and previous experience of personnel to make an accurate appraisal of the individual's proficiency and to identify his training requirements. Commanding officers may waive portions of an experienced and qualified trainee's flight and training requirements. To ensure a unit does not waive complete stages of training, the trainee is required to fly or complete the last event or check flight/evaluated event in each stage. Syllabus events or stages are not waived simply because the command lacks logistic support or training assets.

Schoolhouse/Ground Training Policies

Each unit conducts specific ground training for technical and tactical subjects that complement the respective training syllabus. Crewmembers complete supplemental courses of instruction prior to event training as outlined in the T&R syllabi. Units instruct ground courses in technical subjects, tactical subjects, instrument flight and navigation procedures, safety, NATOPS, and intelligence and air control procedures. Four to five hours of academic training are conducted weekly. This training is in addition to more formal schoolhouse courses, such as those taught by MAWTS-1.

Relationships Between Training Events and Readiness

Unit proficiency is evaluated through the Marine Corps Combat Readiness Evaluation System (MCCRES) (USMC, 1999c). T&R syllabus events relate to the Mission Performance Standards (MPS) of the MCCRES and are evaluated according to the MCCRES standards. METLs serve as the foundation for the development of the MCCRES program by facilitating development of MPS and tasks each Marine aviation unit is expected to accomplish. One vehicle to measure readiness is a unit's MCCRES evaluation—a snapshot of a unit's combat readiness.

Squadrons typically complete a MCCRES in conjunction with their CAX or during their air-to-air or air-to-ground detachments. External WTIs from the Marine Corps group or MAWTS-1 conduct the squadrons' MCCRES evaluation.

Individual readiness of aviation personnel is measured by combat readiness percentage. Individual readiness is reported via the Naval Flight Record Subsystem (NAVFLIRS). NAVFLIRS also provides the flight data necessary to update the Automated Training and Readiness Information Management System (ATRIMS), a special-purpose information management tool used to automate tracking of aircrews executing T&R syllabi. The average combat readiness percentage of the on-hand personnel is not considered an adequate or accurate measure of a unit's overall readiness. The preferred measure for description of a unit's combat readiness is the number of "combat ready" crews available compared to the aircrews assigned. The percentage of combat ready aircrew determines the combat readiness status level.

Unit commanders report the status of readiness and training per the current edition of the Marine Corps Status of Resources and Training System (SORTS) Manual. No connection exists between MCCRES and SORTS.

Training Management and Tracking Tools and Databases

ATRIMS is a special-purpose training management tool to automate the management of T&R syllabi. ATRIMS allows aircrew training activity recording, reporting, analysis, and requirements projection. Commands collect data for ATRIMS via NAVFLIRS and Naval Aviation Logistic Command Information System (NALCOMIS), which record aviation activity involving utilization of aircraft and aircrews. Operations personnel create the ATRIMS database from daily flight/flight training actions completed at the squadron level and recorded on a NAVFLIRS yellow sheet or in the NALCOMIS database.

Training Assets Limitations

Carrier-based Marine Corps squadrons are tied to an aircraft carrier deck cycle. This deck cycle limits the amount of time available to conduct training at tactical airspeeds because fuel consumption must be limited to meet deck cycle times. A shortage of adversary aircraft affects all air-to-air training. The East Coast squadrons have limited facilities available for training and frequently conduct major training events on the West Coast. West Coast squadrons have recently experienced ordnance shortages.

RESOURCING TRAINING

Personnel Assignment and Rotation

The goal is to stabilize USMC squadron manning six to 12 months before deployment. Enlisted and officer manning shortages make it difficult to freeze squadron manning. Therefore, carrier-based F/A-18C squadrons receive the highest-priority manning. It would be preferable to conduct all three major training events after manning is stabilized. However, all three usually cannot be conducted at the end of predeployment training because of operations tempo constraints.

Marine aviators, pilots, and naval flight officers learn basic undergraduate flight skills in Navy undergraduate flight training squadrons. These squadrons use instructors from the Navy, Marine Corps, Coast Guard, and Air Force. A Marine requirement exists for assigning all newly designated naval aviators and naval flight officers to an operational squadron for a minimum of two years after attaining combat capable status—i.e., after completion of the FRS syllabus. Squadrons do not assign aviators outside the squadron unless it is a requirement to complete the combat ready syllabus. The Marine Corps is now experiencing a shortage of midgrade O-3 and junior-grade O-4 F/A-18 pilots stemming from lower-than-desired initial retention. (This is also true for the Navy.) The addition of more newly trained pilots will make up for these shortfalls.

Flight Hour Trends[7]

Figure B.2 shows the programmed, budgeted, and actual flying hours per crew per month over the last several years. Programmed values have stayed fairly constant at approximately 25 hours per crew per month. The budgeted flying hours are, by policy, approximately 83 percent of the programmed values. Where Marine Corps F/A-18 crews actually flew slightly more than the budgeted value in FY 1993 to FY 1995, their flying has been below or equal to the budgeted value over the last few years.

The aggregate values in Figure B.3 mask variations among the different F/A-18 squadrons, especially in the actual hours flown during the IDTC and deployments. Figure B.4 shows the total and strike related flying hours per squadron per month over the last decade. The variability of the monthly averages around the linear trend lines is apparent in the figure. The squadron-level data suggest the monthly flying hours have slightly decreased over the last decade while the strike portion of those flying hours has increased. Figure B.3 shows more clearly the increasing strike portion of the total monthly squadron flying hours. Over the last 10 years, strike-related flying has increased from less than 20 percent of the total to almost 30 percent.

[7]Information Spectrum, Inc., provided the flying hour data in Figure B.2 and the simulator data in Figure B.8. Those data were collected from OP-20 reports and used by OPNAV (N885) in the development of their Fleet Aircrew Simulator Training (FAST) plan. The Center for Naval Analyses (CNA) provided the flight hour data in Figures B.3 through B.7. Those data were collected from the AV3M data system.

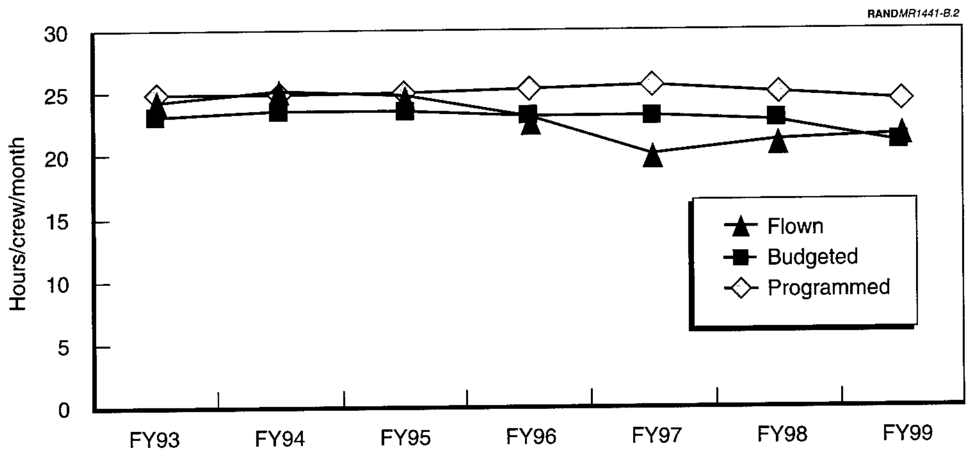

Figure B.2—Programmed, Budgeted, and Actual Flying Hours: USMC F/A-18 Crew per Month

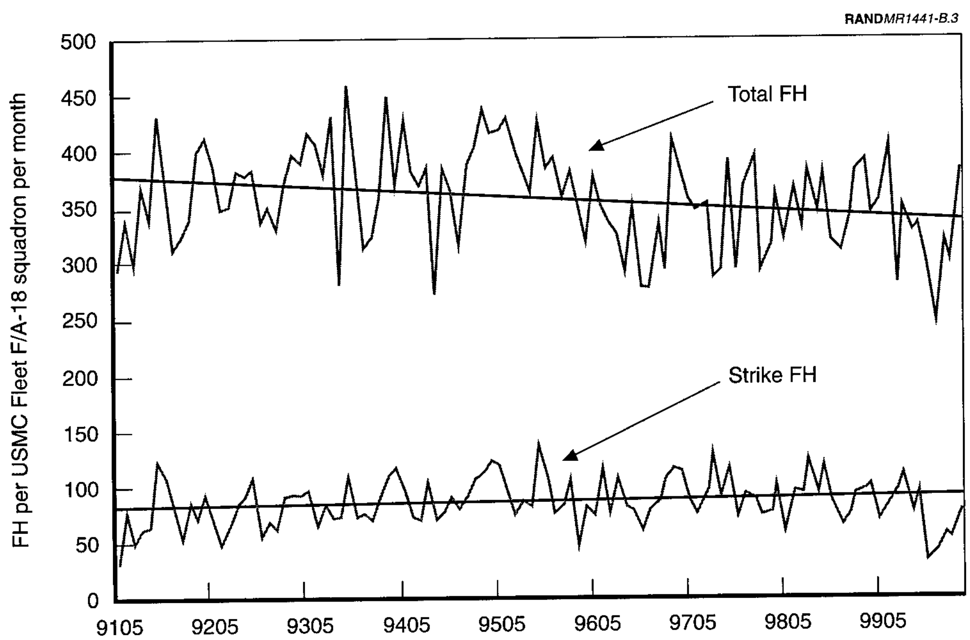

Figure B.3—Total and Strike Flying Hours: USMC F/A-18 Squadron per Month

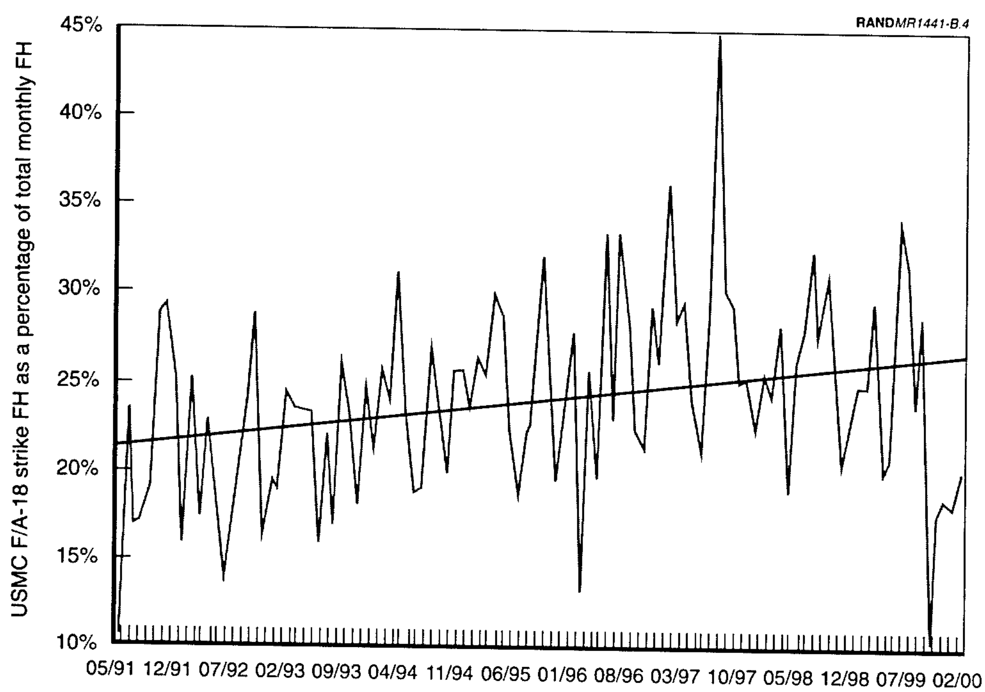

Figure B.4—Strike Flight Hours as a Percentage of Total Monthly Flight Hours

Figure B.5 shows the total and strike-related flying hour pattern over the IDTC/turnaround and deployment cycle for the Marine Corps F/A-18 squadrons that deploy on aircraft carriers as compared to the Navy F/A-18 squadrons. The Marine Corps squadrons fly slightly more hours during their turnaround cycle compared with the Navy squadrons. The buildup in flying hours for the Navy squadrons reflects the Navy's training philosophy and readiness improvement during the IDTC. The relatively constant flying hours for the carrier-deployed Marine Corps squadrons during their turnaround reflects the USMC goal of more consistent readiness level.

Figure B.6 shows the average number of pilots in Marine Corps F/A-18 squadrons and their average years of experience over the last several years. While the average number of pilots in the squadrons has stayed relatively constant, the experience levels increased in the mid-1990s and then decreased.

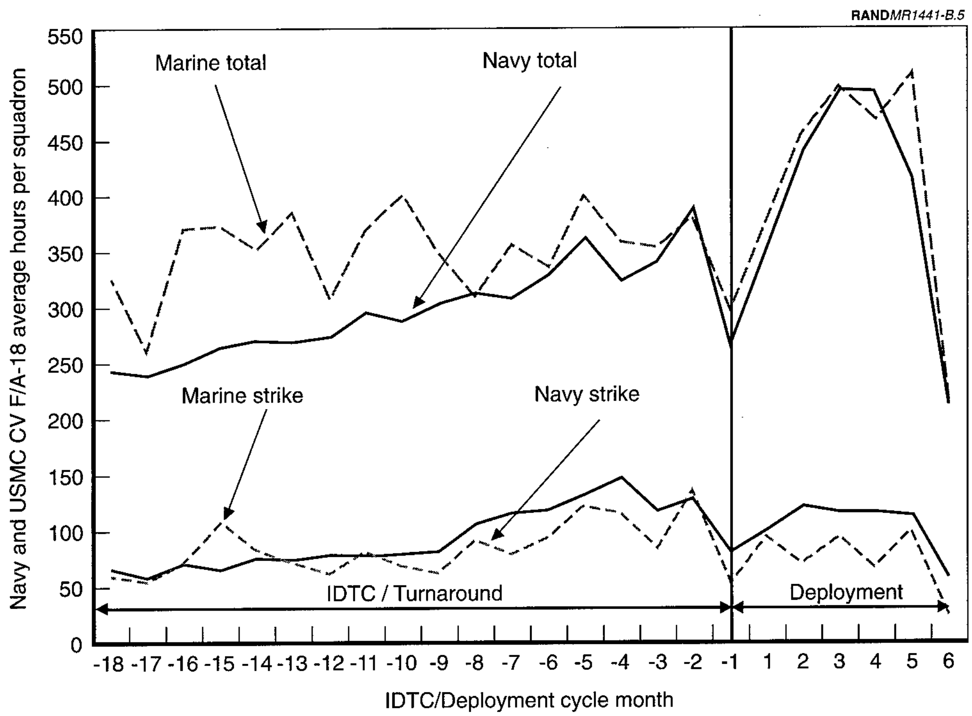

Figure B.5—Flying Hour Patterns for USMC and Navy F/A-18 Squadrons

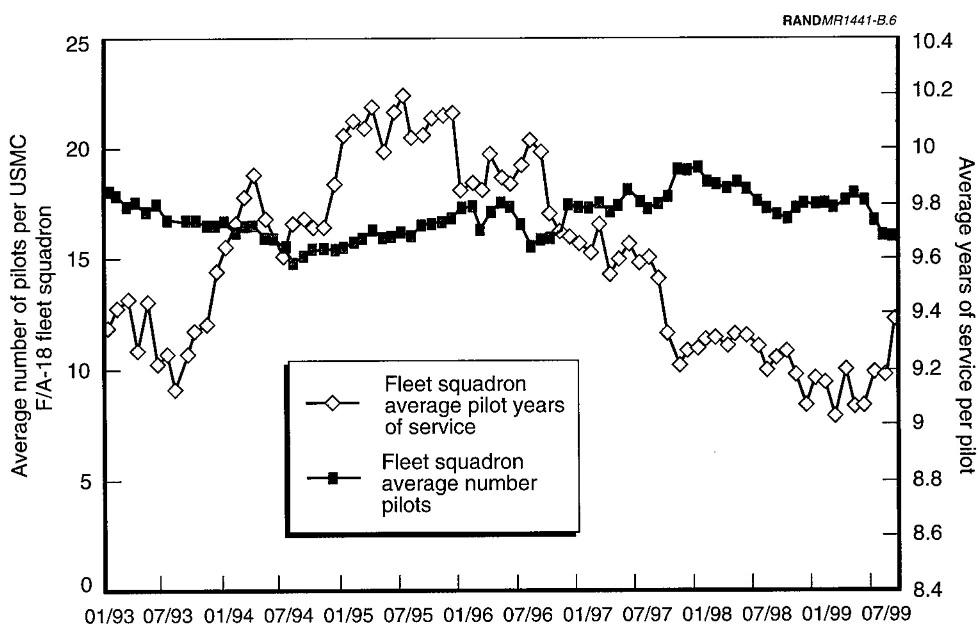

Figure B.6—Number of Pilots and Years of Experience for USMC F/A-18 Squadrons

Combining the average number of pilots in a squadron with the average flying hours per squadron provides a measure of the average flying hours and strike-related flying hours per pilot (see Figure B.7). As is evident from Figure B.7, the flying hours for Marine Corps F/A-18 pilots have decreased over the last several years while the number of strike-related flying hours has remained fairly constant.

Simulator Policies

The overall objective of the Marine Corps Simulator Master Plan is to conduct mission rehearsal in simulators prior to execution. The Marine Corps master plan has the following goals for use of aviation simulators:

- Serve as an adjunct to aircraft sorties.
- Maintain or increase combat readiness.
- Build pilot experience base.
- Ease the burden on aging/expensive aircraft.
- Offset range encroachment and weapons training.

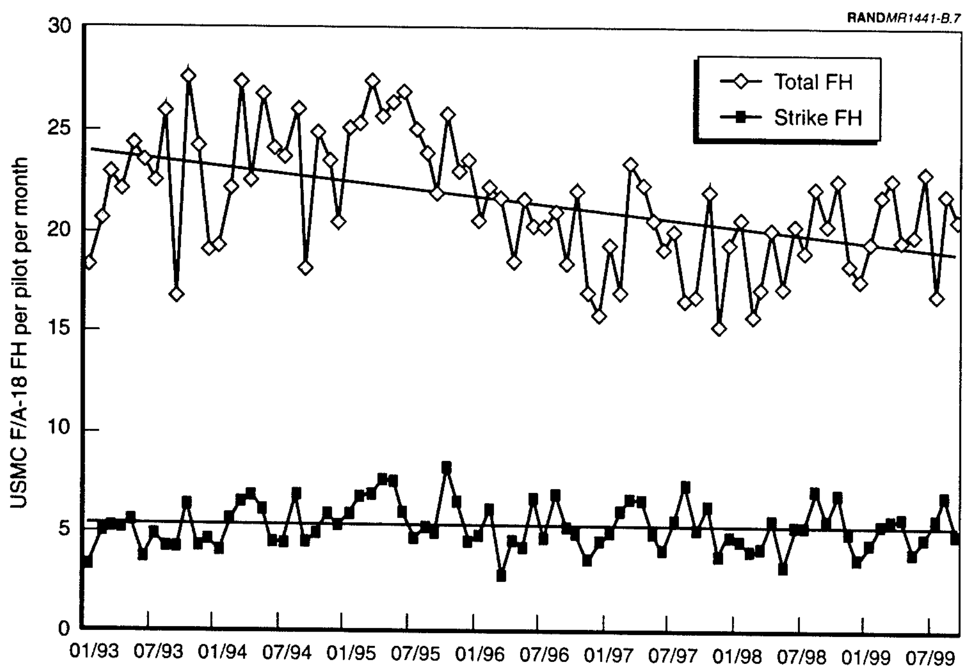

Figure B.7—Total and Strike Flying Hours for USMC F/A-18 Pilots

Figure B.8 shows the aggregate use of simulators by the Marine Corps F/A-18 community. The majority of simulator use is by the FRS, with the fleet squadrons using the simulator for only about one hour per crew per month. A significant amount of available simulator time goes unused. The downward trend in simulator use over the past few years reflects the poor fidelity of the simulators compared with the actual aircraft. The simulators have not kept pace with the upgrades made to the combat suite of the F/A-18s.

Table B.9 lists the F/A-18 simulators currently used and planned during the FY 2000 to FY 2006 Future Years Defense Plan. The Marine Corps would like to have at least two simulators linked at each station to allow simulation of section training, consistent with training "the way they fight."

Simulators are viewed as a means to develop and hone those critical skills required for professional development. USMC (1999a) states: "The development of simulator training events for each [type/model/series] T&R syllabus

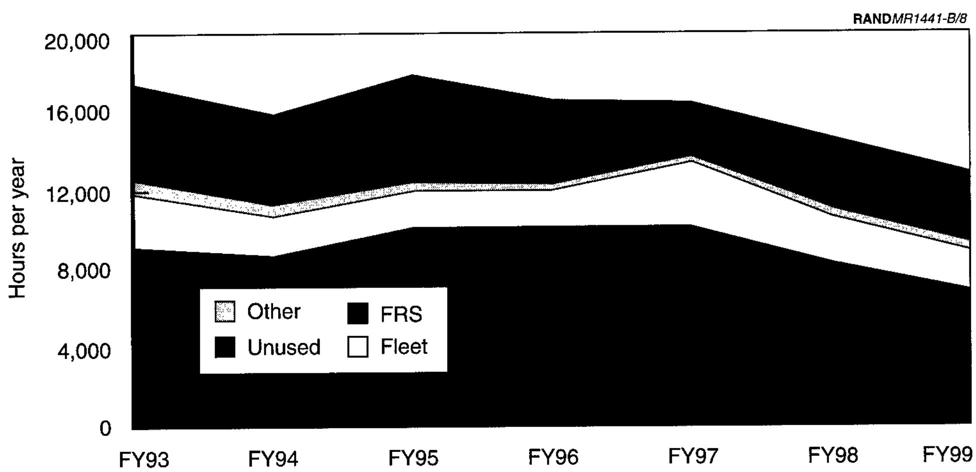

Figure B.8—Aggregate USMC F/A-18 Simulator Use

Table B.9

USMC F/A-18 Simulators

Location	WTT	OFT	PTT	WST	TOFT	APT
Miramar	2	2	1			Planned
Beaufort		1		1		Planned
Iwakuni		1				Planned
Andrews		1				
Fort Worth		1				
Atlanta					1	

will help maintain valuable combat resources while reducing training costs." Where simulators are not available, commanders may authorize the simulator events to be either waived or flown in the aircraft. The assignment of T&R events to the simulator is based on simulator fidelity and capability that closely matches the actual event. Appropriate CRP credit is assigned to those simulator events. If available, annual instrument and NATOPS evaluations should be completed in the simulator under the supervision of an evaluator. The T&R manual categorizes events as: simulator only; flight only; simulator preferred, flight optional; or flight preferred, simulator optional. In the past, the Marine Corps did not assign CPR credit to simulator events. This change reflects the MACP efforts.

All aircrews must use a flight simulator to complete a monthly review of emergency procedures. If a simulator is not available, appropriate examinations or cockpit drills may substitute for the simulator emergency procedures review.

Simulator-aircraft software mismatch, poor video representation, and simulation inaccuracies limit the usefulness of simulator flights. The Marine F/A-18 community feels that better simulators would not reduce the need for flight hours for training but would build the experience of the most-junior aircrews. Also, these most-junior pilots have time available in their workweek to take advantage of the increased simulator training and would benefit the most.

MACP plans expanded use of simulators with a specific focus on the post-FRS aviator and efficient mission rehearsal as a prelude to combat flight training. The Marine Corps plans to fund simulator improvements through savings achieved in the flying hour program. The plan also calls for linking simulators to allow multiplane training with integrated threat scenarios. MACP plans for two networked simulators at each active-duty Marine F/A-18 base in the continental United States, one simulator for each overseas F/A-18 base, and one simulator for each Reserve F/A-18 base not co-located with active-duty F/A-18 squadrons (see Table B.10).

Table B.10

Marine Aviation Campaign Plan F/A-18 Simulator Plan

Location	MACP Planned Simulators	Squadron Component
Miramar	2	Active-duty
Beaufort	2	Active-duty
Iwakuni	1	Active-duty
Andrews	1	Reserve
Fort Worth	1	Reserve
Atlanta	1	Reserve

Appendix C

USAF F-16 TRAINING

TRAINING PHILOSOPHY

The Air Force philosophy has been that all wings theoretically go to war at any time and thus has not followed a deployment pattern of training. The Expeditionary Aerospace Force concept is designed to schedule deployments with wings in a lesser readiness state after deployment. The Air Force has 10 such organizations. Two are deployed or prepared to deploy at any one time for 90 days over about a 15-month cycle to meet known, rotational, steady-state deployments. Two additional wings share on-call responsibility for contingencies over a 90-day period. No long-term patterns have emerged as yet.

Sortie requirements are provided annually to each unit as a basis for building its training program. Units are required to have a minimum number of pilots trained in special capabilities (e.g., instructor pilots, flight leads, CSAR). Some of these capabilities receive additional sorties. Pilots must fly the total number of directed sorties as a minimum, but the mix of sorties can be varied to ensure inexperienced and experienced pilots are accomplished in such mission types as Basic Surface Attack, Surface Attack Tactics, Close Air Support, Suppression of Enemy Air Defenses (for designated units), Sweep, Force Protection, Defensive Counterair, Air Combat Maneuvering, and Basic Fighter Maneuvers. Moreover, within the mission sortie allocation, pilots are expected to maintain required weapons qualification and become proficient in such tactical events as dropping chaff.

HOW USAF F-16 SQUADRONS ARE ORGANIZED

There are 15 F-16 active operational units, with 10 in Air Combat Command (ACC), two in U.S. Air Forces in Europe, and three in Pacific Air Forces. Some squadrons have 18 primary aircraft while others have 24, which is preferred. The plan is for the Air Force to have 427 primary mission aircraft in the active-duty component in FY 2001 with another 420 in the air reserve component. The F-16C is a single-seat aircraft, and the D is a two-seat model. Crew ratios are

1.25 with additional two billets for the command element so typically squadrons have either 25 or 32 pilots authorized.[1] In a squadron authorized 25 pilots, the grade breakout of pilots is designed to be two O-5, three O-4, nine O-3, and 16 O-2. Additional F-16 pilots are authorized at wing and above wing level. For the coming year, the Air Force will produce about 136 new F-16 pilots for the active-duty component and another 34 for the Air National Guard and Air Force Reserve. However, the emphasis on pilot data shown below will be on pilots assigned at the squadron level in the active-duty component.

HOW TRAINING IS PLANNED

The USAF uses a tiered training progression. Training programs are designed to move pilots from one qualification level to another. For example, the basic course in the Formal Training Unit (FTU) provides the training necessary for initial qualification of pilots in an aircraft and flying duties without regard to the unit's mission. Mission Qualification Training (MQT) and Continuation Training (CT) occurs in the operational unit. MQT is a unit-developed training program that provides the training necessary for initial qualification or requalification of pilots in a specific position to perform the mission assigned to a specific unit. MQT, upgrade qualification training, and CT are a mix of classroom (ground) training, simulator training, and flying training.

Following completion of MQT, a new pilot is certified as Combat Mission Ready (CMR). A more-experienced MQT pilot assigned to a wing in a position that has a primary supervising staff functions that directly support flying is certified as Basic Mission Capable (BMC). As such, he should be familiarized in all, and may be qualified and proficient in some, of the primary missions tasked to the assigned unit and weapons systems. CMR positions are filled with pilots qualified and proficient in all of the primary missions tasked to the assigned units and weapons system. With some allowable exceptions, all squadron flying positions are designated CMR. CMR pilots must maintain currencies, accomplish all core designated flight training (sorties and events), and all mission ground training. Failure to complete training or maintain currencies results in regression to a non-CMR status that requires a tailored program to regain CMR status. While non-CMR, a pilot may perform missions in which the pilot is current, qualified, familiar, or proficient.

The Air Force defines these terms as follows:

---

[1]While calculated differently, the results are similar to how the Navy computes number of pilots. The Navy uses a crew ratio of 1.4 but counts all billets in it. Both Navy and Air Force round up in the computation. For a unit authorized 12 aircraft, both methods would arrive at 17 pilots.

- Current—minimum frequency required to perform an event or sortie safely.
- Qualified—demonstrated capability to put appropriate ordnance on target according to established criteria for an event.
- Familiar—normally a minimum of six weapons deliveries for PGMs and bombing events in a 12-month cycle.
- Proficient—demonstrated ability to accomplish tasked event safely and effectively; also requires currency in the event if applicable.

CT is the highest tier in the training progression. CT is split into classroom (ground) training to include simulators and flying training. Minimum simulator training requirements are set. Tactical simulator missions may be accomplished in either the OFT if available,[2] the WTT, or a unit training device (UTD). If a unit does not have access to these simulators, certain missions can be accomplished in the cockpit familiarization trainer—a training device in which controls, switches, and instruments do not have to respond to trainee inputs. The WTT is a part-task training device, while the UTD is a squadron-level trainer for emergency and instrument procedures and air-to-ground weapons employment. It has a high-fidelity cockpit replica for pilot interactions, an out-the-window visual scene, and an instructor operator station.

CT has two aspects. The first consists of pilot training in such basic flying skills such as instruments or precision approach. This requirement has both live and simulator events. These skills ensure safe operation of the aircraft. The second aspect of CT consists of specific mission-related training required to accomplish the unit's assigned missions. This aspect of CT is called the Ready Aircrew Program (RAP).

RAP focuses training on capabilities needed to accomplish a unit's core tasked missions. Each RAP qualification level is defined by a total number of RAP sorties broken down into mission types plus specific weapons qualifications and associated events. The total number of RAP sorties for a qualification level is the primary factor for maintaining an individual's qualification level. RAP sorties are set out in an Air Force Instruction and updated and changed through a periodic (usually annual) RAP tasking message. The tasking message specifies type/mission sorties and event and weapons requirements of BMC and CMR inexperienced and experienced. These sorties and events are minimum requirements (total sorties are not supposed to be reduced) and may be

[2]The OFT dynamically simulates flight characteristics. At one time, operational flight units had OFT, but it became too expensive to upgrade their computers. OFTs are now typically available only at FTUs.

increased based on individual pilot utilization and qualification. The squadron commander determines qualification in a mission. The commander's first priority is to train all designated pilots to CMR.

F-16 squadrons build their flying hour program for training on the number of sorties needed to accomplish mission-related continuation training. Inexperienced pilots are allocated more sorties than are experienced ones. Units are expected to design training programs to achieve the highest degree of combat readiness consistent with flight safety and resource availability. Training must balance the need for realism against the expected threat, pilot capabilities, and safety. Unit flying hour programs are built on sorties needed to accomplish training. Inexperienced pilots (fewer than 600 hours) are allocated more sorties to maintain BMC and CMR status. As shown in Table C.1, in general, 72 sorties for inexperienced and 60 sorties for experienced pilots make up the annual sortie requirement for BMC and 116 and 96, respectively, make up the annual requirement for CMR.

Mission sorties consume the bulk of the sortie allocation. The squadron commander can vary the mission sortie mix based on individual pilot needs and has a number of sorties reserved for specifying training. Additional sorties are allocated to maintain a required number of pilots with special capabilities. Proficiency and qualification in tactical events (e.g., chaff, flare, secure voice, air refueling) and weapons qualification are to be gained while flying mission sorties. As a general rule, only one mission can be flown per sortie. However, if an air-to-air refueling occurs, a new mission can be accomplished afterward. To these annual sorties are added collateral or cost-of-business sorties (functional check flights, ferry flights, incentive/orientation flights, deployments, air shows) and attrition sorties (poor weather, air aborts, etc.). However, while the training

Table C.1

Tiered Training Sortie Requirements for USAF F-16

Type Sorties for RAP	Basic Mission-Capable (Inexper/Exper)	Combat Mission-Ready (Inexper/Exper)
Minimum Annual Sorties	72/60	116/96
Mission Sorties	32/24 (one per sortie)	112/98 (one per sortie)
Commander Option	40/36	10/10
Special Capabilities—e.g., Flight Lead, Instructor Pilot	16/22 (above annual min)	16/22 (above annual min)
Tactical and Weapons Events	64 (ICW Mission Sorties)	155 (ICW Mission Sorties)
Collateral; Attrition Sorties	As needed	As needed

NOTE: Annual sorties may not be reduced.

is designed in this fashion, in practice, we were told that because of funding, every sortie has become a RAP sortie and proficiency has declined as a result.

HOW THE TRAINING IS RESOURCED

Flying Hours

Hours per crew per month (HCM) has come to be viewed as one measure of readiness along with crew force experience levels, crew ratios, unit manning levels, equipment status, and level of spares. (Programmed versus actual HCM is a flying hour metric submitted by DoD as part of the Government Performance and Results Act.)

Figure C.1 is a summary of HCM for F-16 squadron pilots[3] for the last 10 years. Since 1992, flying hours had been decreasing, until recently. (The data before 1994 may not be comparable to 1994 and after. While both use flying hours and assigned squadron level pilots, both the numerator and denominator are from different databases beginning in 1994.)

The dark colored bar for 1999 shows sorties per month. A typical sortie uses about one hour and 40 minutes. The light colored bar in the figure shows that programmed flying hours for 1999 were higher than actual flight hours. The

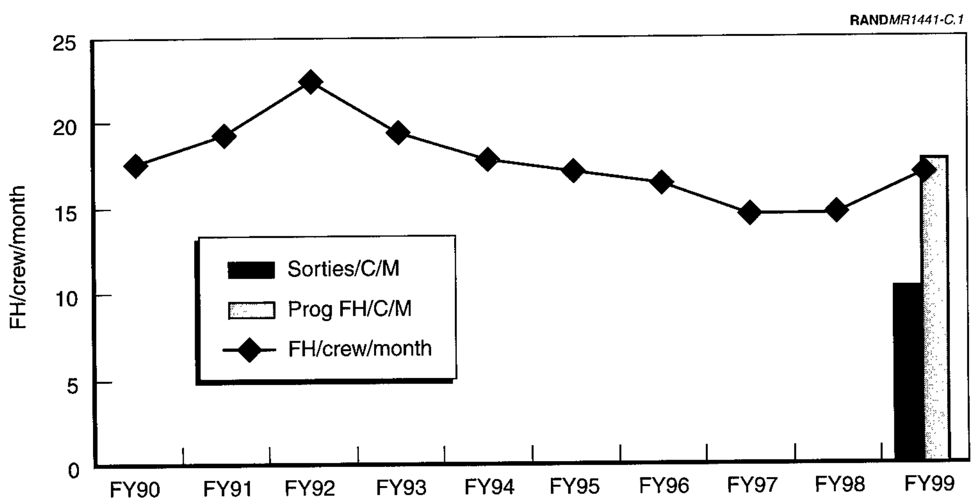

Figure C.1—USAF F-16 Flying Hours

[3]AP1 pilots are squadron pilots in flying positions. Data are tracked separately for wing staff/ supervisors and above wing pilots.

actual hours may differ from programmed hours for several reasons. Flying hours are programmed using authorized strengths while actual HCM is based on assigned strengths. If a squadron or community is overmanned, the actual hours will be under the programmed hours. This occurs because a larger number of crews is used in the calculation, thus HCM declines. Also, over- or underexecution of the program affects HCM. In 1999, ACC underexecuted the program, which drove actual HCM down. Moreover, squadron officers and wing staff have separate programmed hours, but if there are more staff flyers than authorized or if they fly at a greater rate than programmed, squadron HCM will decrease, which happened in the fighter community. Programmed HCM for squadron-level pilots in the F-16 for 2000 are 15.9 for ACC, 19.0 for Pacific Air Forces, and 17.3 for U.S. Air Forces in Europe.

Currency

Currency requirements (periodicity or refly rates) are specified. Table C.2 provides a sample of those specified. As shown in Table C.2, some of these currency requirements vary by the experience level of the pilot, and some affect CMR status while others do not.

Simulators

Much of the recent Air Force discussion about simulators and their use has involved the distributed mission trainer (DMT) for the F-15. The idea for the DMT originated in ACC. DMT is described as a system of linked, high-fidelity simulators that allow combat aircrews to train more effectively for an increasingly complex combat environment. Part of the follow-on debate about DMT dealt with the issue of using it to supplant or supplement flight hours.

Table C.2

Selected F-16 Pilot Currencies

Event	To Update, Fly the Following	Inexperienced	Experienced	Affects CMR?
Demanding Sortie	Any Sortie	21	30	No
Landing	Landing	30	45	No
Air Combat	Air Combat	60	90	Yes
Weapons Delivery	Event	60	90	Yes
Terrain Following Radar	Night Event	30	45	No
Low Air-to-Air	Low Air-to-Air Events	60	90	No
Aerial Refueling	Day or Night Aerial Refueling	180	180	Yes
Formation Takeoff	Event	60	90	No
Precision Approach	Event	30	45	No

Eventually F-16 and other wings would be expected to join the DMT network. As of this writing, it is not clear that this vision will be achieved because the future status of the DMT is uncertain.

Within the existing F-16 training program, both classroom and simulator training are specified as part of the unit ground training requirement. There are minimum requirements to use the operational flight trainer for total sorties (12 inexperienced/eight experienced) of which eight and four, respectively, must be tactical sorties. These latter tactical simulator missions may be accomplished in the OFT, in the WTT, or in the UTD. F-16 simulators are described as being behind the airframe and may never catch up.

Appendix D

ALLIED TRAINING

This appendix considers the training of some U.S. allies. Specifically, it reviews the training of the Royal Air Force (RAF) for its Tornado and Harrier crews and that of the French Air Force for its Super Etendard and E-2C crews.

ROYAL AIR FORCE FIGHTER TRAINING

Training Philosophy

The United States and the United Kingdom have different training philosophies. The United Kingdom trains to high standards in its training units. A pilot goes to a squadron fully capable. The United States stops formal training earlier and assigns more training to the units.

How RAF Squadrons Are Organized

The RAF operates approximately 160 Tornado aircraft, used primarily for strike and attack missions, and 78 Harriers designated as attack aircraft. These aircraft are organized in squadrons of 12 aircraft with 15 authorized pilots and are stationed in the United Kingdom and overseas. In addition, the Royal Navy has two six-plane squadrons of Sea Harriers. Because the Tornados have more similarities with the U.S. Navy F/A-18s, our focus is primarily on unit training for the RAF.

How Training Is Planned

Training progresses from initial flying training to basic and then advanced fighter training and then to an operational conversion unit (OCU). The training agency agrees with the RAF on the level of proficiency required of newly trained pilots across a range of flying and mission skills. The RAF is different from USAF in that a wingman is trained to a higher level before reporting to a squadron and is capable of lead/mission completion. (This is similar to the U.S. Navy.)

How Training Is Resourced

Personnel. The RAF has two accession programs for its pilots. One involves a shorter term of service than the other does. The 12-year short-service commission is the least desired by the RAF but is the one most frequently chosen by the pilots. The 16/38 program (service to 16 years or age 38) is more desirable to the RAF. About 212 candidates enter pilot training each year, with about 140 graduating to squadrons (consistent with operational requirements) after initial flight training and OCU training. About 60 pilots are assigned to fighter aircraft with the remaining 80 assigned to multiengine aircraft and helicopters.[1] At age 38, there is a reasonable flow from fighters to multiengine aircraft; some helicopter pilots flow to fighter aircraft at an earlier age. It costs about £5.7 million to train a pilot reporting to a squadron with training taking approximately 4.2 years on average.

The flying units have a shortage of experienced pilots. This is caused by a combination of failing to achieve targets for new pilots and by pilots leaving early or not extending their service. The RAF (like USAF) is constrained by a maximum number of new pilots in flying units so as not to increase the ratio of inexperienced pilots to experienced pilots to unacceptable levels.

Squadron tours last about three years, and it is not unusual for a pilot to do sequential tours. Most "ground" tours have been eliminated (because of low numbers of RAF pilots). A pilot must do a minimum of six years after OCU before leaving. The goal is to get 12 years' return of service. To encourage pilots with two years remaining to complete their service, the RAF reimburses the cost of gaining a commercial pilot license. After age 38, a person who stays in a squadron is specialist aircrew and will enter a fly-only track until age 55.

After a first squadron tour, a pilot is qualified as a section lead. Typically, the best pilots go to a program like Top Gun and then return to the squadron as a qualified weapons instructor. Other top pilots take flight instructor training and return to the squadron as a qualified flight instructor. Pilots may also rotate to another squadron.

The RAF recently started a full-time reservist program whereby a pilot retires from active commission and comes back as a Reservist (on active duty) at lower

[1]The Royal Navy requires eight new fast-jet pilots per year and meets this requirement through a combination of the very best new entrants, experienced helicopter pilots, and fighter pilots who transfer from the RAF or other countries' militaries.

rank/pay grade but with an additional pension. It has a series of contracts for five years up to a maximum of age 60, which essentially allows a 50-year-old to serve two tours to age 60, after which an individual can draw an active pension with an added increment of Reserve pension. This is a very popular program. Many of the Reserve pilots go into the training system but they can serve almost anywhere in the community.

Pilot work is 200 man-days per year, and they view themselves as getting high productivity out of each man-day. They attempt to get maximum value out of every flight hour.

Flying Hours. Views on the number of required live flight hours (see Figure D.1) vary widely. The NATO minimum is 180 hours (15 per month). RAF flying hours for jet pilots is between 180 and 240 per year (18.5 month on average). Of these hours, 150 hours (12–14 hours per month; 12.5 on average) are felt to be a safety-of-flight minimum (instruments, takeoffs, landings). The RAF also feels the additional increment for military elements of flying (e.g., warfare tactics) is about three hours per month or 36 per year for a total of 186 annual hours (15.5 hours monthly). The 180–240 hours include all flying (e.g., transit and overhead flights) not just military elements or high-quality flying, which is estimated at 75–80 percent of the total.

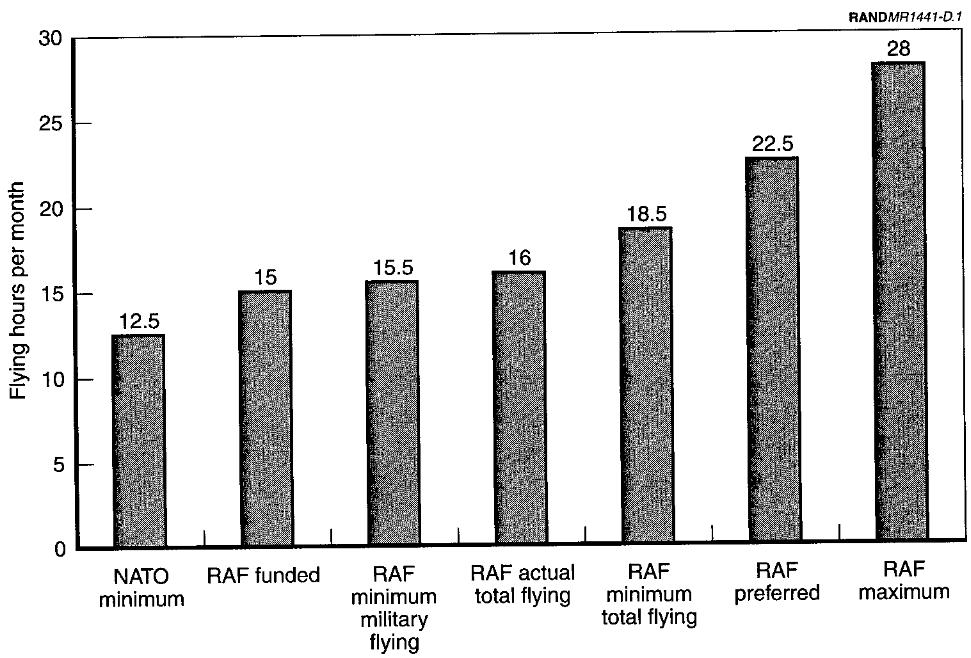

Figure D.1—RAF Flying Hour Benchmarks

RAF jet pilots are funded at 180 hours annually (15 per month). On average, they can fly more than budgeted. A desired number of monthly flight hours would be about 22.5, but they acknowledge it would be difficult to fly more than 28 hours per month given all the other things that pilots must accomplish.

The Tornado has fewer flying hours than maritime patrol aircraft (MPA) but far more sorties (a typical Tornado sortie is an hour and a half). For Red Flag, there is a pretty intensive workup. There is no deployment pattern except for Red Flag, and a more constant level of flying exists in the RAF.

Compared with their RAF counterparts, Royal Navy aviators get six to eight weeks of additional training, including 30 additional flight hours and 15 to 25 hours on the simulators.

Simulators: Then, Now, and in the Future

The Flying Training Development Wing at RAF Halton helps to develop the training requirements for future RAF aircraft, including the development of proposals on the mix of live and simulator training. This section draws on our discussions with this group and presents some of their ideas about how live and simulator training will be used for the next generation of aircraft.

One way to think of the progression of aircraft and simulators is by defining the following four generations:

- World War I,
- World War II,
- Current (e.g., F-16 or F/A-18), and
- Future (F/A-18E/F, Eurofighter, JSF).

In prior generations of aircraft and simulators, the RAF trained in the air and practiced in the simulator. In future aircraft and simulators, the RAF believes it will need to teach and train in the simulator and consolidate in the air. With new technology and new generation aircraft, cognitive, cockpit, and systems management skills are as important as hand-eye coordination. As the emphasis on skills takes new directions, the training system must avoid teaching skills and practices that will rarely if ever be used in modern aircraft. The present system forces too much training on to the OCUs and often to the front-line squadrons.

Many senior officers in the RAF have perceptions about simulators based on bad experiences with the quality and availability of existing simulators. They fear that future budgetary decisions may force the direct substitution of simulator hours for flight hours without careful analysis and proper resourcing. In the future, simulator training must be thought of as enhancing the total time spent training and not as replacing flight with simulator hours. The trade-off between live and simulator is too often perceived as an "either-or" decision without necessarily considering the use of either type of hours. In reality, the goal is neither flight nor simulator hours, but rather is training effectiveness. If simulators are used to practice the less complex training events, a pilot could focus flying hours on the more complex tasks. Similarly, simulator hours could concentrate on complex tasks difficult to train for using flying hours, and flying hours could focus on tasks best accomplished by them. Fewer live flight hours could lead to the same training outcome if effective and efficient simulators were available. As a result, live flight hours could be reduced while increasing proficiency.

A fourth-generation training view requires significant changes in attitudes, beliefs, and measures of behaviors. For example, the RAF measures pilot experience in hours. An open question is how to count simulator hours in the future. Flying hours are the widely accepted performance metric driving the structure of the system, as opposed to their being one measure of outcomes.

Very few people have jumped to fourth-generation concepts because they do not want to replace live flying with simulators. With the current third generation, fighter pilots spend one or two hours a month in a simulator. With the new fourth-generation simulators, pilots will spend 38 hours a year in a simulator. "Which 38 hours?" is the question. They will be able to trade real aircraft flight time for simulator training, which will help in buying the simulator capability. It will be expensive to fly 240 hours in an aircraft like the JSF, but only 50 hours would be insufficient. The live flying hours do not have to be used the same way in the future as they are now.

A vision of fourth-generation simulators is one where the simulator can do everything a pilot would want it to do. Pilots could brief a flight without concern about whether it was accomplished in an aircraft or in a simulator.

Simulator realism might become so good as to have psychological effects on the user (related to the time difference between simulation doing something, or being perceived as doing something, and real-world time). There is also a concern that you may not be able to put the "fear factor" into a simulator and that pilots will get complacent about mistakes.

The fourth-generation simulator could "link" with real-time flights and participate with them. For example, the simulator pilots could become part of a real-world flight in Kosovo. The fourth-generation simulator should be deployable and could also be used to maintain proficiency of (older) pilots in desk jobs. The level of simulation available on land should also be available on a ship. Fourth-generation simulators should be upgraded before the aircraft/system is.

Research on using sophisticated simulation in ab initio training is sparse. A study is under way at RAF Valley with Hawk simulators, which may serve as the basis for experiential data on simulator versus live trade-offs in initial training.

The next generation of simulator includes 95 percent of the previous generation and a 5 percent enhancement. The 5 percent advance is where the flight hour substitution potential lies. With a simulator, mission fidelity, not aircraft fidelity, is required. One way to keep simulators up to date is to make them important to the pilots and to their training. Funding the conversion from flight hours to simulators requires front-end money for putting simulators in place. The purchase decision for a simulator is so integral to the overall aircraft procurement and subsequent flying program(s) that great care must be taken to only buy simulator technologies that are available, not capabilities promised for the future. The RAF has some bitter experiences with simulators delivered later than planned and with less capability than originally proposed.[2]

It is critically important to know and answer the following questions:

- What is the minimum number of live hours acceptable?
- What is the minimum total live/simulation hours required?
- What is the acceptable ratio of live to simulation?
- What types of simulation training can be put into logbooks?
- What can be done (will be done) in the simulator?
- What cannot be done (will not be done) in the simulator?

With respect to these last two questions, the Defence Evaluation and Research Agency (DERA) has been conducting forward-looking research. It has set up an experiment that simulated a fourth-generation simulator capability and had experienced pilots use it. They then were able to get quantitative and qualitative reactions to the different methods.

Their research demonstrated the following:

- The current generation of simulators is ineffective in all mission tasks.
- Some mission tasks can be satisfactorily accomplished in an aircraft and in a fourth-generation simulator.

[2]The Hawk flying program (for training) had been 140 hours per year per pilot and had been cut seven years ago to 102 hours per pilot with the funding to be used for a simulator, which would supplant the 38 hours. The simulator took seven years to put in place, and the RAF has been struggling to execute its training with a flying hour program based on 102 hours.

- A networked simulator (a fourth-generation simulator) is capable of providing satisfactory mission training in those mission tasks that are less than satisfactory in the aircraft.
- The aircraft are lacking in some areas because they do not have a very good debrief capability (e.g., U.S. Navy fighters have tapes of their live flights to assist in debriefing; RAF fighters do not).

Just-in-time training will play a more important role and requires decisions on what level of training to provide. Some weapons are used only in war and the solution may be to train in the use of those weapons just prior to deployment.

Currently, the RAF uses simulators a good bit in its OCUs. But squadrons use simulators very little, maybe one hour per month. The flight-hour-to-simulator ratios vary by stage in the training pipeline. For initial training (Hawk), there is a 5:1 (live:simulator) ratio using a legacy syllabus. Pilots do 140 flying hours and 28 simulator hours. The new syllabus is a ratio of 1.8:1 with reduction of flight hours from 140 to 106, and an increase in simulator hours from 28 to 60. In the OCU, the ratio is 4:1 with the legacy syllabus and a second-generation simulator. The ratio will go to 2:1 in the future with a new simulator (80 flying hours and 40 simulator hours). For squadron continuation training, the current ratio is about 15:1 (180–240 flying hours to 12 simulator hours). A more realistic ratio will be 3:1 (180 flying hours and 60 simulator hours). The simulator hours will consist of one currency period and four tactical periods. There will be a big reduction in "wasted" flying with fourth-generation simulators. The same number of total hours will be flown far better.

FRENCH NAVY CARRIER AIRCRAFT UNIT TRAINING

The French Navy operates various types of carrier aircraft including the Super Etendard and the Hawkeye (E-2C). Of these, the Super Etendards are allocated the strike missions against naval and land targets. Approximately 30 Super Etendard aircraft are allocated between two squadrons (11 Flotille and 17 Flotille) based at Landivisiau. The new French aircraft carrier, the *Charles de Gaulle* can accommodate as many of as 40 of these aircraft.[3]

Training Philosophy

The primary philosophy of the French Navy is to train as it fights and fight as it trains. It uses extensive preflight and postflight debriefings to emphasize the

[3]The *Charles de Gaulle* will soon join the fleet for its first operational deployment. The two older aircraft carriers, the *Foch* and the *Clemenceau*, have recently been retired.

objectives and conduct of the training events. To compensate for limited assets, French squadrons place special emphasis on ensuring that each flight hour and sortie results in high-value training. They minimize transit time (typical sortie lengths are 1.5 hours and do not involve refueling) during their training flights and typically do not have indirect or overhead flights. They focus on mission planning and try to ensure that each flight accomplishes a number of objectives so it is as productive as they can make it.

How Training Is Planned

French naval carrier pilots receive their initial jet training from the U.S. Navy (at VT-7 in Meridian, Mississippi) after primary flight training in France. Young pilots have approximately 400 hours of flight time when they enter the fleet squadron. After about one year and 200 more flight hours, they become operational pilots. In approximately another three years and 400 flight hours (and approximately 100 day carrier landings), they qualify as a section leader and are capable of night carrier landings. Finally, after about five years in the squadron (seven or eight years of total service) and a total of 1,300 flight hours, a pilot becomes a division leader. The final progression step is to mission commander where they are able to lead missions of eight or more aircraft.[4] Typically, about half of the squadron's pilots have eight or more years of experience. French naval pilots, like their U.S. counterparts, have numerous ground duties to keep them busy when they are not flying.

How Training Is Conducted

The French squadrons follow an Operational Training Program (similar to the U.S. Navy's T&R matrices) that coordinates training events for all pilots to ensure sufficient pilots are qualified for all missions. Given the small community, training is tailored to reflect the strengths and weaknesses of individual pilots. Squadron commanders typically know the capabilities of their pilots and structure an individual's training accordingly. In addition to successfully completing the various training events, pilots receive continuous subjective evaluations from their superiors.

The squadrons try to apportion flying hours on a linear basis throughout the year. If exercises or deployments result in increased flying for a month, they will cut back their flying in the following months. The French Navy firmly

[4]French Navy pilots receive appropriate civilian certification as they progress in their military flying experience.

believes that its pilots must fly at least 150 hours per year or problems will result.

French squadrons attempt to participate in various joint and combined exercises as often as possible. Each year, they conduct two air-to-ground training exercises in the south of France. Annually, they send one pilot from each squadron (soon to increase to two pilots per squadron) to NATO's Tactical Leadership Program.[5] They also conduct joint exercises with their British counterparts. Many of these joint exercises are flown from land bases rather than from an aircraft carrier.

How Training Is Resourced

Personnel. The Super Etendard community is small—a total of 40 pilots for 30 aircraft. Each year, five to eight new pilots enter the squadrons. These new pilots enter the Navy from two sources. After their initial training, graduates of the Naval Academy (about three or four per squadron) are assigned to a squadron for a seven-year tour, after which they continue their careers in staff positions, including acquisition, or in other operational assignments. Non–Academy graduates join the squadron for approximately 10 years. After their tour in the fighter squadron, they typically spend three to four years either in a transport squadron or as an instructor. In total, they serve a minimum of 15 years with most pilots typically serving 17 to 18 years.

Flight Hours. Young pilots receive from 140 to 150 flying hours per year in the Super Etendard, supplemented with 40 to 50 hours of instrument training flight time in the Falcon 10, and 40 hours in a simulator. Operational pilots fly about 180 hours per year and night carrier landing–qualified pilots receive approximately 220 flying hours per year. Approximately 40 percent of their flight hours are dedicated to strike training. Each pilot drops one live bomb each year.

Simulators. The French fighter squadrons have very limited simulation assets. Their simulators have acceptable reliability and realism but no ability to link together. They have fair visual displays but very little variation in the embedded training scenarios. The simulators are primarily used for "switchology" and safety of flight (if pilots have not flown in 15 days or more, they will use the simulator before their next flight). Only about 2 percent of their strike training is done on simulators.

They attempt to keep the simulator software current with the versions on the operational aircraft. Although they have no simulation capability on board

---

[5]Completion of the Tactical Leadership Program is needed to become a mission commander.

their aircraft carriers, they plan to have a Rafale link simulator on the *Charles de Gaulle* when the Rafale program comes on line. In the interim, they plan to upgrade the Super Etendard simulator. The Rafale program will include a network simulation capability and real-time replay of a training flight using videotape from cameras mounted in a pod on the aircraft. The Rafale simulator is part of the procurement contract, although the aircraft will be introduced into the fleet before the simulator arrives.

Appendix E

MARITIME PATROL AIRCRAFT AND ASW TRAINING

This appendix describes the tactical training of U.S. Navy P-3C squadrons, focusing on ASW missions. It outlines the current training philosophy and organizational responsibilities during the IDTC, the various mission-related events in the T&R matrix, and the use of live, simulated, and schoolhouse events in tactical unit training. The appendix also includes a description of the training philosophy and approach for British and French MPA units. It concludes with a comparison of the U.S., British, and French tactical unit training.

NAVY P-3C TRAINING

How Navy P-3C Units Are Organized and Based

Currently, 12 active-duty P-3C squadrons are equally distributed between the East Coast and West Coast.[1] Three of the East Coast squadrons are based at NAS Brunswick, Maine, and the other three are at NAS Jacksonville, Florida. The P-3C FRS is also based at Jacksonville. The West Coast squadrons are equally divided between Whidbey Island, Washington, and bases in Hawaii. Each of the four operating locations of three squadrons constitutes a wing. East Coast squadrons have nine aircraft each while West Coast units have either nine (Whidbey Island squadrons) or 10 (Hawaii squadrons) aircraft.

How Training Is Planned

All squadrons closely follow an 18-month cycle—a twelve-month IDTC followed by a six-month deployment. Therefore, each wing typically has one squadron deployed with the other two in its IDTCs. Typical deployments for East Coast squadrons include Sigonella, Italy, NAS Keflavik, Iceland, Roosevelt Roads, Puerto Rico, with concurrent detachments to locations in South Amer-

[1]Prior to Base Realignment and Closure decisions, 24 active-duty squadrons and two FRSs were equally divided between the two coasts.

ica, northern Europe, and the eastern Mediterranean. Among other locations, West Coast squadrons deploy to Misawa AB, Japan, Diego Garcia, Okinawa, and the Middle East.

Each squadron is authorized 12 crews, each with 11 crewmembers. Five crewmembers man the cockpit—three pilots (patrol plane commander [PPC], patrol plane pilot [PPP], and patrol plane copilot [PPCP]) and two flight engineers. The six crewmembers manning the aft portion of the aircraft include two naval flight officers (NFOs) (patrol plane tactical coordinator [PPTC] and patrol plane navigator/communicator [PPNC]), two acoustic sensor operators (SS1/SS2), one electronic warfare operator (SS3), and one in-flight technician. A subset of the crew, referred to as the Tactical Nucleus (TACNUC), is composed of the four positions considered essential for ensuring tactical mission crew coordination: the PPC, PPTC, SS1, and SS3. The manning of the TACNUC positions must remain consistent for all crew certifications and qualifications.[2]

How Training Is Conducted and Managed

Crews returning from deployments typically lose some crewmembers and gain new ones during the IDTC.[3] Therefore, at the beginning of the IDTC, individuals and crews must restart the process of certification and qualification in the various training events in the T&R matrix. As training events are completed, points are accumulated in one or more of the PMAs.

The first key milestone in the training of a crew is completion of the Tactical Proficiency Course (TPC). The TPC is administered by each wing and is intended to enhance combat aircrew performance over the broad spectrum of the PMAs. The course emphasizes crew coordination, tactical awareness, and in-flight standardization. The three modules of the TPC are the Basic Module (one day of classroom instruction plus one ASW session on the Weapon System Trainer [WST]), the ASW Module (three days of classroom plus two ASW sessions on the WST), and the Multimission Module (two days of classroom plus two ASW/ASUW sessions on the WST). A crew remains TPC current so long as at least two of the TACNUC completed TPC with that crew.

A crew is designated as fully formed if all 11 crew positions are filled. It is considered a TPC tactically formed crew if all tactical crew positions necessary to

[2]Certification applies to achieving the minimum proficiency level in mobility-related training events. Qualification applies to achieving minimum proficiency in the PMA training events.

[3]WTM policy suggests that crews should be fully manned at least 90 days prior to deployment. The goal during the IDTC is for squadrons to have a minimum SORTS rating of C-2 (preferably C-1) in training and C-2 in personnel no later than 90 days prior to deployment.

conduct TPC training are filled. A crew becomes TPC current if it has successfully completed the TPC.

Each crew has seven individual T-Rates, one for each PMA, which are combined into an overall T-Rate for the crew. The criteria for the various individual T-Rates are show in Table E.1. A crew is considered combat-ready in a PMA if its T-Rate is T-2 or better in that PMA.

A crew's overall readiness, or T-Rate (overall), is determined based on the lower level derived from the following criteria (from the WTM):

- T-Rate (overall) is equal to the lowest of the individual PMA T-Rates, unless the crew is limited to that level by only one PMA, in which case its T-Rate (overall) is equal to one level higher than the lowest PMA T-Rate,
- T-Rate (overall) may not be higher than the T-Rate for MOB.

The goals for the number of combat-ready crews in a squadron over the IDTC are shown in Figure E.1. A squadron is rated as T-1 in a PMA if 12 crews are T-1 in that PMA. The squadron is T-2 in a PMA if at least 10 crews are T-2 or better in that PMA. (Note that a squadron is authorized only 12 crews.) The squadron is T-3 if at least eight crews are T-3 or better in that PMA. If a squadron does not meet the T-3 requirement, it is T-4 in that PMA.

There are a series of classroom events, training qualifications and certifications, and operational exercises each P-3C crew completes during the IDTC. In general, training progresses from the classroom to a simulator to live flights.

Development and maintenance of MOB PMA T-1/T-2 training currency is continuous throughout the IDTC. IDTC training in the six tactical PMAs starts with

Table E.1

Criteria for PMA T-Rates

PMA T-Rate	Criteria
T-4	Crew does not meet T-3 requirements
T-3	Crew is TPC tactically formed Crew is safety-of-flight certified For PMAs other than MOB, crew is current in TPC Crew holds 55 or more PMA points
T-2	Crew is fully formed Crew meets T-3 safety-of-flight and TPC requirements Crew holds 70 or more PMA points
T-1	Crew meets T-2 requirements Crew holds 85 or more PMA points

SOURCE: Wing Training Manual.

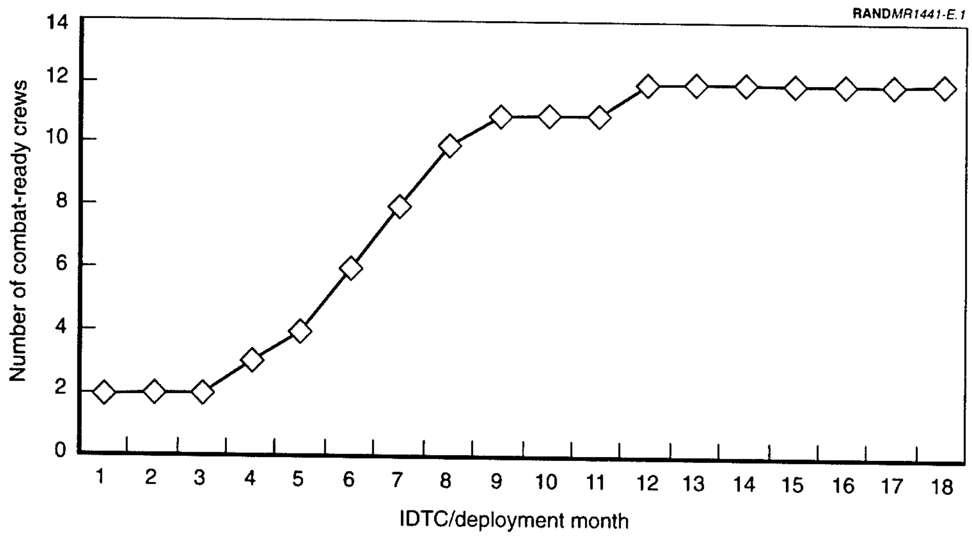

Figure E.1—Goals for Number of Combat-Ready Crews per Squadron

the TPC (matrix event MOB 8), mentioned above.[4] Once a crew completes the TPC certification, it concentrates on developing tactical PMA expertise first through completion of the core tactical qualifications (ASW1, ASW2, C2W1, INT1) that provide sufficient points (55 or more) to advance the crew to a T-3 rate, then progressing to the T-3- and T-2-associated matrix events. Once a crew attains T-2 (combat-ready) status, it is expected to maintain that level through the end of its next deployment.

Other key milestones in the training cycle include the following:

- BT 101: a five-day class with lectures in the morning and simulator work in the afternoon (five WST sessions). The course is ASW-oriented and must be completed by at least two crews in the squadron.
- USWPT/C2X: a battle group exercise that provides support to the fleet.
- FAST Cruise: an Operational Readiness Evaluation (ORE) that tests the ability of the P-3C crews.[5]

---

[4]For the purposes of timing the various classroom and course requirements, each of the 12 crews in a squadron will accomplish the various training events in the T&R matrix in a slightly different order. We describe the typical training milestones for the lead crew in the squadron.

[5]The JTFEX, the exercise that "tests" most of the units in the battle group, does not evaluate the P-3Cs. The FAST Cruise, therefore, provides that evaluation. FAST Cruise is mandatory for West Coast squadrons and done by most East Coast squadrons.

- Squadron Advanced Tactical Training (SATT): a one-week crash course usually provided just prior to deployment that gives theater-specific information, taught by the Weapons and Tactics Unit (WTU) of the FRS.

In addition to the crew-related training courses and events, a number of courses are required for individuals.[6] These courses are primarily taught by the Fleet Aviation Specialized Operational (FASO) training group and cover the various positions in both the front and the back of the aircraft. Some courses are conducted in a classroom environment, while others are computer-based training courses taken by an individual during time available.

Specific training policies and recommendations for P-3C squadrons and crewmembers are provided in their WTM (U.S. Navy, 2000b). This manual amplifies the seven PMAs assigned to the P-3C via OPNAVINST C3501.275A (ROC/POE):

- ASW
- ASUW
- Command and Control Warfare (C2W)
- CCC
- Intelligence (INT)
- MIW
- MOB.

The first six PMAs listed above address the tactical application of the P-3C aircraft as a weapon system. Training readiness in these tactical PMAs focuses on the crew versus the individual members. The MOB PMA differs from the tactical PMAs in that the successful completion of training events is associated with both the individual members of the crew and the coordinated crew as a whole. A crew's MOB readiness status is based on the aggregate of MOB training accomplished by individuals in the crew. Completion of the basic MOB training events is a prerequisite to the conduct of tactical operations.

Additionally, OPNAVINST C3501.275A assigns the following seven secondary mission areas to the P-3C:

- AAW
- AMW

---

[6]Chapter Four, Section Two, Squadron Training Management, of the WTM lists 13 different formal courses and 12 computer-based learning courses for individuals in the crew.

- Fleet Support Operations (FSO)
- Logistics
- Noncombat Operations
- Strike
- Missions of State (MOS).

The WTM includes the T&R matrix[7] for the P-3C squadrons, which defines the training events necessary to attain different training levels of readiness (or T-Rates), including the flying hours or simulator hours required for each event. The T&R matrix also shows currency periods for each event (i.e., the length of time a crew stays qualified once an event is completed) and the number of "points" the completion of the event contributes to a crew's T-Rate. Note that the T&R matrix only addresses training events for the PMAs.

The number of training events in each PMA, along with the annual flying hour and simulator hour requirements per crew, are shown in Table E.2.

How Training Is Resourced

Historical Flying Hours.[8] Figure E.2 shows the aggregate monthly flying hours per P-3C crew programmed, budgeted, and actually flown over the past several

Table E.2

P-3C PMA Training Events and Hours per Crew

PMA	Number of Events	Event Hours	Annual Flying Hours[a]	Annual Simulator Hours[a]
MOB	9	32	244	175
C2W	1	4	12	4
ASW	6	24	80	36
INT	3	10	30	0
ASUW	5	16	48	4
MIW	1	2	2	0
Total	25	88	416	219

[a]Annual hours are a multiple of event hours based on the currency period for an event. These hours include "on station" time only and do not include the transit times necessary to reach operating areas.

---

[7]T&R matrices for all U.S. Navy aircraft are provided in U.S. Navy (2000a).

[8]Information Spectrum, Inc., provided the flying hour and simulator usage data in Figures E.2 and E.7. Those data were collected from OP-20 reports and used by OPNAV (N885) in the development of their FAST plan. Pete Glueck, a resource analyst with the P-3C wing at NAS Brunswick, provided the flight and simulator data used in Figures E.3, E.4, E.5, E.8, and E.9.

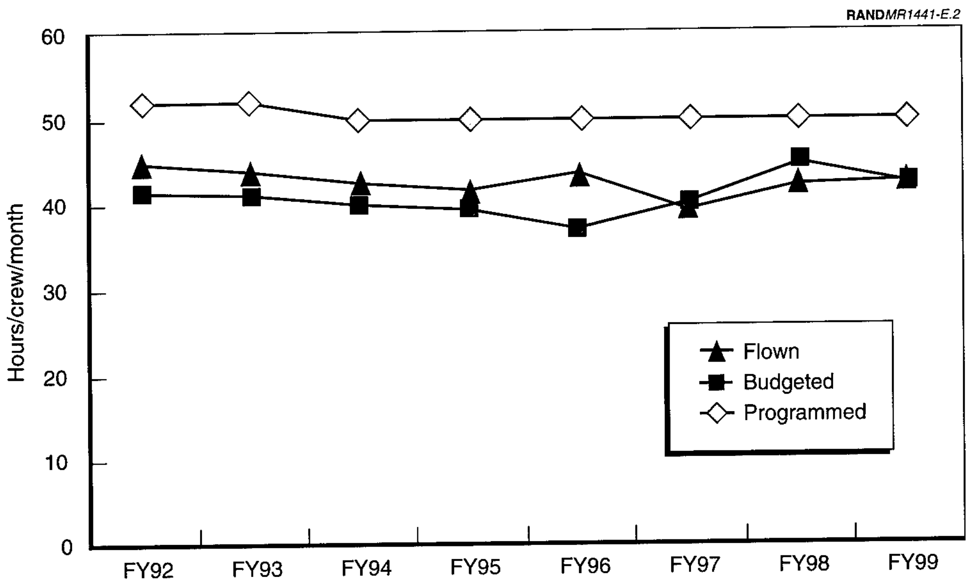

Figure E.2—Aggregate P-3C Flying Hours per Crew per Month

years. Since FY 1994, programmed hours have been constant at 50 hours per crew per month. The budgeted hours are typically, by policy, 83 percent of the programmed figure. The actual hours flown were usually equal to or greater than the hours budgeted.

The aggregate hours shown in Figure E.2 hide the flying hour variations that exist among squadrons, the crews within a squadron, and over time. Figure E.3 shows both the total flying hours and the ASW flying hours per crew per month over the last decade. While on average the flying hours per crew have slightly increased, the ASW flying hours have decreased across the period. However, variations occur within the period. For example, a sharp decline occurred with the end of the Cold War, sinking below 10 percent in 1993. Since then, a modest increase has occurred.

The data in Figure E.3 also show the wide variation in the monthly average across all crews, especially during the early 1990s. This variation is a function of the decline in ASW assets during the IDTC as well as availability of real-world and friendly submarines for training. The ASW flight hours appear to portray three different periods. From the beginning of the data to approximately 1993, ASW hours decreased, largely because of aircraft availability and the incorporation of new missions to include counterdrug missions and surveillance missions during operations in the Adriatic. From 1993 to 1996, a slight increase

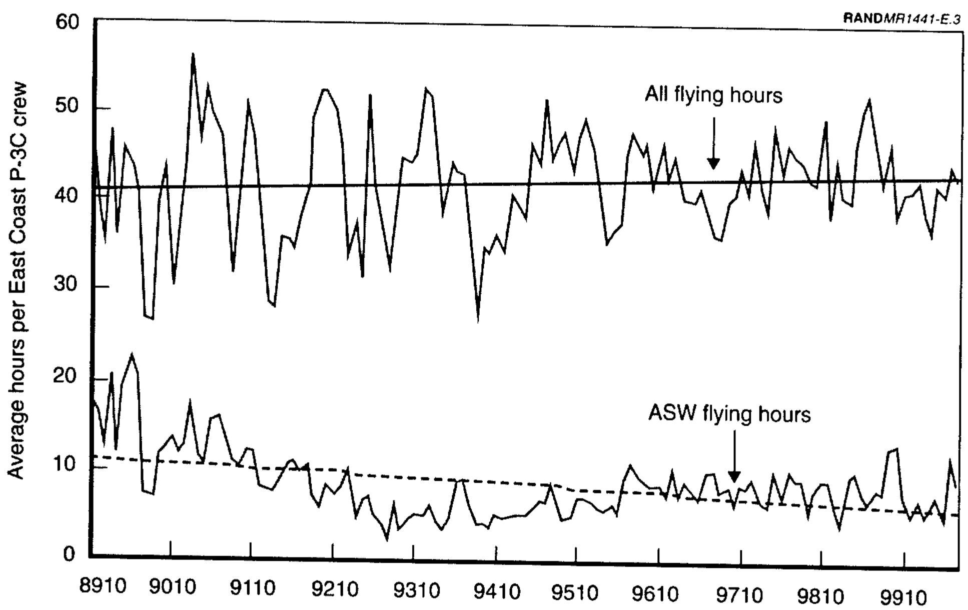

Figure E.3—Total and ASW Flying Hours per East Coast Crew per Month

occurred in ASW-related flying hours. From 1996 to the present, the ASW hours have again slightly decreased.

Figure E.4 shows ASW flying hours as a percentage of the total flying hours. Again, the incorporation of new missions, the wide variability in the monthly average, and the three basic trends are obvious. The declining trend in ASW hours is a function of the new mission requirements for the P-3C, the difficulty in ASW training that stems from the lack of "real" targets, and the decrease in importance of ASW compared to some new missions, such as surface strike.

Part of the variability in both the total flying hours and the ASW-related flying hours stems from the deployment cycle for the P-3C squadrons. Figure E.5 shows both total and ASW flying hours per crew over the 12-month IDTC and the subsequent six-month deployment. The data show not only the large increase in total flying hours during a deployment, but also the reduction in the percentage of the total hours dedicated to ASW missions during deployments.

Figure E.6 shows the average number of aviators in East Coast squadrons and the average length of service (LOS) of those aviators.[9] Although the number of

[9]Aviators are those classified as pilots or NFOs.

RANDMR1441-E.4

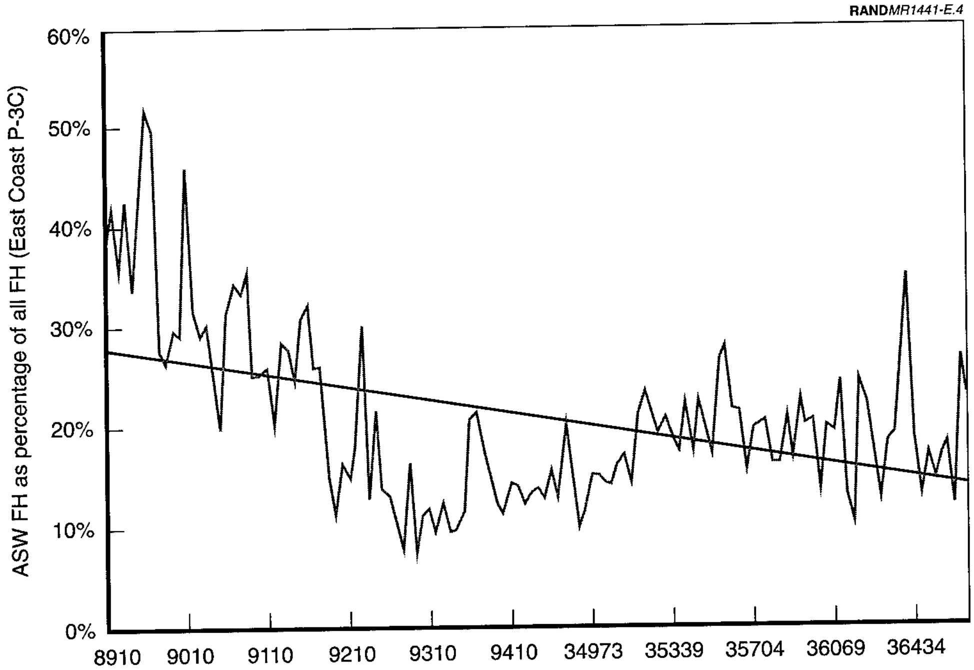

Figure E.4—ASW Flying Hours as a Percentage of Total Flying Hours

aviators slightly increased during the early part of the data, decreases over the past few years have brought the number of aviators back to the levels of the early 1990s. The aviators in the P-3C community have increased experience, which may account for the slight decrease in flying hours per crew. However, the LOS data do not show relevant ASW experience.

Simulators. The P-3C community employs simulators extensively for training both individuals and crews. Almost half (12 of 25) of the events in the T&R matrix require some degree of training on a simulator, resulting in an annual P-3C requirement for 219 simulator-training hours.[10] Many of the other 13 events require practice on a simulator as a prerequisite to conduct the training event in flight.

---

[10]The 12 events requiring simulators include seven of the nine MOB events, three of the six ASW events, one of the five ASUW events, and the one C2W event.

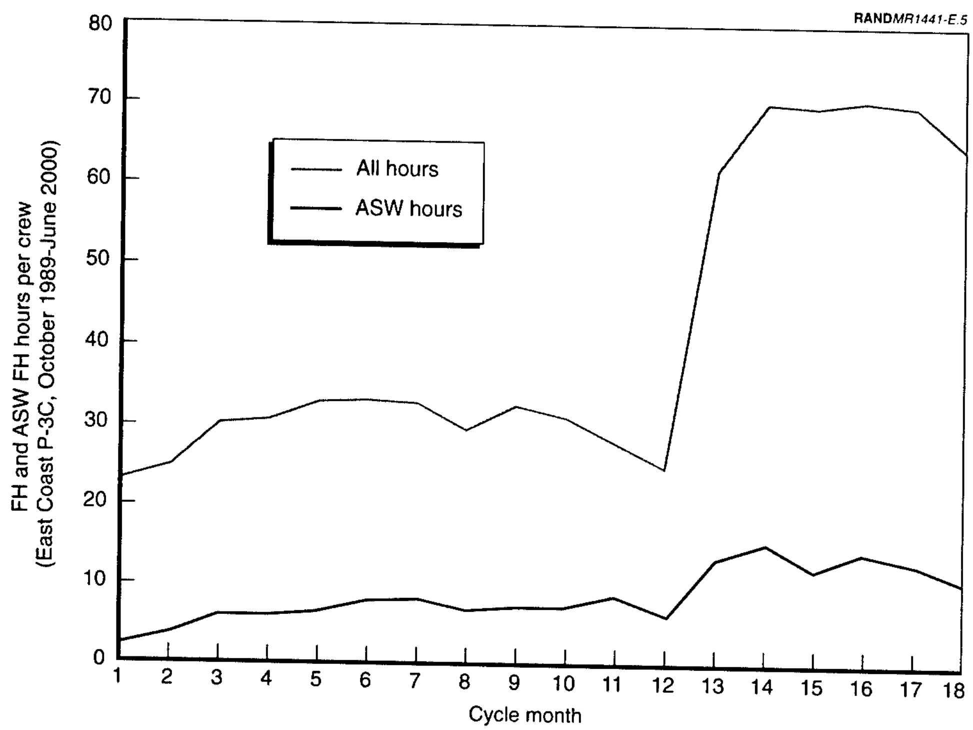

Figure E.5—Total and ASW Flying Hours per East Coast Crew over the IDTC and Deployment Cycle

The P-3C simulators include the following:

- The Operational Flight Trainer (OFT) trains pilots and flight engineers in general airmanship, including emergency procedures. Nondeployed pilots typically spend approximately two hours in the OFT each month.
- The Tactical Operational Readiness Trainer (TORT) provides synthetic signatures for the training of the various sensor positions.
- The WST is formed when the OFT and the TORT operate in a coupled mode. This allows the flight crew to participate in the tactical exercise while engaged in a simulated flight.
- The Acoustic Part-Task Trainer (PTT) provides tactical, high-fidelity acoustic and Extended Echo Ranging (EER) training.
- The Cockpit Procedures Trainer (CPT) provides cockpit familiarization training for pilots and flight engineers at a fraction of the cost of the OFT.

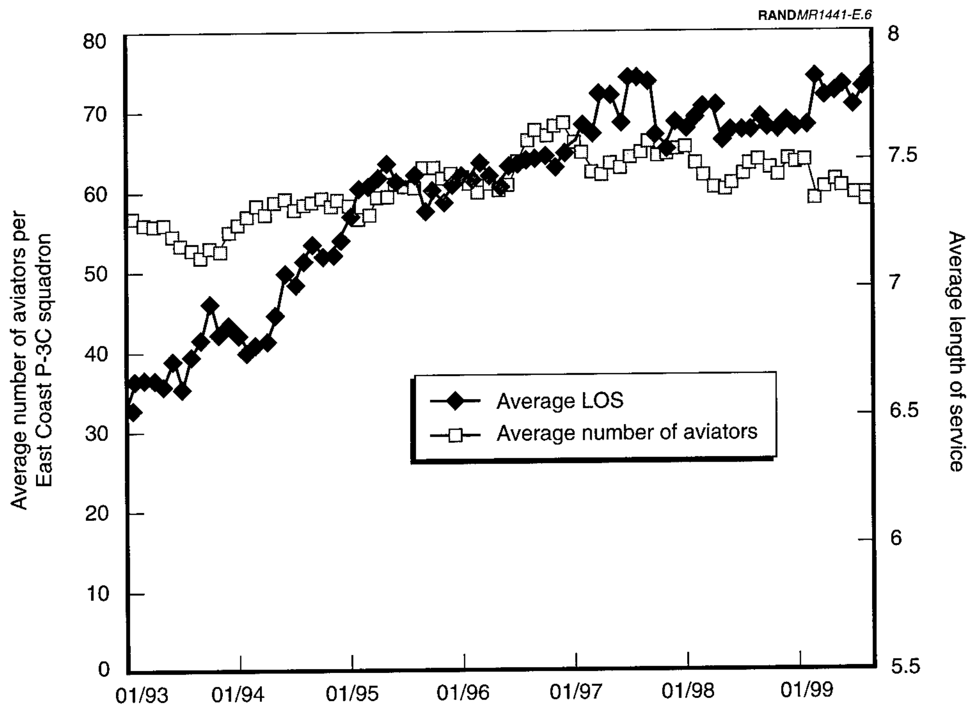

Figure E.6—Average Numbers of Aviators and LOS per East Coast Squadron

- The Sensor Station Three PTT provides nonacoustic (e.g., radar, infrared, and magnetic anomaly detector [MAD]) operator training through synthetic or actual signatures.

Figure E.7 shows the historical aggregate simulator usage in the P-3C community. Unlike the fighter world, the operational P-3C squadrons use the majority of the available simulator time. These data suggest an average simulator use of approximately 21 hours per crew per month during the IDTC.[11]

Figure E.8 shows the average monthly simulator hours per squadron for tactical missions (i.e., not for the mobility training of pilots and flight engineers) and the portion of those hours dedicated to ASW missions for East Coast squadrons over the last decade.[12] The simulator data at the squadron level show similar,

[11]Averaging across all crews yields 14 hours of simulator use per crew per month. During any given month, one-third of the squadrons, and therefore one-third of the crews, are deployed.

[12]The data in Figure E.8 apply for the East Coast squadrons that are in their IDTCs. Therefore, on average, the hours shown in Figure E.8 are spread across four squadrons.

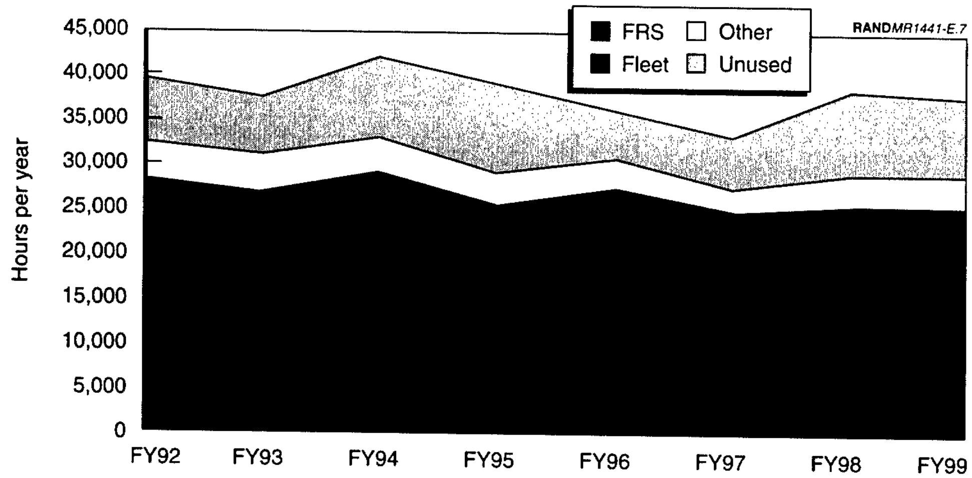

Figure E.7—Aggregate Simulator Usage in the P-3C Community

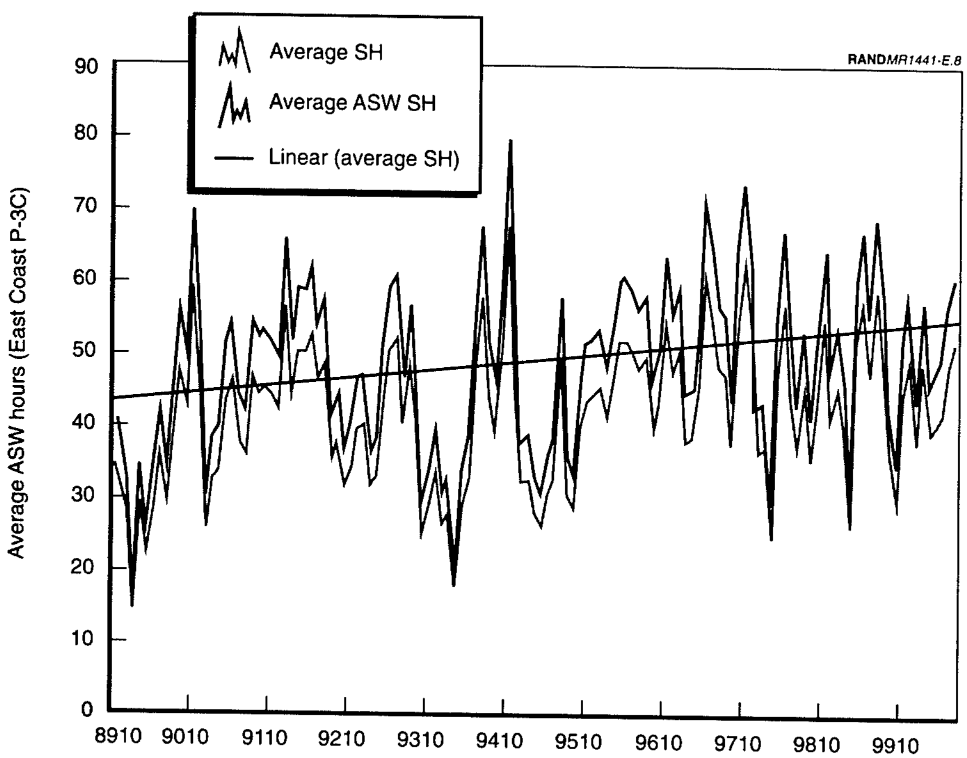

Figure E.8—P-3C East Coast Squadron Simulator Usage

but opposite trends from the flying hour data in Figure E.4. From 1989 to 1991, simulator use was rising while the flying hours were decreasing. From 1991 to 1994, simulator usage declined while flying hours were increasing. Simulator use increased in the mid-1990s until approximately 1996. From 1996 until the present, simulator hours, and flight hours, have been fairly constant.

Figure E.9 shows the average simulator usage for tactical mission training and the portion dedicated to ASW training over the 12-month IDTC and the six-month deployment. The lack of deployable simulators accounts for the significant decrease in simulator training during the six-month deployment.

RAF MPA UNIT TRAINING

The Nimrod MR2 is the RAF MPA used primarily in the roles of maritime surface surveillance, ASUW, ASW, and search and rescue (SAR). It can also assist in other missions, such as enforcing UN sanctions. The aircraft is fitted with radar

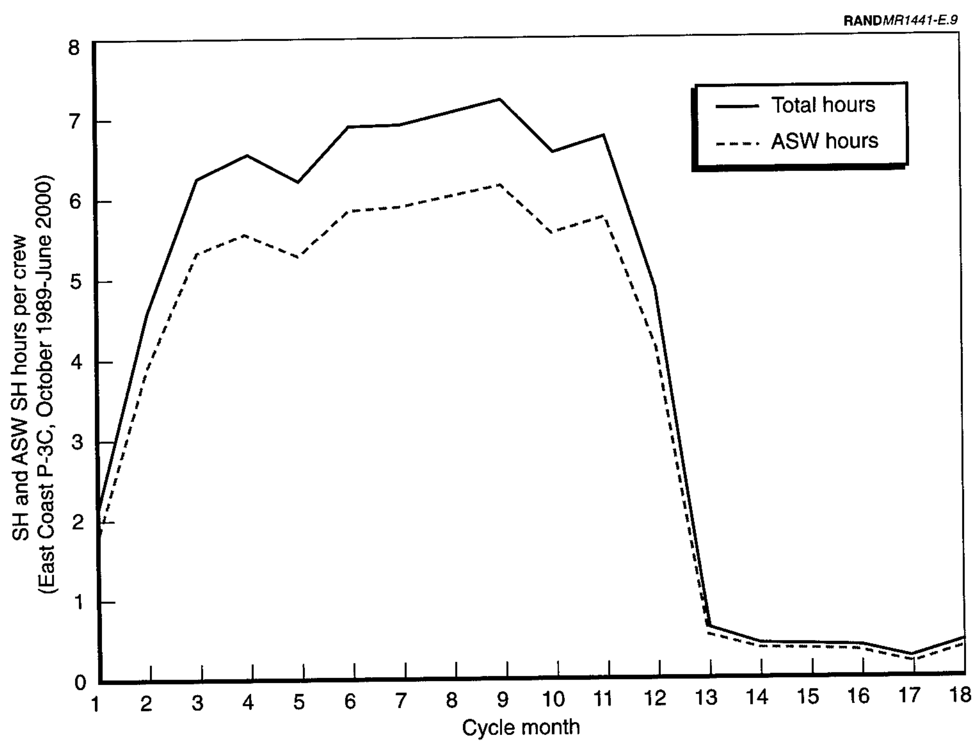

Figure E.9—Total and ASW Simulator Hours During IDTC and Deployment

and magnetic and acoustic detection equipment.[13] Sensors include Searchwater Radar, two AQS-901 acoustic systems and associated sonobuoys, Yellowgate Electronic Support Measures (ESM), MAD, Sandpiper infrared detection system, and a Missile Alert Warning System (MAWS), coupled with wing-mounted chaff and flare dispensers. Its weapons include Stingray torpedoes for ASW, Harpoon missiles for ASUW, and Sidewinder missiles for self-defense. Nimrods operate all over the world, frequently training in the United States, Canada, Germany, France, Norway, Iceland, Cyprus, Gibraltar, Oman, Sicily, the Netherlands, and the Falkland Islands. Occasional visits are also made to Malaysia, Australia, and New Zealand.

Training Philosophy

RAF MPAs use an ab initio training concept. The OCU trains six student crews each year and assigns individuals to operational crews. It usually takes seven months for an individual to achieve limited combat-ready status. After graduation, individuals have nine months to gain combat-ready status, in which they are recertified every 12 months. If the crew as a whole is limited combat-ready, it must go through a six-month training evolution, which includes live flights, simulator time, and an evaluation. Individuals progress upward within a crew and the members in key positions tend to stay together for 12 months. There is a five-year posting cycle so crews lose about one-fifth of their members each year. Losses may be to a sister crew for an individual to gain a higher position. Sometimes crews are rebalanced to keep them at comparable capabilities. Typically, seven out of nine crews are combat-ready with two working toward that goal. There is a "captain" of each crew who comes from one of the senior positions (pilot, flight engineer, or navigator). The crew goes to limited combat-capable if one of the three key positions is limited as an individual.

How Nimrod Squadrons Are Organized and Based

RAF Kinloss, situated 29 miles east of Inverness, Scotland, and approximately 550 miles north of London, is the home base for the three operational squadrons (120, 201 and 206 Squadrons) and an OCU, the equivalent of the U.S. Navy's FRS. The Nimrod fleet totals 28 aircraft with seven airplanes in each of the three operational squadrons and seven airplanes in the OCU. Thirty-one

---

[13]Although retaining the airframe of the MR1, the Nimrod MR2 has completely updated search sensors with advanced radar, new sound detection equipment, and a vastly increased computer capacity. Nimrod 2000 will replace the MR2 fleet in a refurbishment program managed by British Aerospace. The refurbished aircraft, to be delivered between 2001 and 2006, will have new wings, BMW/Rolls-Royce fuel-efficient engines, modern control systems, "glass" cockpit instrumentation, and a comprehensive suite of the latest sensor, computer, and communications equipment.

crews are needed to man the 21 planes in the operational squadrons, but the budget provides for only 24 crews, eight crews per operational squadron (three additional crews are with the OCU). The squadrons fight and train on a wing basis with combat-ready crews and limited combat-ready crews. They select crews from the wings that are combat-ready and deploy them as needed.

Readiness levels have decreased for a number of reasons. The Nimrod MR2 aircraft is old, especially the airframe and sensor systems, making it difficult to keep mission-ready aircraft available for training and operations. More important, the RAF is experiencing difficulties recruiting and keeping enough people. Personnel problems plus budget constraints have kept the number of crews below the 31 authorized. The original goal for the MPA squadrons was to have 16 aircraft and 21 crews combat-ready with 10 days' notice. To meet this goal, instructor crews would have to be integrated into the operational squadrons.

How Training Is Conducted

The Nimrod has a crew of 13 that utilizes five of the aircrew trades in the RAF. A crew, once constituted, stays together in training and operations. Two pilots and an air engineer make up the flight deck, while two navigators and an air electronics officer (AEO) work alongside seven air electronics operators in the back of the plane. The Nimrod captain can be a pilot, a navigator, or the AEO.

The navigators are classed as Nav1 and Nav2 and take turns in the two seats available to them—the TacNav's position and the RouteNav's position. The RouteNav is involved in the main navigation of the aircraft, concerned with where the aircraft is in the world at any given time. The TacNav "fights" the aircraft, absorbing the mass of sensor information available and using it to achieve the given task. The AEO serves as a liaison between the navigators and the sensor operators. He works closely with the TacNav, ensuring that the right information is filtered from the sensor operators.

The seven air electronic operators divide into two teams, the "wet team" and the "dry team." The wet team operates two on-board acoustics sensors. This system monitors sonobuoys, which the crew drops into the sea to monitor acoustics. The wet team is chiefly responsible for photography, although all air electronic operators can perform this task. The dry team manages the above-water sensors—namely the Searchwater radar, the Yellowgate ESM system, and the MAD—and operates the Nimrod's extensive communications suite.

The Nimrod has no tactical display on the flight deck, so the operators in the back of the plane must verbally provide the complete combat picture. Therefore, the flight deck officers primarily operate the aircraft, while one of the navigators in the back of the aircraft actually coordinates the missions.

With the new aircraft, the size of the crew will decrease from 13 to 10 (the crew will lose an engineer, an AEO, and a sensor operator). Simulator requirements for the new aircraft will be based on the use of the current aircraft—i.e., 50 hours per month—while flying hours will slightly decrease. With better equipment, the MPA fleet should have better capability, and, therefore, fewer crews and less training should be one advantage of the upgrades.

Nimrods have three core missions—ASW, ASUW (Strike), and SAR—far fewer than the missions of the U.S. Navy's P-3C. The RAF perceives that the P-3C is moving away from ASW missions to more of a land-attack role with missiles—e.g., the Standoff Land-Attack Missile (SLAM).

The Operational Training Requirements (OTRs) consist of four areas, each with multiple training events.

- For the flight deck (pilots), some events are done either live or on a simulator, while other events can only be done live or only done on a simulator (e.g., stalling).
- Crew emergency training (such as ditching skills) is accomplished with half live flying and half simulator time.
- Role training is all simulator-based and includes an SAR exercise. This type of simulator training is perceived as better than the training value of actual operations because Nimrods normally go on operations autonomously and thus have no assets to train with. Occasionally a crew can integrate with an ongoing exercise for live training, but this is a bonus.
- Weapons training consists of ground-based lectures and a simulator event to practice procedures. This is similar to the training procedures of the OCU. Crews first hear material in a classroom, then practice on a simulator, then test on a simulator, and in the end actually do the procedure in the air.

How Training Is Resourced

Personnel. Nimrod crew experience is generally much higher than that of P-3C crews. Senior noncommissioned officer crew members are career aircrew. They usually enter at age 18 and stay until age 55. Most of their time is spent at the one operating base in Scotland. Occasionally, they go to such organizations as DERA as analysts or to the OCU as instructors. The community can integrate junior people easily because of the number of senior people with experience. Also, because equipment changes slowly, experience matters more.

Officers have different career patterns. If they are on a career path (which most are), they rotate to staff assignments, which may hinder their operational experience. If they are on an aviation career path, they can fly to age 55. In this status, personnel do not get an increase in rank but do get pay increases. With downsizing, the Nimrods lost one operational squadron and one base, so both officers and enlisted go to Scotland for their squadron posting. Crew retention has been decreasing with more people leaving now at reenlistment points resulting in fewer experienced people in the units.

Flying Hours. Each crew has a minimum of 30 hours of live training per month. The minimum has been constant over time, but actual flying hours have been decreasing toward this minimum. The crew captain can pick specific training missions for up to 30 percent of the 30-hour requirement. A typical crew-training sortie can last up to eight hours and be flown anywhere between Iceland and the west coast of France.[14]

About 10,000 flying hours are budgeted per year for the base. After conducting assigned operations, the remaining hours are used for training. Actual hours flown per month can swing widely month-by-month. Each crew gets about 360 flying hours per year. Of this, about 11 percent goes for ASW operations; 20 percent is of no training value (e.g., ferrying); 40 percent is for training (core plus three roles plus pilot training and exercise support); the rest is used for targets of opportunity training, exercises, and non-ASW operations (in support of other departments). For the training part, an experienced officer estimated that about 50 percent is ASW, 35 to 40 percent is ASUW, and 10 to 15 percent is SAR.

Simulators. A mandated level of currency in certain events includes time in a very good full mission simulator. This includes 10 five-hour sessions per crew every six months. The Nimrod has an embedded acoustic simulator so it can train without an actual target during flights. This on-board acoustic training computer is considered key to success. The crew can decouple it to do cubicle exercises on long transits. Each pilot gets three hours per month in the dynamic simulator. The British also have acoustic, navigation, electronic warfare, and radar cubicles, and each operator must complete one cubicle event per month to keep up individual qualifications. Figure E.10 shows the average hours per month Nimrod crews spend on ASW operations and training, both in live flight and on a simulator.

The simulators have good fidelity. Targets can have multiple signatures (e.g., acoustic, EW, radar). A crew can fight a complete major war or against only

---

[14]The Nimrod has a flight time of nine hours (14.5 hours with in-flight refueling). It flies to its area at the same altitudes as a commercial airliner before descending to as low as 200 feet over the sea while "on task." The four Spey engines allow a fast transit to the operating areas. Once there, one engine is usually shut down, with another idling to conserve fuel and extend mission times.

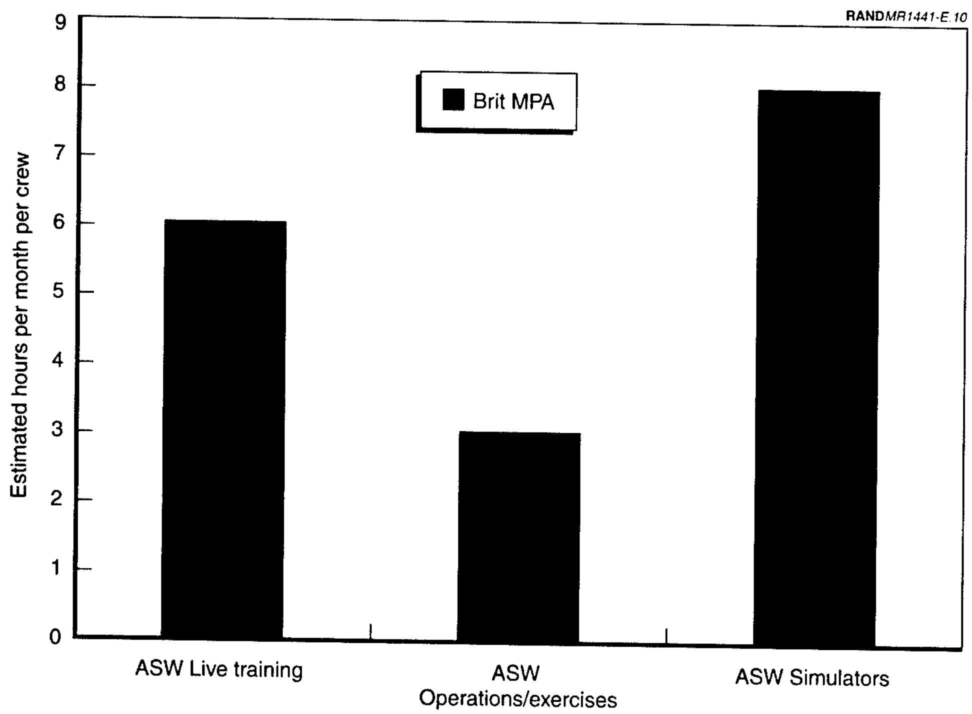

Figure E.10—British MPA Estimated Hours per Crew

certain platforms. The capacity of the simulators is designed and sized for the 31 crews. They are available 18 hours a day. The OCU frequently uses the same simulators and has priority for daytime slots. A mix of active-duty and retired military and civilian personnel staffs the simulators. The RAF MPA community view is that Nimrod simulator capability is 10 to 15 years ahead of other countries (e.g., the United States or Australia). The full mission simulator came with the aircraft. The RAF upgrades it as the aircraft and its sensor suite is modified. The upgrade, with integration, is included with the aircraft modification contract. However, simulator modifications may lag the changes made to the Nimrod by up to six months. New contracts always include simulator upgrades.

FRENCH NAVY MPA UNIT TRAINING

How MPA Squadrons Are Organized and Based

The French Navy operates several MPA squadrons composed of different types of aircraft (see Figure E.11). Two squadrons of Atlantique 2 aircraft perform the

RANDMR1441-E.11

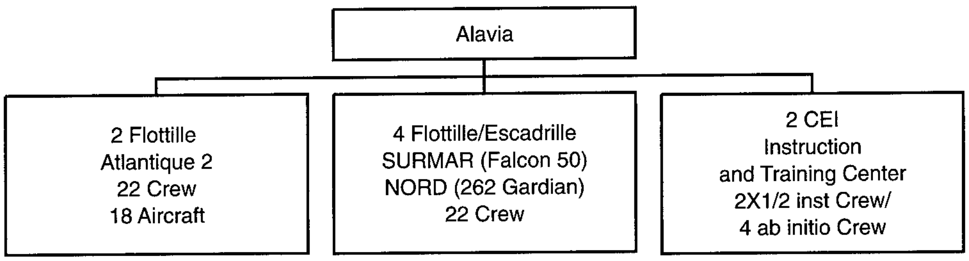

Figure E.11—French Navy MPA Organization

ASW mission.[15] One squadron (21 Flotille) is based at Nimes-Garons and the other (23 Flotille) is based at Lann-Bihoue. Each squadron has nine aircraft and 11 crews.

The Atlantique 2 squadrons are land-based but are devoted to combat missions over the ocean. The basic missions are ASW and ASUW that include locating enemy ships and submarines, which they can subsequently attack and destroy. Secondary missions include intelligence gathering, SAR, humanitarian operations, and joint operations with the French Air Force and Army. In peacetime, the Atlantique 2 squadrons are tasked to monitor pollution and fisheries in addition to other civilian-oriented missions. The French Navy is trying to decrease the Atlantique 2's role in these types of missions and transfer them to the Falcon 50 squadrons because of their smaller crews and lower costs.

Each Atlantique has 13 crewmembers: two pilots (pilot and copilot), two flight engineers, one tactical coordinator, three acoustic operators, two or three radar/navigation operators, and two or three electronic transmission operators (see Figure E.12). Once formed, a crew remains together for three to four years.

Individual training for eventual crewmembers is conducted at Nimes. Graduates of individual training join an operational crew as a third operator to build up experience. After one year in this position, crewmembers qualify to become a member of a three-year operational crew and enter the ab initio crew process.

---

[15]The Atlantique 2s were introduced in 1991. The design is very similar to the Atlantique 1 with a newer airframe. See http://frenchnavy.free.fr/Atlantique_2.htm for details of the Atlantique 2 aircraft.

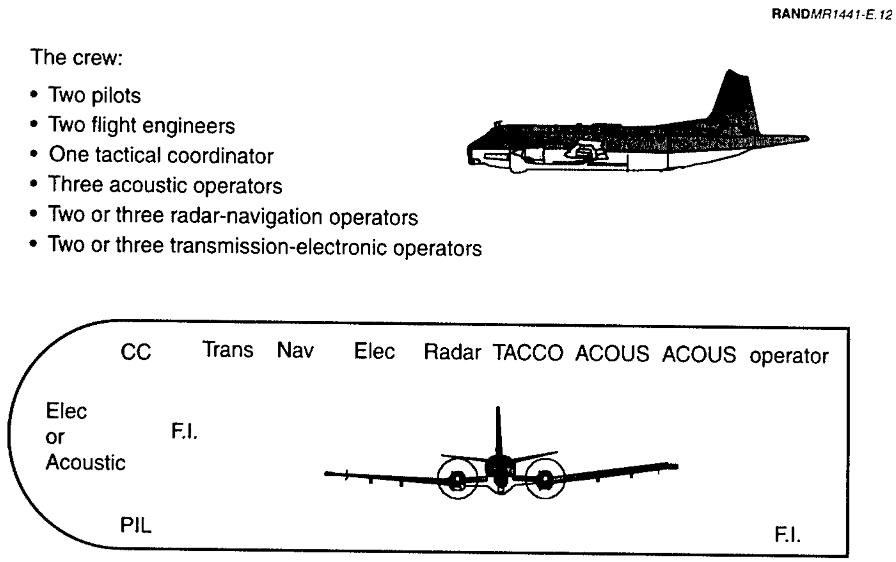

Figure E.12—Atlantique 2 Crew Composition

The ab initio process allows crew members to advance together. For example, the copilot in an existing crew will enter the ab initio process as a pilot for a new crew. Other members of former crews advance to new positions in the ab initio crew. The ab initio training is conducted at the school at Nimes and Lorient and lasts approximately nine months.[16] The course includes 200 flight hours in the Atlantique 2, 35 tactical simulator events of four hours each, and 25 flight simulator events of two hours each. The crew also drops approximately 600 sonobuoys during the training process. At the end of the training, the crew takes a comprehensive examination 60 hours long that lasts three to four weeks. Once the examination is passed, the crew receives certification for full operational missions. As mentioned, operational crews stay together for three to four years.

How Training Is Conducted

The French MPA community places special emphasis on crew stabilization and integrated training. During the training process, the focus is on crew qualification, not qualification of individual crewmembers. Training is first done on a crew basis and then advances to cooperation between crews and eventually to

[16]There are six instructors for the two or three ab initio crews in training at any point in time.

battle group training. Although the French Navy once considered having specialized crews for specific missions, all crews are trained in all MPA missions.

Like their counterparts in the fighter community, each crew must accomplish a series of training events to become operationally ready to perform the range of MPA missions. The community has performed analyses to determine which events can be accomplished in a simulator and which must be done with live flights.

How Training Is Resourced

Personnel. Two basic officer career patterns occur in the MPA squadrons. Naval Academy graduates join a crew for two years as copilots before going to ab initio training for advancement to pilot positions. Afterward, they serve two to three years in their new crew. After their initial seven-year tour, Naval Academy graduates will transition to a staff or acquisition-related position. Non–Academy graduates serve three years as copilots before entering the ab initio process. They then spend the remainder of their careers (typically 15 to 20 years) in either operational squadrons or in the training squadron.

Flying Hours. Typical crews get 300 to 350 flying hours per year, of which approximately 30 percent are dedicated to ASW training events. These live events include at least one flight per week to ensure safety of flight. Sortie lengths can be 10 to 12 hours long, of which transit time can be as low as one hour for local missions and up to five hours for missions in the Indian Ocean region. Although they have no operational training ranges, the MPA squadrons receive excellent support from French and other European nations' submarines for training. Each crew drops one torpedo annually in training. Every two years, one crew in each squadron fires an Exocet missile. The live-fire flight is supplemented with one three-hour flight simulator event and one four-hour tactical simulator event.

Simulators. Simulators are important to French MPA training because they are moving to less flying time and more simulator use. Typically, crews use simulators to plan and practice (rehearsal) before they fly a mission. Simulators are located at each base as well as at the training squadron. All the crew, including the pilots, uses the tactical simulator. Only the pilot, copilot, and flight engineer use the flight simulator. The simulators are kept current with any changes in the aircraft. No on-board simulation capabilities are on the Atlantique 2. The flight simulator emphasizes procedures, such as instrument procedures and emergency actions.

Previously, the French MPA community would use 15 actual flights of one to 1.5 hours to ensure aircrew qualifications. The last flight was basically an examination conducted by the squadron commanding officer. The cost of this method (approximately $10,000 per flight) was judged to be prohibitive and emphasis was shifted to the use of the simulator. Now, 10 to 12 simulator events take place and then two live flights, the second of which is the examination.

COMPARISON OF UNIT TRAINING FOR MPA AIRCRAFT

Table E.3 compares the average flying hours and simulator hours per crew per month for the U.S. Navy P-3Cs, the British Nimrods, and the French Atlantiques. The total simulator hours for the P-3C are based on the data displayed in Figure E.7. The executed flying hours and tactical mission simulator hours for the P-3C are based on the data for the East Coast squadrons and represent averages for FY 1999. The mobility simulation hours for the P-3C are the total hours minus the tactical mission hours.[17] The British and French values are our best estimates based on our discussions with the Nimrod and Atlantique communities.

The average flying hours per crew per month for the P-3Cs are much greater than the flying hours for the Nimrods and Atlantiques. However, the average of 45 hours per month is really not representative of the P-3C community. During their IDTC, the P-3C crews fly an average of approximately 30 hours per month, while during deployments, the crews average close to 70 hours per month. The P-3C flying hours during the IDTC are very similar to the flying hours for the Nimrods and Atlantiques.

The similarity between the flying hours in the three communities is striking considering other differences among the three cases. The British Nimrods and

Table E.3

MPA Flying and Simulator Hour Comparisons

	Flying Hours per Crew per Month		Simulator Hours per Crew per IDTC Month		
	Programmed	Executed	Mobility	Tactical	Total
USN P-3C	50	45	14.4	6.6	21.0
RAF Nimrods	30		3.0	9.3	12.3
French Navy Atlantiques	27		3.5	6.2	9.7

[17]The mobility simulator hours calculated in this fashion compare favorably with the monthly mobility simulator hours in the WTM (see Table 2.10)

the French Atlantiques have far fewer missions than the P-3Cs. Where the P-3Cs have seven primary missions (and seven secondary missions), the British and French MPA have only three with some specialization among their squadrons. Also, the British and French have greater crew experience levels and continuity. These factors suggest they can attain the same levels of readiness as the P-3Cs with fewer flying hours.

One difference in flying hours may be how transit and other indirect time factor into the flying hour averages. As indicated in Table 3.1, the P-3C flying hours include only "on station" hours. The French and British values may include transit time, biasing their flying hours upward compared with the P-3C. An alternative explanation is that all three communities fly similar hours, but the French and British concentrate more of their hours on ASW missions and attain a higher degree of proficiency in ASW missions. Unfortunately, further data and information are needed to understand the similarities and differences in the flying hour programs and simulator usage in the three communities.

Table E.3 shows that the tactical mission training simulator hours are very similar for the P-3Cs and the French Atlantiques. What is striking is that the British appear to use about 50 percent more hours for tactical mission training compared with both the P-3Cs and the Atlantiques. Also, both the French and the British use far fewer simulator hours for the training of their pilots and flight engineers compared with the P-3Cs. The small number of mobility-related simulator hours might stem from the higher experience levels of the British and French crews compared with the experience level of the average P-3C crew or from the fact that the British and French do not have the IDTC deployment pattern of the P-3Cs.

Appendix F

SURFACE SHIP ASW TRAINING

This appendix describes the tactical training of DDG-51-class ships, focusing on the ASW mission.[1] It outlines the current training philosophy and organizational responsibilities during IDTC, the various mission-related events in the T&R matrix, and the use of live, simulated, and schoolhouse events in tactical unit training. The section also describes the training philosophy and approach for British and French ASW ships. It concludes with a comparison of U.S., British, and French tactical unit training.

USN DDG-51-CLASS TACTICAL TRAINING

DDG-51-class destroyers, like most U.S. Navy ships, typically deploy for six-month at a stretch. The time between deployments—the IDTC—currently lasts approximately 18 months. When a ship returns from deployment, the first six months of the IDTC is devoted to crew leave, ship maintenance, and a ship shakedown period to prepare the ship and crew for the training prior to the next deployment. The training phase of the IDTC is approximately 12 of the 18 months.

Over the last few years, a number of workload reduction and quality-of-life improvements initiated by the former Chief of Naval Operations (CNO) have substantially modified the duration and training philosophy of the IDTC. The major changes and current status of the IDTC include the following:

- The length of the IDTC has increased to 18 months.
- The length of the formal Basic Phase training period (discussed below) is now 16 weeks versus 26. The commanding officer of the ship has control over how the other 10 weeks are spent.

[1]U.S. Navy ships are assigned undersea warfare (USW) missions in the *Surface Force Training Manual* (U.S. Navy, 1999b). These missions are primarily ASW but also include antimine warfare. We use the term ASW to indicate the USW missions for DDG-51-class destroyers.

- Time away from the homeport during the IDTC is limited to an average of no more than 28 days per quarter.
- The commanding officer determines which training events are needed during the Basic Phase. These are then approved by the immediate superior in command (ISIC). Training resources and assistance are "pulled" from various training providers versus "pushed" to the ship by those providers.
- Many of the former mandatory inspections, certifications, assessments, and reporting requirements have either been eliminated or greatly reduced.

How IDTC Training Is Conducted

The approximately 12-month training portion of the IDTC is broken into three phases: Basic, Intermediate, and Advanced.[2] The Basic Phase lasts approximately six months and is the responsibility of the type commanders and the ship's commanding officer. It concentrates on unit-level training emphasizing mobility (navigation, seamanship, damage control, engineering, and flight operations), basic command and control, weapons employment, and warfare specialties. The goal for the ship is the M-2 level of proficiency in all mission areas by the end of the Basic Phase.

The numbered fleet commanders have the responsibility for training during the Intermediate and Advanced phases. The Intermediate Phase lasts approximately three months and concentrates on warfare team training and initial multiunit operations. During this phase, ships begin to develop warfare skills in coordination with other units while continuing to maintain unit proficiency. The Intermediate Phase involves one or more combined (i.e., multiunit) exercises.

The last two months of the IDTC is the Advanced Phase of training, which continues to develop and refine integrated battle group warfare skills and command and control procedures. The objective of this phase is to ensure that all units in the battle group are prepared to support the battle group commanders specific mission requirements. A joint exercise involving multiple surface, air, and subsurface units is part of the Advanced Phase. By the end of the Advanced Phase, a unit should have completed all training events and exercises and be M-1 in all mission areas.

---

[2]The training objectives and approach for all ships during the IDTC is outlined in the *Surface Force Training Manual* (U.S. Navy, 1999b). This basic instruction is supplemented by *Surface Force Training Manual Bulletins* that provide more-specific mission area information and other selected training information and guidance.

Specific Milestones During the IDTC. The various milestones that occur during a ship's training cycle are shown in Figure F.1. A ship's training cycle begins with the initial Command Assessment of Readiness and Training (CART I) developed about halfway through a ship's deployment. CART I is a ship's self-assessment of operational proficiency, formal school training requirements (based on the current and projected crew composition), team training requirements, and material/equipment status. CART I helps the ship's commander and training officer focus on training strengths and weaknesses to properly plan the training required during the IDTC.

CART II, conducted by the ISIC with support from the Afloat Training Group (ATG), normally follows the maintenance period after deployment. It is used to determine the specific training necessary during the Tailored Ships Training Availability (TSTA). CART II nominally lasts one week, including two to four days under way, and focuses on a full spectrum validation of existing strengths in training team organization and watchteam performance.

Following CART II, ships undergo one or possibly two TSTAs, which are specific training periods that support the ship's and ISIC's training syllabus. They are supported and evaluated by the ATG. The focus is on the shortfalls in training team development and watchteam proficiency identified during CART II. Duration of the TSTAs varies depending on the ship's demonstrated proficiency during CART II. Ships requiring the most training have a three-week TSTA with one-week in port and two weeks under way starting approximately three weeks after CART II. A second TSTA starts approximately two weeks later and includes one week in port and three weeks under way.

Specialty training includes salvage training, MIW training, AMW training, and special operations training. The type commander determines if these specialty-training areas are integrated with the TSTAs or are conducted separately.

RAND*MR1441-F.1*

Deploy	Basic	Intermediate	Advanced
CART I	CART II TSTA 2 TSTA 1 Specialty FEP	COMPTUEX	JTFEX

Figure F.1—Milestones During the IDTC

The Basic Phase concludes with the Final Evaluation Period (FEP). The FEP is conducted by the ISIC with support from the ATG. The purpose of the FEP is to ensure that the ship has the training tools in place to continue effective training throughout the IDTC and to ensure that the ship possesses sufficient watch-team proficiency to proceed to the Intermediate and Advanced phases of training. The ISIC provides the final evaluation of the ship's ability to proceed in training.

During the Intermediate and Advanced phases, the numbered fleet commanders assume overall responsibility for training. The focus of training shifts from the individual ship to coordination between multiple units and within the battle group context. The Intermediate Phase has a major COMPTUEX and the Advanced Phase has a JTFEX involving the entire battle group.

Training Events During the IDTC. The Surface Force Training Manual lists formal school training requirements and various training events each class of ship must accomplish in its assigned missions areas. The number of training events designated for each phase of the IDTC for Pacific Fleet[3] DDG-51-class destroyers is shown in Table F.1.

Certain training events, because of their particular importance in maintaining operator or team proficiency, must be repeated at regular intervals. These are listed in Table F.1 as repetitive events. For example, the ASW training event

Table F.1

Pacific Fleet DDG-51-Class T&R Events

Mission Area	Basic	Inter-mediate	Advanced	Equiva-lencies	Repetitive Events
AMW	2	0	0	1	2
AAW	22	4	4	20	3
Command and control warfare	14	7	3	2	9
CCC	28	1	0	7	29
Fleet support operations	11	0	0	0	11
Intelligence	7	0	10	0	0
MIW	1	0	0	0	1
Mobility	46	1	1	0	36
Noncombat operations	18	0	0	0	14
STW	2	0	0	0	2
Surface warfare	13	3	0	7	10
Undersea warfare	20	15	7	26	23

SOURCE: U.S. Navy, 1999b.

[3]Certain events accomplished during the Basic Phase by Pacific Fleet ships, particularly those that involve the use of live fire ranges, take place during the Intermediate Phase by Atlantic Fleet ships.

"Acoustic Environment Prediction" (ASW-2-SF) must be repeated every three months to maintain the M-1 proficiency level. If not, the proficiency level drops to M-2 after three months, M-3 after six months, and finally, M-4 after nine months.

The Surface Force Training Manual allows certain training events to be accomplished through the use of training devices and simulators. Often, these devices input signals or scenarios into the actual on-board equipment to simulate a contact or other needed training input (i.e., they stimulate the equipment). An "equivalency" may be granted when the objective of a training event is essentially fulfilled through the use of on-board or shore-based training devices. The ISIC has the authority to grant equivalencies. The number of events in each mission area that can be accomplished on training devices and simulators is also shown in Table F.1.[4]

Use of Steaming Days During the IDTC

As is evident from the numerous mission areas and training events shown in Table F.1, a ship must accomplish many things during the IDTC. However, many different events, in different mission areas, are often accomplished during one training period. For example, the ship commander may use a steaming day to qualify in most or all of the mobility and fleet support events and, at the same time, accomplish training events in other mission areas. Also, the ship does not have to be under way to qualify in many events. As mentioned, the use of on-board training devices can provide equivalencies in certain events while the ship is at the pier.

For the above reasons, it is impossible to associate steaming days with training in specific mission areas. Even when a ship steams to a training range for specific mission training, the ship's commanding officer will attempt to qualify in other training events during the time at sea.

How Training Is Managed

Various ratings under the SORTS are used to describe the ability of the ship's personnel and equipment to perform the various wartime missions. In the training area, the ratings range from M-4, the lowest or least ready, to M-1, the

[4]Note that not all classes of ships have on-board training devices that can be used for equivalencies. For example, one shipboard scenario generator that can be used for equivalencies for many ASW training events is the AEGIS Combat Training System, which is only on AEGIS-equipped ships.

highest or most ready.[5] The objective of the training portion of the IDTC is to bring the ship to the M-1 level by the end of the Advanced Phase of training.

The majority of the training events listed to Table F.1 have a readiness "clock" under which the training rating for the event decreases over time until the ship is again certified in the event. That is, when a ship successfully completes a training event, it is awarded M-1 in that event. If an event is repetitive (i.e., has a readiness "clock") with, for example, time settings of three, six, and nine months, the M rating will decrease to M-2 if the event is not accomplished again within three months, to M-3 if not accomplished within six months, and to M-4 if not accomplished within nine months.

The Surface Training Manual contains a formula for converting the M status of each of the ship's events into a composite M rating for SORTS.[6] The formula gives four points for each M-1 event, three points for each M-2 event, and two points for each M-3 event (with no credit for events at the M-4 level). The total number of points "earned" is divided by the total number of points possible (four times the number of events) to develop the composite score between zero and one. The composite score is converted to an overall M-rating based on a graduated scale (e.g., composite scored of 0.850 to 1.000 result in an M-1 rating).

Conducting ASW Training

ASW Mission Areas. During the Cold War, ASW was the primary focus for U.S. destroyers. The large and powerful nuclear submarine force of the Soviet Union was viewed as the primary threat to U.S. Navy operations, particularly in the open oceans of the world. ASW dominated much of the training for destroyers. Also, the presence of Russian submarines provided numerous opportunities to practice that training during deployments.

The end of the Cold War and the collapse of the Russian submarine force led to a reduction in the priority of ASW training. Other missions, such as antiair, land strike, and ASUW, now have higher priorities, both in operations and in training. Likewise, the focus for ASW training has shifted from the threat of nuclear-powered, deep-water submarines to diesel-powered submarines in shallow water. Advances in stealth techniques for diesel-powered submarines plus the

[5]Training events are "zeroed" (i.e., set to M-4) at the start of an overhaul or major maintenance period of six months or longer. Ships in an overhaul status are assigned an M-5 rating, which is raised to M-4 on completion of the overhaul.

[6]See Chapter Five, Section Two, page 5-2-2 of the *Surface Force Training Manual* for a description of the readiness formula.

detection difficulties in a littoral environment have made the ASW mission even more difficult.

This increasing difficulty is compounded by the lack of real-world training opportunities. The U.S. Navy has no adequate shallow-water training areas, and ASW teams have few opportunities to practice against diesel submarines. Foreign submarines are rarely available as potential training targets and, even when they participate in joint and combined exercises, their operations are often restricted or orchestrated. Therefore, although ASW is part of training during the IDTC, there is little opportunity to practice that training in a purely "live" environment, especially when deployed.

Numerous people are involved in ASW operations on board a DDG-51-class ship.[7] Fifteen to 20 people in the ship's Combat Information Center (CIC), including sonar technicians (STs),[8] operations specialists, and EW analysts participate in ASW missions (as well as many other mission areas). In addition, approximately eight STs operate various sonar and other detection equipment that feed information to the CIC. Thus, ASW team training is manpower intensive and requires a good deal of coordination and integration.

Figure F.2 shows the average number of STs assigned to DDG-51-class ships over the past several years. The number assigned grew from approximately 12 per ship in 1993 to approximately 18 per ship in 1995. Since then, the average number of STs on DDG-51-class ships has stayed between 16 and 18.

Figure F.3 shows the average years of service for STs on DDG-51-class ships over the past several years. Average years of service peaked at approximately 7.6 years in 1997. STs currently average approximately 6.8 years of service.

Schoolhouse Training for ASW Technicians. STs take various schoolhouse courses as they progress through their careers. New recruits in the ST field take basic sonar introduction, basic acoustic analysis, and sonar system operator courses. Those recruits on four-year enlistment are then detailed to a ship to receive unit-level training. Recruits who have agreed to six-year enlistment take additional courses in digital electronics and equipment repair before they are assigned to a ship. At this stage of their careers, they are considered apprentices in the field.

---

[7]ASW operations require the coordination of many different types of assets. For example, protecting a battle group against enemy submarines will involve different ships of different classes, helicopters, and MPA all operating in an integrated manner.

[8]A DDG-51-class ship has a requirement for 20 STs in the Ship Manpower Document with 17 to 19 actually assigned to a ship (see Figure F.2). The STs on a ship are divided into two teams to provide around-the-clock coverage when required.

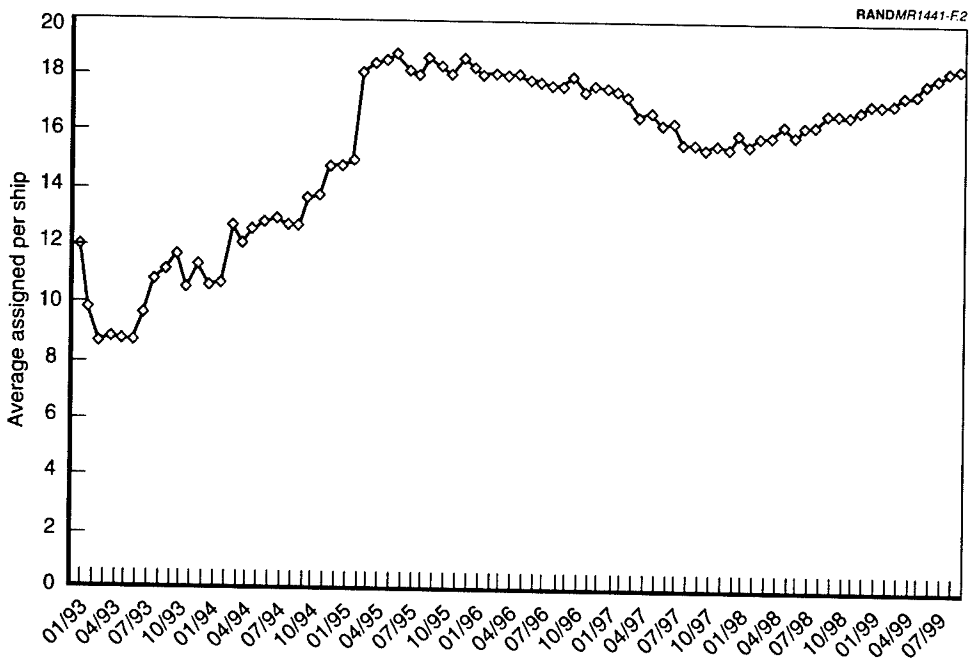

Figure F.2—Average Number of STs Assigned to DDG-51-Class Ships

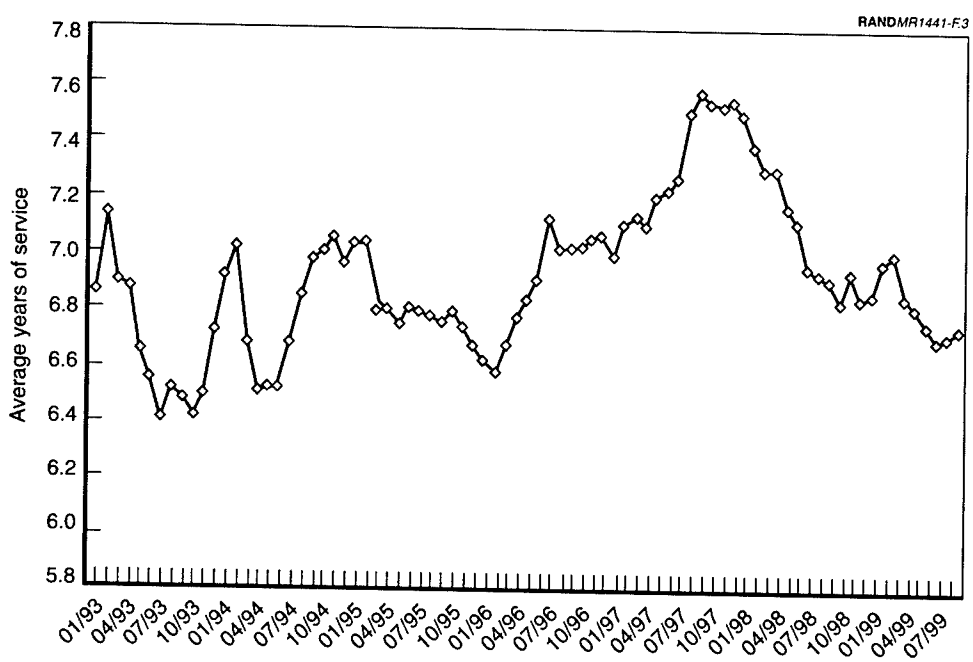

Figure F.3—Average Years of Service of STs on DDG-51-Class Ships

After their first deployment on a ship, STs will take additional individual-level courses and, depending on their career decisions, may advance to journeyman and eventually master levels in the ST field.

Once assigned to a ship, STs will have schoolhouse training at the team (i.e., ship) and task group level. The Surface Force Training Manual lists 15 different ASW courses for the DDG-51-class ships. Some of these courses are at the team level, while others are at the individual level. The manual also defines the number of STs on a ship that must receive various courses. For example, at least two of a ship's STs must take the ASW evaluator course.

The primary school for ASW-related courses is the Fleet ASW Training Center (FLEASWTRACEN) in San Diego.[9] This school provides both individual training (A and C school) and unit/team training for surface ships. While the A and C school courses concentrate on instruction in the operations and repair of equipment and on the recognition of various sonar inputs, the unit/team courses concentrate on coordination, integration, and thinking through a tactical situation.

The primary unit/team course is the single-ship ASW course. This course includes six days of classroom instruction plus six days of training on the schoolhouse simulators. The course is offered almost on a continuous basis and is one of the course requirements during a ship's Basic Phase of training.

The ASW evaluator course is another requirement during a ship's Basic Phase. It includes approximately 16 days of classroom instruction and 10 days of training on the simulators. Two other team courses are offered by the FLEASWTRACEN. One is the relatively new task group ASW team course. The other is the coordinated ASW course that involves aviators (i.e., MPA and Light Airborne Multipurpose System crews) working together with surface ASW teams.

Resourcing the Training: Simulators for ASW Missions

Because of the lack of real-world targets, almost all ASW training involves some degree of simulation. The Surface Force Training Manual recognizes the need for simulation by allowing simulator equivalencies for 26 of the 42 ASW training events.

Individual ships typically have on-board trainers that stimulate the ship sonar equipment through the input of recorded data. The FLEASWTRACEN also has a

[9]There is no separate FLEASWTRACEN for the Atlantic Fleet. The Fleet Training Center in Norfolk has a separate department that teaches the ASW courses at the unit/team level.

Tactical Control Device that sends signals to the on-board trainers when a ship is at the pier. These devices allow the STs on a ship to train with their own equipment.

The FLEASWTRACEN has various simulators they use for their individual and unit/team courses. These simulators are generic and do not attempt to emulate in detail any specific system. The 14A12 trainer focuses on single-ship training and has a high-fidelity display but a low-fidelity interface.

The Battle Force Tactical Trainer (BFTT) is a new system that will eventually replace the Tactical Control Device. BFTT is capable of supporting all mission areas and allows connecting multiple ships to provide task group training. It operates via telecommunication lines and is currently limited to training at the pier (versus while at sea). BFTT is being installed on the new-construction DDG-51-class ships.

Two other devices used by ships in ASW training are the Mk. 30 and the Mk. 39. They are small, torpedo-shaped devices launched from the ship to simulate targets. They have numerous transit profiles and signal packages to emulate various types of real-world targets. The Mk. 30s cost several thousand dollars and are recovered after each use. The Mk. 39s are relatively inexpensive and are, therefore, treated as expendable.

Southern California Offshore Range (SCORE). SCORE was established in 1985 to support Pacific Fleet training.[10] Initially, SCORE was dedicated to ASW. The capabilities and functions of SCORE have expanded over the years such that it schedules and conducts a variety of fleet training operations including multiwarfare and battle group exercises on and around San Clemente Island. Surface ships, submarines, MPA and fighter aircraft all use SCORE to accomplish training in numerous mission areas.[11] Currently, ASW operations represent approximately 25 percent of the total training events at SCORE. A list of the number of training events in various PMAs is shown in Table F.2.

Part of SCORE is the Southern California ASW Range (SOAR), a 665-square-mile instrumented range utilizing air/surface tracking systems and underwater tracking through an elaborate 84-hydrophone system.[12] SOAR is used in all

[10]Information on SCORE is available at http://www.score.net.

[11]During FY 1999, 123 surface ships used SCORE for ASW training. Also, 52 fixed-wing aircraft, 380 rotary-wing aircraft, and 56 submarines used SCORE for ASW training.

[12]There are plans to develop an instrumented shallow-water range within the SCORE complex. However, the instrumentation of the range has not yet been funded.

Table F.2

Tempo of Operations at SCORE

Type Operation	FY 94	FY 95	FY 96	FY 97	FY 98	FY 99	FY 00[a]
Undersea warfare	377	326	338	339	325	248	194
Surface warfare	0	0	1	5	2	106	68
STW	1	3	17	24	43	53	24
Naval special warfare	0	0	0	4	22	14	249
MIW	46	55	68	104	144	52	33
Command and control warfare	0	0	0	0	4	13	16
AAW	0	0	0	0	4	13	16
AMW	0	0	0	62	53	72	48
Total events	799	930	1,005	1,086	1,133	1,107	1,088
USW percentage of total	47	35	34	31	29	22	18

[a]FY 00 as of July 20, 2000.

three phases of training—Basic, Intermediate, and Advanced. For MPAs and DDGs, SCORE supports torpedo exercises, tracking exercises, coordinated operations, JTFEX, and MEFEX. The primary threat targets for ASW training are the Mk. 30 and the Mk. 39 systems.

The ISIC or ATG schedules ships for events at SCORE. SCORE does not evaluate a ship's performance during a training event but provides feedback to the ships, the ISIC, and the ATG on various measures of performance. Therefore, SCORE does not grant qualification or certification in training events.

A ship can accomplish multiple training events while on the range and can actually accomplish all required ASW training during a SCORE event. Ships will make one, or possibly two, visits to SCORE during TSTA 2 typically with instructors from the ATG on board.

ROYAL NAVY ASW TRAINING

This section describes how the Royal Navy carries out both its general approach to training and specifically how it does ASW training.

Training Philosophy

The Flag Officer, Sea Training (FOST), is responsible to the Commander in Chief Fleet for surface ship training to meet current and contingent tasks. Since the concept of Operational Sea Training (OST) was established in 1958, the various training syllabi to meet this responsibility have been adapted to keep pace with significant changes in the roles and composition of the fleet. From a headquarters at HM Naval Base, Devonport, FOST administers a number of training packages, each of which is tailored to meet the needs of the individual ship. This training concentrates on how the ship operates both alone and in concert with other ships.

Systems Approach to ASW Training: Individual to Unit

The training philosophy described above for overall training is the basis for the Royal Navy systems approach to ASW training. Training progresses through a series of steps from job analysis (training needs) to training design to training execution to on-the-job training and finally to the trained individual. There is external quality control between the trained individual and job analysis, which completes a feedback loop.

A Training Performance Statement (TPS) is developed by the School of Maritime Operations (SMOPS) that defines what students should be able to do at the end of formal individual training. Individuals go from theory to computer-based training to simulator use as part of individual training. An Operational Performance Statement (OPS) is developed by FOST that specifies what the crew should be able to do operationally. Ship-based OJT makes up the difference, that is TPS plus OJT equals OPS.

The Royal Navy approach to building ASW operational capability follows this model. It progresses from individual (from SMOPS) to team to continuation training. It lifts a sailor from TPS to OPS by providing the OJT. The cyclical progression beginning with first entry is basic training, general ASW training (HMS *Dryad*), ship tour (OJT), more-specific ASW training, second ship tour, more training, and ship tour as petty officer. OST includes both individual and collective ASW training. There are very clear value distinctions (i.e., six outcomes grade from below standard to very good) for ASW accomplishment. ASW appears to be a high-priority mission and, therefore, practiced often. ASW training depends less on the deployment cycle than does other training and is considered the "general life of the ship."

How the Royal Navy ASW Fleet Is Organized and Based

The Royal Navy fleet consists of

- 129 ships and submarines,
- 182 aircraft,
- 36,000 uniformed personnel,
- 6,000 civilian personnel working directly for the Royal Navy,

- 12,000 civilians working for Chief of Fleet Support in the Defence Logistics Organization,
- 11 destroyers, and
- 20 frigates (two more arriving by 2002).

The destroyers and frigates make up the Royal Navy's escort ships. Three frigate squadrons are at Portsmouth and Devonport, and two destroyer squadrons are at Portsmouth. These constitute the Surface Flotilla. This contemporary surface flotilla is smaller than 10 years ago (some 50 or more such ships would have been involved in antisubmarine duties then) but continues to be involved around the globe on a variety of tasks. On a typical day, about half will be deployed in various operations (e.g., antidrug patrol, protecting oil tankers), training at sea off Plymouth, on duty with NATO, or engaged in multinational exercises. The other half is being serviced, operating in local waters, or on port visits/crew leaves.

Of the 22 frigates, six are Type 22 frigates, optimized for ASW. There are 14 (plus two more in 2002) Type 23 general-purpose frigates, which is the newest design.[13]

How Training Is Conducted

The Royal Navy's concept of training for a ship and crew involves several deployment cycles (see Figure F.4). These cycles are like those of the U.S. Navy in that a ship enters a refit or maintenance period, trains up, then deploys for about six months, returns for stand-down, and maintenance and then trains up for another deployment. During the "in-port" period, there may be a number of shorter at sea periods.

Ship in Retrofit or Under Maintenance. A majority of the crew leaves the ship during a major maintenance or modification action (usually six months or more). For shorter maintenance periods (less than six months), the crew remains with the ship. In either event, maintenance periods involve unit

[13]Although originally designed as specialist antisubmarine platforms, the Type 22 Frigates have evolved into surface combatants. The most recent batch 3 ships have substantial antisurface, antisubmarine, and antiaircraft weapons systems. The Type 23 is optimized to produce a ship capable of silent running, such that it would be undetectable to the submarine it was hunting while optimizing the capability of its own underwater sensors. It detects submarines through a combination of active and passive sonar systems, and attacks are carried out using Stingray homing torpedoes launched from the ships "magazine launching system" for short-range engagements or dropped from the ship's Lynx helicopter at longer ranges.

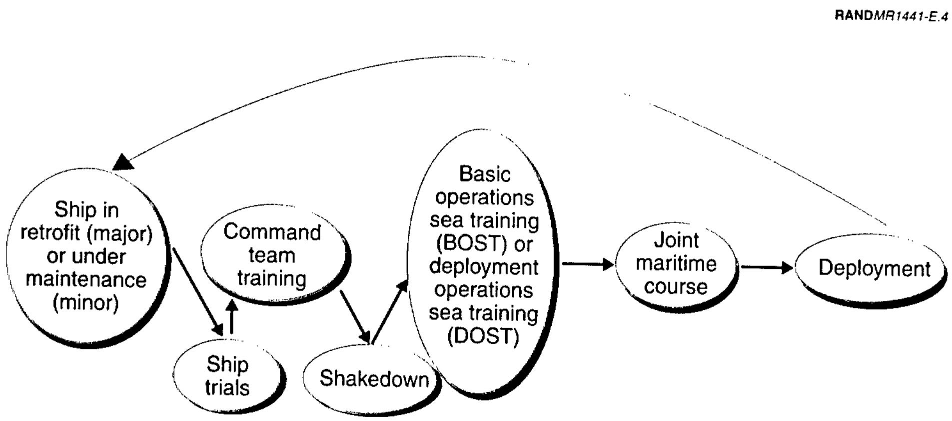

Figure F.4—Deployment and Training Cycles

training, and this training is both standards- and event-driven with a focus on individual proficiency and crew qualification. The operations officer plans this training for accomplishment while a ship is in the down cycle. The Fleet Classified Document (FCD3) covers all ships and defines the required training events, the amount of time to devote to the events, and how to conduct the training. This document appears to be a combination of the U.S. Navy training matrices, a METL, and shore-based school training tasks.

Royal Navy shore training does not provide full operational performance. Additional training on the ship is expected and needed. Also a computer program (PRISM-OC)[14] tracks training accomplishment and manpower flows in great detail. Squadron staff[15] monitors output from PRISM. Moreover, based on manpower status, training status, and other resource status, this system can compute ship capability.

While in port, the ship might send certain rates to HMS *Dryad*[16] to assist in training, which also helps improve its own unit training and capability. This phase is the start of unit-level training that will continue throughout the entire cycle based on FCD3 requirements. This first stage of a ship's training is known as Tier One Training.

---

[14]The Planning and Reporting Information System for Operational Capability is an at-sea system that reports data to the shore for training evaluation.

[15]Hierarchy is ship, squadron, and flotilla. The Royal Navy has three frigate squadrons and two destroyer squadrons, each having five or six ships.

[16]The Royal Navy SMOPS at HMS *Dryad* was formed in 1974 and is one of the principal shore establishments. Warfare training for naval officers and ratings from an elementary stage to the most-advanced levels is provided.

Ship Trials. These are broadly engineering-oriented but also focus on training and sea safety. Basic operational exercises, monitored by squadron staff, are conducted. This is a feeling-out period for both the ship commander and squadron staff for how capable the ship is and what additional training is needed. Here, the crew is beginning to meld as a team. This is also Tier One training and is again governed by the FCD3 document.

Command Team Training. SMOPS provides a week of simulator training prior to OST, which is deemed critical to successful training accomplishment. This is conducted as part of the HMS *Dryad* training establishment at Fareham, near Portsmouth, in SMOPS. It is a one- or two-week course, which begins with lectures, moves to tabletop tactics (e.g., an ASW problem), and eventually to simulator training. The training focus begins to move from individual to team effort at this stage in the cycle. Experts are available throughout from different warfare areas. The simulators are replicas of ship operations rooms. The simulations can go from crew training to a full war. They are considered to be excellent and described as providing everything but ship movement. The staff is largely civilian and contractor so training classes cease at 4:30 p.m. Often students will meet afterward to discuss results and give feedback. Part of the value of Command Team Training results from having everything recorded in the computer for replay.

Shakedown. This is a one- to two-week period at sea monitored by FOSF. It is the final step prior to OST.

Basic (BOST) or Deployment (DOST) Operational Sea Training. BOST is a package for new ships or for ships coming from a major maintenance period. It prepares the ship and her company for operational missions. DOST is a tailored package for predeployment ships, focusing on the demands of their deployment role. Packages for foreign ships are tailored to their needs and typically involve five- or six-week OST packages.

BOST is six weeks long. DOST is for ships where most of the crew is intact from the last deployment and is four weeks long. Both include a two-week harbor period. This is also Tier One training and focuses on individual ship preparation.

Inspectors perform detailed evaluations of the ship to certify it as ready for sea training. The objective of this training is to bring the ship to Tier One readiness (satisfactory). Getting a very satisfactory or good rating is exceptional; a very good rating is rare.[17] The sea training staff consists of specially selected officers

---

[17]The perception of the Royal Navy is that the U.S. Navy tends to use more metrics at the task level while the Royal Navy tends to use fewer metrics but at the system level (e.g., fire torpedo) to judge accomplishment.

and ratings from throughout the Royal Navy and Royal Fleet Auxiliary (RFA), together with a small number from other navies. All are experts in their own specialty.

The training packages encompass phases of instruction, assessment, and finally inspection in warfare, engineering, supply, and executive disciplines. This ensures that any material or procedural shortcomings are identified quickly and rectified. The focus of all sea-riding staff is quality with flexibility. The best people (the top 25 percent of chiefs and officers) staff FOST. Training and evaluation rely a lot on individual judgment of the sea-riders. Philosophy is to train ships well and track how they score. This period is described as "bloody hard work."

Once BOST is passed, the ship is considered fit until the next cycle for a ship (approximately two years), which will be DOST. DOST is tailored to the ship's destination for its next deployment. For example, if the ship is going to the Caribbean, there will be a disaster relief portion.

This high-quality training is in great demand. As well as training Royal Navy and RFA ships, FOST regularly trains foreign customers from NATO countries and non-NATO countries in support of defense sales. These include ships from Germany, Italy, Brazil, Portugal, and the Netherlands.

Joint Maritime Course. The next stage is to prepare ships to work effectively in a joint service environment, or Tier Two training. This is coordinated by the Joint Maritime Operational Training Staff based in Northwood, under the direction of FOST and his RAF counterpart. It is very structured and accomplished entirely at sea. The RAF, Royal Navy, and sometimes the British Army participate. The training lasts two weeks and is accomplished off the west coast of Scotland, which provides both littoral and blue-water operations. It is geared to getting UK assets to readiness levels with Tier Two training, but all NATO countries are invited and many show up. The course runs every four months if budget is available. The course includes ASW Area Capability Training. It consists of structured training as well as a free-play element designed to build on the core skills learned in Tier One training. This training is also highly valued by other NATO navies and air forces that regularly send units to participate.

How ASW Training Is Conducted

Individual ASW Training. Individuals have a training performance statement that sets forth the percentage of skills to be taught initially in the classroom. This ranges from CAT 1 (90–100 percent) to CAT 4 (25–49 percent). Key warfare and safety skills are trained to CAT 1. Other skills are trained to between CAT 2 and 4. The school and the fleet decide in advance which skills are taught at

HMS *Dryad* and which in the fleet, attempting to teach the skill where the equipment is available. Fewer individual skills are taught in the schoolhouse, which means that more shipboard training is needed. Sixty percent of training is at sea. Ships provide OJT and track progress through the use of task books for each occupation.[18] Individuals move up a performance ladder over time. On a ship, there is never a fully trained ASW team. Probably two of four team members are in some stage of development because of turnover, etc. Sixty percent of ASW training is now at sea with on-board equipment.

Collective ASW Training. Collective ASW training is the responsibility of the department head. The department head can use FOSF ASW staff and its sea-riding visits. FOSF staff makes administrative visits to a ship 12 weeks before OST or on return from deployment to check material and organizational fitness. The staff makes a routine in-harbor visit one month prior to OST and then routine sea visits during pre-OST shakedown and when requested. The squadron ASW staff also makes sea-riding visits for a "quality control top-up."

ASW Tier One training during OST uses simulators and is mainly procedural, not tactical training. The focus is on teamwork under stress. PRISM is used to track ASW training accomplishments and manpower flows. Based on manpower status, training status, and other resource status, PRISM can compute ship ASW (and other mission area) capability. Tier One is the start of ASW unit-level training that will continue throughout the entire cycle based on FCD3 requirements.

Continuation ASW Training. Continuation ASW training is prior, during, and after deployment but is not as much driven by deployment cycle as the U.S. Navy's ASW training is. There is a whole series of opportunities. On-Board trainers (OBTs), normally very good training devices, are used by an individual or by the whole team. The OBT can be used in port as if the ship were at sea with the OBT stimulating the equipment with what looks like "real" signals. Other training resources include the following:

- Flotilla On-Board Training Support Cell is a team that go to ships and help standardize ASW training using a "train the trainers" approach.
- Active Sonar Training Team comes from FOSF to ships to provide training and assistance.
- Towed Array Reaction Teams include a warrant officer in radar and sonar. They will train a ship to include individual and team integration. They will also help a ship conduct operations.

[18]Officer training is more subjective and usually time-based—i.e., has been doing this task for so long therefore qualified (or not).

- Sonar Trainer teaches and tests passive skills. It is low-cost (£14,000), fitted to all ships as a stand-alone PC, and very useful. Paper and tape schemes are now amalgamated into the Sonar Trainer. The Sonar Trainer also has computer-based text to help students get more information on various topics.

Training goals (e.g., number of assessed torpedo firings per month) come from the FCD3. They set minimum quality and standards of training to include periodicity. They allow for simulated events—e.g., a simulated active exercise of 12 hours a month. There are monthly targets that are not relaxed when a ship is in port (although a ship in port may be below its targeted readiness). Key is a standard that must be consistently met. Some events can only be done at sea. These standards tie to readiness level, which is a whole-ship concept and not an individual warfare area.

Training monitoring is through PRISM. Twice monthly reports go from ship to FOSF. This is how the Royal Navy monitors the individual warfare areas, such as ASW. PRISM thus tracks asset availability and allows the case to be made for more money in certain areas if more capability is desired. There is a relationship between cost and performance. Training standards tie to operational capability.

FRENCH NAVY ASW TRAINING

Training Philosophy

French naval ships typically have the capability to conduct all missions for which they were designed. However, many ships tend to specialize in one or a few missions such as AAW or ASW. For example, an ASW frigate will focus on that mission during its training cycle using a special training package tailored to ASW operations. The ships based in Brest tend to concentrate on ASW while those in Toulon tend to emphasize amphibious operations. The new frigate class currently in the design stage will be multimission, but the French Navy may continue to have ships specialize in certain missions.

How the French Navy Is Organized and Based

The French Navy operates approximately 13 destroyers and 24 frigates that are either deployed overseas or based in France at Brest on the Atlantic Ocean or at Toulon on the Mediterranean. It stations ships at overseas locations (such as Tahiti, New Caledonia, Martinique, and French Guiana) for a period of four to five years and thus focuses less on the concept of deployments. For other ships that may be deployed from their homeport in France, the normal deployment period is four months. Typically, ships are under way 80 to 90 days a year, although some ships, such as the frigates, may have up to 100 steaming days.

Typically, French naval ships will have a major overhaul every six years with minor overhauls halfway between the major refits. During years when there are no major or minor overhauls, a ship will have an annual maintenance period. The major and minor overhauls are of sufficient duration that a ship will lose its operational qualification and must go through a new train-up cycle. The annual refits are short enough that ships normally maintain their operational qualification. Ships can also lose qualification if a 50 percent or greater turnover in the crew takes place.

How Training Is Conducted

Crew training is done in the fleet and is the responsibility of ALFAN (French Navy Training Command) and the ship's commanding officer. The ALFAN Training Department has about 80 instructors divided between Toulon and Brest organized into several specific departments (e.g., engineering, damage control). Their training facilities are located adjacent to the piers providing easy access for a ship's crew. The ALFAN instructors, like all petty officers, rotate from the fleet to the school on a fairly regular basis. Some may stay at the school for as little as six months. ALFAN would like to extend the instructor tour to three years to provide stability at the training center. However, ALFAN tours are typically more difficult than ship tours because the instructors spend much of their time aboard ships, providing training services or performing operational evaluations. Also, it is often difficult to return to ship duty if away from the operational environment for extended periods of time.

When a ship loses its operational qualification, ALFAN is responsible for retraining the ship. As mentioned, a ship will lose its qualification if it has undergone a major or minor refit, if it has 50 percent or higher turnover in its crew, or if the type commander's evaluation results in a loss of qualification. Given the approximately 45 ships (out of the approximately 100 ships that ALFAN has responsibility for) that ALFAN trains each year, an average of 10 ships per year undergo a complete requalification training.

ALFAN conducts its training in three phases—Initial, Basic, and Operational. The Initial Phase emphasizes safe operation of the ship. The Basic Phase concentrates on the operation of equipment and systems. The Operational Phase qualifies the ship in all warfare mission areas. For a frigate, ALFAN training time lasts approximately six weeks (slightly longer for an aircraft carrier).

During the Initial Phase, ALFAN will have two or three instructors aboard the ship to certify navigational and damage-control qualification. They act as external, objective evaluators to ensure the ship can safely conduct at-sea operations.

Basic qualifications are normally conducted with the Initial Phase during the at-sea period. ALFAN will have one or two officers and seven to 10 petty officer instructors on board the ship. Specialists will be added to this basic cadre of instructors when dictated by the needs of a specific ship. The training focus is on seamanship and the ability to operate all equipment to perform such basic missions as surveillance, port-of-call, and self-defense.

ALFAN's final phase of training concentrates on all warfare mission areas and includes a final exercise in each warfare area. All training during this phase is aboard ship except for a two- or three-day period in the ALFAN schoolhouse that may include the use of various simulators. The initial phases of ASW training involve more schoolhouse time for the crew to learn how to operate the equipment. ASW qualification includes about a week of operations with MPA and nuclear submarines. The result of the Operational Phase is the award of Operational Qualification. The qualifications may be awarded with "restrictions" that require additional training and requalification in the specific area.

Once ALFAN has completed its training (assuming the ship is fully operationally qualified), the responsibility for training reverts to the commanding officer of the ship. The French Navy has a system similar to the U.S. Navy's T&R matrix that defines specific training events for the ship. For a French Navy frigate, approximately 200 actions must be completed within specific time periods to maintain qualification in all warfare areas.

The ship's commanding officer conducts this advanced training phase. It consists of Global Follow-Up or Specific Follow-Up, which then leads to permanent evaluation by the type commander. The end result is the ship being qualified for Upper Operations, for Operational Distinction, or becoming restricted. If restricted, the ship must go through a specific training period and be operationally qualified again by ALFAN. Figure F.5 shows the specific phases and steps in the qualification of a French Navy ship.

How Training Is Managed

The French system results in points being awarded for different training actions with the specific points awarded based on the importance of the event. Total points relate to qualifications in the following way:

- 0 to 50 points—restricted qualifications,
- 50 to 80 points—normal qualification, and
- 80-plus points—superior qualification.

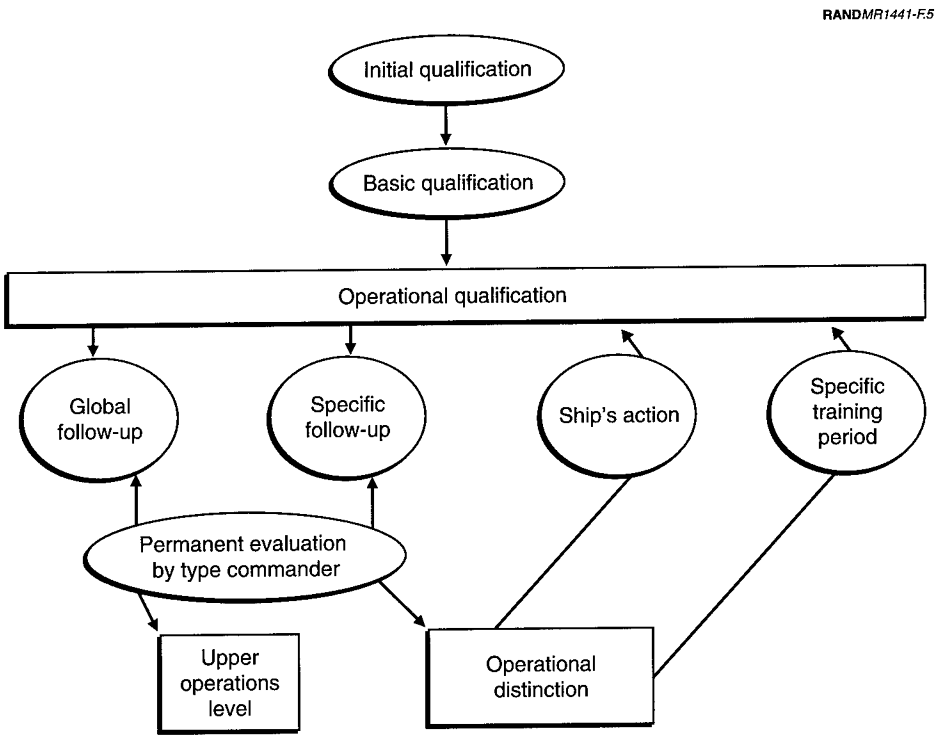

Figure F.5—Steps in the Qualification of a French Navy Ship

Each ship maintains a "board" that lists the actions for each warfare area. Each month, the actions accomplished are scored and weighted by event importance to provide the resulting points earned. The board shows the points in each warfare area for the preceding 12 months, which assists the commanding officer in determining what training actions must be accomplished.

How Training Is Resourced

Personnel. The French military recently converted to an all-volunteer force. Because the Navy is small (approximately 50,000) and entry-level pay is fairly good, the French Navy currently has no difficulty recruiting the approximately 2,000 annual accessions needed to maintain personnel strength. It has started to integrate female sailors on to their ships with seven ships currently having mixed-gender crews (the *Charles de Gaulle* is one of these ships). Berthing restrictions on older ships make it difficult to integrate women into the crew. All newer ships will have the appropriate berthing for women.

The typical first term of enlistment for a French sailor is eight to 11 years (although special four-year enlistments are available). The process of continuing for a second and subsequent terms is based on the quality of the individual and the needs of the Navy. Those not selected are helped in finding a position in the civilian world. Those selected for reenlistment are offered a minimum four-year contract that can be renewed. Many sailors stay in the Navy for 17 years, at which point they have an immediate annuity. Some sailors will be given "tenure" and stay until 48 to 56 years of age.

Schools provide technical training and knowledge (termed "formation") to individual sailors to a fairly high level. There are three levels to schoolhouse, or formation, training. The first level is a four-month elementary or basic phase, at the end of which the sailor has an individualized training program (with a line of progression) completed on board a ship within a two-year period. The second phase after experience is gained is currently nine months in duration and attempts to advance individual sailors to a "good" level of competency in their specific warfare skill area. The final level, one year in length, is systems-oriented and concentrates on theory and depth of knowledge.

Simulations. Simulation is authorized for some of the 200 training events. For some of the events that may use a simulator, simulation is restricted to a specific percentage of the training time. In ASW, for example, a French frigate must maintain currency in 25 events, 10 of which may be simulated. Of these 10 events, 30 percent of the points may come from using the simulator (e.g., if an event requires 10 hours of training, three hours can be accounted for on simulators). Each frigate has four or five ASW training periods against an actual submarine each year to maintain its crew's qualifications.

While a ship is in port, the crew can use the ALFAN simulators for training. These "simulators" take a different design approach from that we observed elsewhere. The simulators are desktop computers that emulate on screen with software the displays and switches of specific equipment (which differs from the U.S. Navy's approach of providing equipment and then simulating the inputs and outputs). Using software, crewmembers can more easily replicate the specific equipment of the combat information center of any ship. ALFAN maintains separate contracts to keep its software upgraded as equipment changes aboard the ships. No passive sonar capability is currently on the simulators, although ships have the ability to simulate this capability.

COMPARISON OF SURFACE SHIP ASW TRAINING

Both similarities and differences exist between the ASW training of U.S. Navy DDG-51-class ships and the ASW training for French and British Navy ships. The primary difference is the number of missions each Navy assigns to its ships.

The U.S. Navy DDG-51-class ships have 10 warfare mission areas plus two ship-related (mobility and fleet support operations) mission areas. Each mission area has numerous events that a ship must accomplish to reach desired readiness levels for deployment. British and French ships have far fewer warfare mission areas, allowing them to specialize and concentrate their training. There is also a movement, at least in the French Navy, to specialize individual ships in specific mission areas.

Another factor that influences the training of French and British is the greater experience levels and operational continuity of their officers and enlisted crewmembers. While the typical career pattern for U.S. Navy officers takes them away from the operational ship world to various headquarters and staff assignments, French and British naval officers may stay in the operational community throughout their careers. Enlisted sailors in the French and British navies also have longer initial service commitments than those of U.S. Navy sailors. The greater experience levels and continuity of crews help reduce the overall training requirements for French and British ships.

Although recent changes in the conduct of training during the IDTC allow U.S. Navy ships to determine their specific training needs and "pull" the needed support from the training community, each DDG-51-class ship still undergoes the same basic set of training events. Training for British and French ships is more tailored to the needs of specific ships because of the overall smaller number of ships. Also, the British and French have one primary organization involved with the training of their ships—ALFAN for the French and FOST for the British. Several organizations are involved in the training of DDG-51-class ships, especially in the area of ASW training.

Putting those basic differences aside, all training for the U.S., British, and French forces is events-based, requiring the completion of a set of specified events to attain operational capability. Also, all three navies extensively use some form of simulation for their ASW training. The United States and the British tend to duplicate operational equipment at their training locations while the French emulate the displays and controls of various equipment using software on desktop computers.

BIBLIOGRAPHY

Brobst, William D., and Alan C. Brown, *Developing Measures of Performance for F/A-18 Aircrew Skills*, CRM 96-129.00, Alexandria, Va.: Center for Naval Analyses, 1996.

Brobst, William D., Laura A. Geis, and Alan C. Brown, *Analysis of NSAWC Aircrew Training Study: Summary and Recommendations*, CRM 98-172, Alexandria, Va.: Center for Naval Analyses, 1999.

Brobst, William D., Laura A. Geis, and Alan C. Brown, *NSAWC Aircrew Training Study: Methodology and Analysis*, CRM 98-171, Alexandria, Va.: Center for Naval Analyses, 1999.

Brobst, William D., Laura A. Trader, David M. Rodney, and Alan C. Brown, *Skills-Based F/A-18 Aircrew Mission Readiness Assessment System: Summary and Comparison to Current T&R Matrix*, CRM 98-82, Alexandria, Va.: Center for Naval Analyses, 1998.

Brobst, William D., Laura A. Trader, David M. Rodney, Ann E. Miller, and Alan C. Brown, *Analysis of Aircrew Skills-Based Mission Readiness Assessment Systems Project: Summary*, CRM 98-109, Alexandria Va.: Center for Naval Analyses, 1998.

Carretta, Thomas R., and Ronald D. Dunlap, *Transfer of Training Effectiveness in Flight Simulation: 1986 to 1997*, AFRL-HE-AZ-TR-1998-0078, U.S. Air Force Research Laboratory, 1998.

Cooley, J., *On-Board Training for Naval Combat Systems Readiness*, SimTecT99 Papers, The Simulation Technology and Training Conference, 1999.

Cosby, L. Neale, *SIMNET: An Insider's Perspective*, D-1661, Alexandria, Va.: Institute for Defense Analysis, March 1995.

Darvill, David, *Research Issues Related to the Use of Simulations and Simulators: Lessons Learned*, DCIEM No. 90-TN-42, Human Factors Division, Defence and Civil Institute of Environmental Medicine, Department of National Defence, Canada, November 1990.

Defense Science Board, "Report of the Defense Science Board Task Force on Training Superiority and Training Surprise," Washington, D.C., January 2001.

Department of the Air Force, *F-16 Aircrew Training*, Air Force Instruction 11-2F-16, Volume I, May 1998.

Department of Defense (DoD), "Quarterly Readiness Report to Congress," Washington, D.C., January–March 2000, p. 5.

Djang, Philip, et al., "The Army's Unit Training Strategy Model," in *Final Report, 66th MORS Symposium*, Alexandria, Va.: Military Operations Research Society, 1998.

Elliott, Gary S., and Kathleen A. Quinkert, *Performance Measures for Simulation*, Research Product 93-08, Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, June 1993.

Farris, Hilary, William L. Spencer, John D. Winkler, and James P. Kahan, *Computer-Based Training of Cannon Fire Direction Specialists*, Santa Monica, Calif.: RAND, MR-120-A, 1993.

Fleet Area Control and Surveillance Facility, *SCORE: Range Users Manual*, FACSFAC Instruction 3550.1, San Diego: August 27, 1999.

Gildea, Kerry, "Pacific Naval Officials See ASW Shortage as Growing Problem," *Defense Daily*, July 20, 2000, p. 4.

Goodman, Glenn W., "U.S. Navy's FAST Plan," *Training & Simulation 2000*, Spring 2000, pp. 26–29.

Goodwyn, S. Craig, and John P. Hall, *A Comparison of Navy and Marine Corps F/A-18 Readiness*, CRM 97-79, Alexandria, Va.: Center for Naval Analyses, 1997.

Hogue, J., R. Allen, T. Rosenthal, F. Anderson, C. Pelz, and B. Aponso, *Applying Low-Cost Virtual Environments to Simulation-Based Vehicle Operator Training*, SimTecT99 Papers, The Simulation Technology and Training Conference, 1999.

Junor, Laura J., Gregory N. Suess, John E. Pitale, Carol S. Moore, Peter J. Francis, and James M. Jondrow, *Navy Air Operations and Training Study: Examining the Applicability of Concepts in the USMC Aviation Campaign Plan*, CAB 98-80, Alexandria, Va.: Center for Naval Analyses, 1999.

Junor, Laura, Christopher Duquette, and James Jondrow, *Linking Aviation Metrics to FMC Trends*, CRM 99-56, Alexandria, Va.: Center for Naval Analyses, 1999.

Kapos Associates, Inc., "Assessment of the Utility of Simulation in Fleet Training," Arlington, Va.: KAI, TR 2-98, 1998.

Kessler, Craig, Tim Bergland, and Dave Gibson, "Training Like You Fight on USS *Virginia*," *Undersea Warfare*, Fall 2000, pp. 11–13.

Linder, Bruce R. and Michael E. McDevitt, "Anti-Submarine Warfare (ASW) Measures of Proficiency," in *Final Report 66th MORS Symposium*, Alexandria, Va.: Military Operations Research Society, 1998.

Malmin, O. Kim, *Aircraft Simulator Use by Operational Squadrons*, CAB 95-60, Alexandria, Va.: Center for Naval Analyses, 1995.

Malmin, O. Kim, and Lyle A. Reibling, *The Contribution of Aircraft Simulators to the Training and Readiness of Operational Navy Aircraft Squadrons*, CRM-143, Alexandria, Va.: Center for Naval Analyses, 1995a.

_____, *Using Simulators to Train Fleet Aviators*, CRM 95-50, Alexandria, Va.: Center for Naval Analyses, 1995b.

McDevitt, Michael, "Strike Warfare Proficiency," unpublished presentation at the 70th MORS Symposium, June 2000.

Moody, Gary A., Susan Way-Smith, Hilary Farris, John D. Winkler, James P. Kahan, and Charles Donnell, *Device-Based Training of Armor Crewmen*, Santa Monica, Calif.: RAND, MR-119-A, 1993.

Office of the Chief of Naval Operations, *Navy Training System Requirements, Acquisition, and Management*, OPNAVINST 1500.76, July 1998.

_____, *Navy Training Technology*, OPNAVINST 3900.29, June 1995.

Orlansky, Jesse, Carl J. Dahlman, Colin P. Hammon, John Metzko, Henry L. Taylor, and Christine Youngblut, *The Value of Simulation for Training*, P-2982, Alexandria, Va.: Institute for Defense Analyses, 1994.

Orlansky, Jesse, Colin P. Hammon, and Stanley A. Horowitz, *Indicators of Training Readiness*, P-3283, Alexandria, Va.: Institute for Defense Analysis, 1997.

Patrick, Pat, and Gregory N. Suess, *Flying Hours, Simulators, and Safety: A Look at Flight Safety Trends*, CIM 618.10, Alexandria, Va.: Center for Naval Analyses, 1999.

Pitale, John E., *The Application of Simulation to Navy Flight Training*, CIM 638, Alexandria, Va.: Center for Naval Analyses, 1999.

Poore, Rodger E., Eric Rodeghiero, and Paul C. Etter, *Achieving Long-Run Improvements in ASW Proficiency, Volume I: Main Text and Appendix A*, CAB 98-107, Alexandria, Va.: Center for Naval Analyses, 1998a.

_____, *Achieving Long-Run Improvements in ASW Proficiency, Volume II: Appendices B to E*, CAB 98-108, Alexandria, Va.: Center for Naval Analyses, 1998b.

Reibling, Lyle A., and O. Kim Malmin, *Relating Simulator Training to Operational Performance*, CRM 95-145, Alexandria, Va.: Center for Naval Analyses, 1995.

Roof, Robert S., "Naval Aviation's Use of Simulators in the Operational Training Environment: A Cost Analysis Perspective," thesis, Naval Postgraduate School, Monterey, Calif., 1996.

Russo, Trish, Victor G. Bonilla, and Richard A. Thurman, *The Basic Fighter Maneuver Visualization Trainer*, AL/HR-TP-1996-0049, San Antonio, Tex.: U.S. Air Force Armstrong Laboratory, 1996.

Seaman, Keith, *Improving F-15C Air Combat Training with Distributed Mission Training Advanced Simulation*, Maxwell AFB, Ala.: Air University, 1999.

Shappell, S. A., and B. J. Bartosh, *Use of a Commercially Available Flight Simulator During Aircrew Performance Testing*, NAMRL Technical Memorandum 91-2, Naval Aerospace Medical Research Laboratory, 1991.

Singer, Michael J., "The Optimization of Simulation-Based Training Systems: A Review of Evaluations and Validation of Rule Bases," Research Report 1653, Alexandria, Va.: U.S. Army Research Institute for Behavioral and Social Sciences, 1993.

Stewart, John E., John A. Dohme, and Robert T. Nullmeyer, *Optimizing Simulator-Aircraft Mix for U.S. Army Initial Entry Rotary Wing Training*, Technical Report 1092, Alexandria, Va.: U.S. Army Research Institute for the Behavioral and Social Sciences, 1999.

Strike Fighter Weapons School, *Strike Fighter Weapons and Tactics: Flight and Simulator Syllabus*, December 1999.

Suess, Gregory N., *A Look at Navy Flying Hour Requirements*, CRM 94-77, Alexandria, Va.: Center for Naval Analyses, 1994.

_____ *Rethinking Flying Hour Requirements*, CRM 99-155.50, Alexandria, Va.: Center for Naval Analyses, November 1999.

_____, with M. Theresa Kimble and Jerome A. Crocker, *Flying Hour Requirements for Budgeting: A Second Report on TACAIR/ASW Methodologies*, CRM 99-138, Alexandria, Va.: Center for Naval Analyses, November 1999.

_____, with John E. Pitale, Timothy J. Sorber, John A. Breast, and Michael S. French, *Flying Hour Requirements for Budgeting: A Report on TACAIR/ASW Methodologies*, CRM 98-122, Alexandria, Va.: Center for Naval Analyses, 1998.

Taylor, William W., S. Craig Moore, and C. Robert Roll, *The Air Force Pilot Shortage: A Crisis for Operational Units?* Santa Monica, Calif.: RAND, MR-1204-AF, 2000.

U.S. Marine Corps, *Aviation Training and Readiness Manual, Volume 1: Administrative*, MCO P3500.14F, 1999a.

_____, *Aviation Training and Readiness Manual, Volume 2: Tactical Fixed-Wing*, MCO P3500.15C, 1999b.

_____, *Marine Corps Combat Readiness Evaluation System, Volume IV: Fixed Wing Squadrons*, MCO 3501.5, 1999c.

U.S. Navy, Commander Naval Air Force U.S. Pacific Fleet, *Air Wing Turnaround Training Requirements and Readiness Standards*, COMNAVAIRPACINST 3500.60B, April 1994.

_____, Commander Naval Air Force U.S. Pacific Fleet and Commander Naval Air Force U.S. Atlantic Fleet, *Policy Concerning Replacement Pilots/Naval Flight Officers Reporting to Deployed Squadrons*, COMNAVAIRPACINST 3500.54B/ COMNAVAIRLANTINST 3500.54F, January 1997.

_____, Commander, Patrol Wings U.S. Atlantic and Commander, Patrol Wings U.S. Pacific Fleet, *Training and Readiness Manual*, COMPATWINGSLANT/ COMPATWINGSPAC Instruction 3500.25A, March 1999a.

_____, Commander Naval Surface Force U.S. Atlantic Fleet and Commander Naval Surface Force U.S. Pacific Fleet, *Surface Force Training Manual*, COM-NAVSURFLANT/PACINST 3502.2E, December 17, 1999b.

_____, Commander Naval Air Force U.S. Pacific Fleet and Commander Naval Air Force U.S. Atlantic Fleet, *Squadron Training and Readiness*, COMNAVAIR-PACINST 3500.67E/COMNAVAIRLANTINST 3500.63E, March 2000a.

_____, Commander, Patrol Wings U.S. Atlantic Fleet and Commander, Patrol Wings U.S. Pacific Fleet, *Wing Training Manual*, COMPATRECONFORLANT/ COMPATRECONFORPAC Instruction 3500.25A, July 2000b.

_____, Commander Strike Fighter Wing U.S. Pacific Fleet, Commander Fighter Wing U.S. Atlantic Fleet, Commander Strike Fighter Wing U.S. Atlantic Fleet, Commander Carrier Air Wing Reserve Twenty, *Strike Fighter Weapons and Tactics (SFWT) Program*, COMSTRKFIGHTWINGPAC/COMSTRKFIGHT-WINGLANT/COMFITWINGLANT Instruction 1525.1C, undated 1.

_____, Commander Strike Fighter Wing U.S. Pacific Fleet, Commander Strike Fighter Wing U.S. Atlantic Fleet, *F/A-18 Wing Training Manual*, COMSTRK-FIGHTWINGLANT/COMSTRKFIGHTWINGPAC Instruction 3500.7A, undated 2.

Wallace, P., K. Walkden, and G. Lintern, *An Analysis of F/A-18A Pilot Training Tasks*, SimTecT99 Papers, The Simulation Technology and Training Conference, 1999.

Wheal, Lieutenant Commander C. A., *Simulators in Flight Training: A Pilot's View, U.S. Naval Proceedings*, Vol. 102, October 1976, pp. 51–55.

Winkler, John D., and J. Michael Polich, *Effectiveness of Interactive Videodisc in Army Communications Training*, Santa Monica, Calif.: RAND, R-3848-FMP, 1990.

Can the U.S. Navy save money by increasing its use of simulators without sacrificing readiness? The authors look at the use of simulators in the Air Force, the Marines, and French and British forces to see if the Navy's current mix of simulator and live training should be changed substantially for the first time since the 1970s. After presenting the data for each service branch and type of simulator, the authors conclude that the Navy must first decide how it wants to measure readiness before an increased use of simulators will yield tangible returns in the form of increased proficiency at lower cost.

ISBN 0-8330-3104-X
52500>
9 780833 031044

MR-1441-NAVY