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FLIGHT HOUR COST VARIANCE
IN THE NAVAL AIR RESERVE:
AN ANALYSIS OF POSSIBLE SOURCES

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Flight Hour Cost Variance in the Naval Air Reserve: An Analysis of Possible Sources

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ABSTRACT

This thesis is an analysis of flight hour cost variance in the Naval Air Reserve and Fourth Marine Aircraft Wing. The broad objective of the thesis was to identify and analyze factors hypothesized to cause variance in cost per flight hour. An overview of the Naval Air Reserve Force structure and budgetary organization is presented. The relatively recent shift in the use and role of reserve forces towards Total Force concept goals is highlighted. An interview process is described in which four possible sources of cost per hour variance were identified for investigation: flight hours, primary mission area, repairables pipeline and overseas detachments by reserve VP squadrons. For each possible variance factor, statistical tests were applied to available cost data to determine if its impact on cost per hour variance was significant. Findings indicate that primary mission area and VP detachments each have a significant impact on cost per hour variance. Recommendations are provided concerning headquarters and field level flight budget execution. Conclusions pinpoint further areas of research gleaned from the investigation.

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I. INTRODUCTION

A. MISSION OVERVIEW

The mission of the Naval Air Reserve is to provide combat ready reserve forces to fleet commanders in the event of mobilization. Simply stated, this means maintenance personnel who can keep aircraft flying and aircrew who can put weapons on target. To accomplish this goal, the key element is training; training to enhance the specialized skills that most reservists acquired during their active duty days; training essential to achieve a state of readiness where a diverse group of reservists can step into uniform and function as a finely-tuned unit, working side by side with their active duty counterparts.

B. FLIGHT HOUR PROGRAM

For the Naval Air Reserve, the centerpiece of this essential training is its annual **flight hour program** which puts reserve aircraft into the air, flown by reserve pilots and maintained by reserve enlisted personnel. The flight hour program is built upon three tiers:

- The budgetary process, which works to obtain funding and tracks ongoing expenditures.
- The flight hour targets, which translate annual funding dollars into hours of flight time available to a reserve squadron.
- The training requirements, which guide a squadron's operations and ensure that flight hours are effectively spent pursuing the mission of the unit.

This thesis will study the interaction between the first and second components of the flight hour program, focusing on a comprehensive flight hour cost measurement known as the cost per hour (CPH). The CPH is a rate which reflects the fuel and maintenance costs of operating an aircraft, including the costs of parts repair and replacement. Each month, the actual CPH is computed by dividing monthly fuel and maintenance costs by monthly flight hours. Consequently, any variance in this actual CPH is a function of changes in either operating costs, flight hours or both.

For each reserve squadron, this actual CPH is tracked and compared with two other CPH measures, a target CPH set at the beginning of each fiscal year and a moving year-to-date average CPH. By this process of comparative analysis, the CPH serves as a linkage between ongoing budget execution and the achievement of flight hour goals.

Specifically, this thesis will attempt to do two things:

1) Use an interview process to identify possible sources of CPH variance which can be investigated utilizing available cost data.

2) Analyze possible sources of variance in the cost per hour of aircraft operated by the Commander, Naval Air Reserve Force (CNARF) and the Marine Corps' air reserve component, the Fourth Marine Aircraft Wing (4th MAW).

It is important to note here the functional relationship between the Navy and Marine Corps reserves. While the 4th MAW is operationally distinct from the Navy, its flight budget is administered by reserve field comptrollers via the Naval Air Reserve flight budget office, part of the CNARF staff in New Orleans. These Navy staff personnel work closely with 4th MAW headquarters co-located there. This reflects the long-standing role of the Navy/Marine Corps team, where Marine forces retain operational integrity while receiving Navy administrative support.

C. COST PER HOUR VARIANCES

In fiscal year 1990, the flight hour program budget for the Naval Air Reserve and 4th MAW totalled over $225 million. A major challenge facing those responsible for flight budget execution is to effectively track and analyze significant variances in the CPH. These variances take one of two forms. The first is a variance from a moving average, or cross sectional mean. In any given month, the actual CPH of operating a squadron's aircraft may vary significantly from its year-to-date average. The second type is a variance of the year-to-date average CPH from a target CPH. For a particular reserve squadron, its average CPH may vary significantly from a standard, or target CPH established for it at the beginning of the year.

Whatever the source, these variances continually arise and can adversely affect the overall success of the flight hour program unless properly resolved. Whether the variance is positive or negative, its existence poses questions for budget analysts both at headquarters and in the field. Is the variance a one-time occurrence or an indication of an emerging trend? Should more funds be held in reserve to cover unanticipated variances in the future? If so, what will the impact be on current flight operations?

In the Naval Air Reserve, these issues are dealt with frequently by the staff of the CNARF flight budget office and the network of reserve comptrollers in the field. At the local level, comptrollers track flight hour cost data from their assigned flying units. Meanwhile, the CNARF flight budget office updates the forcewide status of cost information and year-to-date obligations. A substantial part of the flight hour program management effort is spent tracking and interpreting CPH variances.

D. RESEARCH QUESTION

A number of theories abound concerning the major causes of CPH variance. Some possible factors appear readily evident; others are more subtle or lie hidden behind the effects of time lag. The focus of this thesis can be summarized by the following research question: Can sources of variance in the CPH be identified and can systematic relationships between CPH and the potential sources of variance be documented ?

Addressing the research question requires the following four broad steps:

- Describing the role of CPH in the planning and budget execution process.
- Identifying potential sources of variance in the CPH.

- Forming hypotheses concerning the expected relationships between the CPH and the potential sources of CPH variance.
- Performing statistical analysis to test hypotheses and describe the nature of the relationship.

The objective of this thesis will be to precisely identify possible sources of CPH variance, to statistically measure their effect and to translate findings into usable guidelines for those involved in flight budget execution.

E. BASIC METHODOLOGY

The basic methodology to achieve these goals is as follows:

1) Use an interview process to specifically identify possible sources of CPH variance.

2) Once possible sources have been identified, dete[illegible]ufficient cost data is readily available in order to isolate and e[illegible]e them.

3) If data is available, use statistical analysis to test for the impact of these factors on the CPH variance.

4) From significant findings, develop recommendations which may enhance the overall success of flight budget execution.

F. SCOPE OF THESIS

Several points are noteworthy here. First, this thesis will primarily focus on the budgetary process from the CNARF staff level "down the claimancy" and into the realm of field comptrollers and squadrons. While equally important budgetary relationships exist "up the claimancy", particularly with the major staffs of OP-80, OP-95 and OP-05, they merit further study which is well beyond the scope of this thesis. Hence such budgetary issues as the effect of continuing resolutions, Gramm-Rudmann cutbacks and long-term force structure will not be examined here.

Secondly, the CPH figures reported in this thesis should not be confused with the life cycle costs of operating Naval Reserve aircraft. Although the CPH is used as an effective tracking measure in annual budget execution, its limitations in capturing all aircraft operating costs should be realized. The CPH does not capture the costs of aircraft design, testing or acquisition nor does it encompass the pay and benefits costs of the military personnel who fly and maintain the weapon system. Hence, while the CPH performs an important function within the scope of this thesis, it is not suitable as an indicator of life cycle costs.

G. ORGANIZATION OF THESIS

In Chapter II, a broad overview of the Naval Air Reserve mission is presented, highlighting current force composition and emerging concepts. The flight hour program funding process from major claimancy to field activity is explained. The reserve budgetary organization is illustrated, eventually focusing on reserve field comptrollers and their role in flight budget execution. Inputs to CPH computations are described, followed by a step by step procedure for the handling of significant variances.

Chapter III explains the methodology used to identify potential sources of CPH variance, including research travel and the use of an interview process at the headquarters and field level. The four possible sources of variance developed from the interview process are then described in detail.

Chapter IV focuses on the testing of the research question, namely the effect of the possible sources of variance. The statistical analysis techniques employed are explained and the results of each test are interpreted.

Chapter V contains conclusions and recommendations. The possible sources of CPH variance are evaluated for acceptance or rejection. Trends or patterns gleaned from the research process are detailed. Further areas of research to assist in the execution of the flight hour program budget are identified.

II. BACKGROUND: THE ROLE OF THE COST PER HOUR IN BUDGET EXECUTION

This chapter will present a brief overview of the mission and structure of the Naval Air Reserve. The reserve budgetary organization and the processes surrounding the development of the flight hour program will be described. The CNARF airsite command structure will be illustrated. In order to establish the groundwork for thesis methodology, the role of the field comptroller and the computation of actual CPH's will be explained in detail.

A. STRUCTURE OF THE NAVAL AIR RESERVE AND FOURTH MARINE AIRCRAFT WING

1. Current Force Structure

The Naval Air Reserve Force and Fourth Marine Aircraft Wing operate 34 types of aircraft in 108 reserve squadrons, augmentation units and station activities [Ref.1]. Tables I and II depict the current force structure of CNARF and 4th MAW.

2. The Total Force Concept and Horizontal Integration

a. The Total Force Concept

The Total Force concept, introduced in the early 1980's, set out to merge the sometimes separate and divergent missions of the active duty and reserve Navy. The premise of the Total Force concept is that reserve forces should act as an extension of active duty forces, performing missions that not only enhance the readiness of the reserves but also serve to fulfill the current needs of the active force. This coordinated active duty/reserve interaction then results in a comprehensive force structure, or total force. [Ref. 2: p.46]

A key element of the total force concept calls for reserves to assume peacetime missions for which gaps exist in the capabilities of active duty forces due to shortages of funds, personnel or equipment. It is primarily for this reason that a substantial portion of the Navy's drug

Table I

FORCE COMPOSITION

NAVAL AIR RESERVE FORCE

	Type Aircraft	# of Squadrons
Carrier Airwings (2):		
East Coa... (CVWR-20)	F-14A	2
	F/A-18	1
	A-7E	2
	EA-6B	1
	E-2C	1
West Coast (CVWR-30)	F-14A	2
	F/A-18	2
	A-6E/KA-6D	1
	EA-6B	1
	E-2C	1
Helicopter Wing (CHWR):	SH-3D	1
	SH-3H	1
	SH-2F	3
	RH-53D	2
	HH-60H	2
Logistics Support Wing (CFLSW):	C-9B/DC-9	11
	CT-39G	2
	C-12B	8 *
	C-20D	1
	A-4F/TA-4J	2
	A-4M	1 *
Patrol Wings (2)	P-3A/B/C	15 **
Squadron Augmentation Units:	F/A-18	2
	S-3A/B	2
	F-14A	4
	A-7E	1
	A-6E	3
	SH-3H	3
	E-2C	2
	C-2	1
	P-3C	2

(As of January 1990)

* indicates station units
** includes 2 MAU's

Table II

FORCE COMPOSITION

FOURTH MARINE AIRCRAFT WING

	Type Aircraft	# of Squadrons
Fixed Wing Aircraft:	F-4S	2
	F/A-18	1
	F-5E	1
	A-4M/TA-4F	5
	OV-10A	1
	KC-130T	2
	EA-6A	1
	C-12B	2
Helicopters:	AH-1J	2
	UH-1N	3
	CH-46E	2
	CH-53A	3

interdiction effort today is performed by reserve maritime patrol and early warning squadrons. [Ref. 2: p.47]

b. Horizontal Integration

Traditionally, reserve units were issued older aircraft, most of which had been retired from active duty use as new models had been brought into service. This practice frequently created separate parts and repair pipelines for active duty and reserve forces. In the event of mobilization, reserve units might find themselves deployed to aircraft carriers and distant naval stations which lacked the parts, tools and test equipment to sustain them.

In 1982, then-Secretary of the Navy John Lehman initiated a program to upgrade Naval Reserve equipment. He termed this policy **horizontal integration** or the assignment of the same types of aircraft to active and reserve units. In this way reserve forces would operate a common weapon system with their active duty counterparts, alleviating immensely the logistics effects of a reserve call-up and achieving the mutual support goals of the Total Force Concept. The current structure of reserve carrier airwings and patrol wings closely mirrors that of active duty wings and is largely the result of horizontal integration practices. [Ref. 3]

c. *Squadron Augmentation Units (SAU's)*

Another element of the Total Force concept called for the creation of squadron augmentation units, or SAU's. These are reserve units which have no aircraft assigned to them. The personnel in a SAU drill together on weekends but generally do not deploy as a unit for annual Active Duty for Training (ACDUTRA). Instead, each member is assigned to an active or reserve squadron within their aircraft community. Most spend their two week ACDUTRA period serving with their assigned squadron and also participate in squadron flight operations during the week or at night if available. In the event of mobilization, these personnel would deploy to, or augment, these squadrons and provide needed support during the intensity of round-the-clock combat flight operations.

d. *Changing Force Composition*

In the last decade, the Naval Air Reserve has undergone a dramatic modernization of its force structure as the Total Force concept and its horizontal integration policy have been implemented. In most cases units have transitioned to a newer model of aircraft, but new squadrons have also been commissioned (and older units decommissioned) as reserve missions were updated or consolidated.

For example, until 1989 three reserve units entirely handled two Navy helicopter missions: combat search and rescue (CSAR) and combat support (primarily SEAL insertion/extraction). One squadron conducted CSAR operations while two others were assigned to combat support. In 1990 these two missions were consolidated into two restructured squadrons using the new HH-60H helicopter. This resulted in the decommissioning of one squadron, HC-9, and the retirement of an aircraft type, the HH-3A. As will be discussed in the Methodology chapter, in some cases this relatively rapid change limits the ability to collect sufficient historical cost data for analysis. [Ref. 4]

3. Aircraft Designations

Each Navy and Marine Corps aircraft is designated by a type, a model and a series [Ref. 5]. This type/model/series (T/M/S) scheme is described below:

- **Type**: One or two letters designating primary aircraft type (i.e. F for fighter, SH for ASW helicopter, C for transport, etc.)
- **Model**: Specific model number of that type aircraft (i.e. F-14, SH-60, C-9)
- **Series**: The last letter indicating which version of a particular model (i.e. F-14A, SH-60F, C-9B)

Even for the same model, different series aircraft have peculiar parts requirements and costs. Hence for a basic model such as the A-4 Skyhawk, the Naval Air Reserve maintains separate cost data on the A-4F, the A-4M, the TA-4F and the TA-4J [Ref 1: p. 2].

4. Types of Reserve Airsites

The CNARF and 4th MAW flying units depicted in Tables I and II operate from 15 Naval Air Reserve airsites. These are located throughout the United States at reserve naval air stations (NAS), naval air facilities (NAF) and naval air reserves (NAR). There is a difference in the types of command:

- **NAS** - A reserve naval air station is wholly operated and commanded by the Naval Air Reserve (for example, NAS Dallas).
- **NAF** - A naval air facility is located on part of an Air Force or National Guard base (for example, NAF Washington at Andrews AFB).
- **NAR** - A naval air reserve command is located on an active duty naval air station (for example, NAR Alameda at NAS Alameda, a Pacific Fleet base).

a. Airsite Locations

The following is a list of the fifteen Naval Air Reserve airsites:

- NAS Atlanta

- NAS Glenview, Michigan
- NAS Dallas
- NAS New Orleans
- NAS South Weymouth, Massachusetts
- NAS Willow Grove, Pennsylvania
- NAF Detroit
- NAF Washington D.C.
- NAR Alameda
- NAR Jacksonville
- NAR Memphis
- NAR San Diego
- NAR Pt. Mugu, California
- NAR Norfolk
- NAR Whidbey Island, Washington

b. Local Area Coordinator for Air (LACAIR)

Commanding officers of these reserve airsites assume a collateral duty known as Local Area Coordinator for Air, or LACAIR. They are responsible for administrative support, including flight budget execution, for all reserve flying activities in their local area. For example, the commanding officer of NAR San Diego, located at NAS North Island, provides support for reserve units at NAS North Island and NAS Miramar. Likewise the commanding officer of NAR Alameda, in his LACAIR capacity, administratively oversees reserve activities at NAS Moffett Field. [Ref. 6]

B. BUDGETARY ORGANIZATION OF THE NAVAL RESERVE

1. The Naval Reserve Force Comptroller

The Naval Reserve Force Comptroller is the head of the Naval Reserve budgetary organization. The force comptroller's staff is responsible for the execution of the Naval Reserve budget. For air programs this consists primarily of:

A. Operations and Maintenance (O&M) of the Naval Reserve, including

- Flight Hour Program
- Base Operating Support
- Contract Maintenance
- Travel and Administrative Staff Funding

B. Reserve Personnel Navy

C. Other Procurement Navy

[Ref. 7: p. IV-1-4]

2. The Flight Budget Office

As noted, the CNARF flight budget office handles budget execution for all Naval Air Reserve flying activities as well as the Fourth Marine Aircraft Wing. Administratively, the CNARF flight budget office is part of the comptroller's staff. It works closely with other comptroller divisions to track ongoing budget execution and resolve emerging issues. It is also keenly involved in the formulation of proposed Naval Reserve Force budgets for inclusion in the Navy's medium and long range Program Objectives Memorandum (POM) process. Like most headquarters staff, the role of the flight budget office is one of support and control. It serves as a conduit through which training needs are translated into funded requirements. [Ref. 6]

3. Field Comptrollers

At the field level, the CNARF budget is administered by 15 field comptrollers, one at each reserve airsite. These civilian comptrollers work directly for the commanding officer of their respective reserve command and indirectly for the force comptroller and his support staff. Comptrollers at these commands are responsible for ensuring that each dollar allocated is legally spent for its intended purpose.

While the field comptroller has a myriad of duties and serves as the commanding officer's principal advisor on all financial affairs, the focus here is on flight budget execution only. Under their LACAIR umbrella, these comptrollers administer the flight hour program budget for all Naval Air Reserve and 4th MAW flying activities under their cognizance. [Ref. 8]

C. THE FLIGHT BUDGET FUNDING PROCESS

1. The OP-20

The Naval Air Reserve flight budget office receives its flight hour program mandate in the form of a resource authorization document called the OP-20. The OP-20 is generated by the CNO staff of OP-05 (Air Warfare). The document lists the annual flight hours available to each Naval Air Reserve and 4th MAW T/M/S of aircraft. It further defines target CPH's for each T/M/S. It is the result of an ongoing force structure formulation process between OP-05 and the CNO's Naval Air Reserve staff, OP-095. By delineating the flight hour requirements and the aircraft in which they will be flown, the OP-20 reflects the impact of the POM process on such issues as growth of the reserves, force modernization and the deletion of certain T/M/S's. [Ref. 9]

2. Funding Authorization

The actual funding to accomplish the OP-20 flight time targets is obtained from a resource authorization document, the OP-823. It is generated by the Navy Comptroller's Office (NAVCOMPT) and establishes new obligaticnal authority (NOA). The OP-823 allocation is broken down by claimancy (in this case, Naval Reserve Force), appropriation (Operation and Maintenance, Naval Reserve) and quarterly dollar amounts. [Ref. 10] Basically, it is NAVCOMPT's consolidated funding response to the OP-20 flight program requirements as well as all other reserve force O&M needs. The OP-823 constitutes authority to incur new obligations, or spend money. It also sets the legal obligation limits under Title 31, Section 1517 of the U.S. Code.

The OP-823 appropriations are divided into accounts called budget activities (BA's) which appear in the program and financing schedule of the President's budget. Examples of BA's are BA-1 (Mission Forces), BA-2 (Depot Maintenance) and BA-3 (Base Operations). The Naval Reserve Force

O&M budget officer will suballocate the OP-823 amounts to his respective BA's, both surface and air. The CNARF flight hour program receives its suballocation under BA-1, Activity Group 5A. [Ref. 7: p. IV-1-2]

3. CNARF Current Plan

The CNARF flight budget office takes the information contained in the OP-20 and creates a game plan, called a FY budget current plan, to achieve its flight program goals. Assuming the OP-20 to be a "master budget", the CNARF current plan is akin to a "flexible budget" from which to track progress towards OP-20 goals and detect variances. For instance, while the OP-20 will list the total annual flight hours available to a T/M/S, the CNARF current plan will break that total down into quarterly increments for each squadron within that T/M/S community based on projected training requirements. For example, if the OP-20 allots 12,000 annual flight hours to reserve F-14A Tomcat aircraft, the current plan will reflect the quarterly breakdown of those 12,000 hours among the four F-14 squadrons in the CNARF claimancy. [Ref. 11]

4. CNARF Estimates of CPH

Equally important, while the OP-20 provides target CPH's for each T/M/S aircraft, the CNARF flight budget office will apply its own projected CPH to each squadron within a T/M/S community based on recent cost information. Normally this CNARF CPH estimate is computed by taking each squadron's August CPH from the previous fiscal year and adding a NAVCOMPT-provided inflation adjustment. This CPH modification is necessary due to the fact that even for squadrons operating the same T/M/S aircraft, some squadrons typically have a higher CPH than others. This issue will be examined in greater detail later in the thesis.

Using message traffic, the CNARF flight budget office then issues flight hour targets to all flying activities and NOA to its 15 reserve field comptrollers. The flight budget office typically issues 96% of its first quarter NOA to the field and keeps 4% in reserve as a **funding holdback** to deal with unanticipated or emerging requirements. [Ref. 11]

The CNARF cost per hour estimates are important to successful execution of the flight budget. Inaccurate CPH projections at the beginning of the fiscal year exacerbate the magnitude of budget execution problems throughout the year. These problems can be further compounded by unforeseen events which throw a squadron's flight hour program into disarray, such as a shutdown of flight operations due to maintenance or safety factors.

5. Constraints on Reserve Operations

Ongoing problems with a flight hour program may be even more pronounced for reserve units. For a reserve squadron the key to successful execution of its flight program is proper long range planning. Unlike an active duty command with its personnel readily available, the full time jobs of drilling reservists demand that the squadron develop and schedule its flight opportunities well in advance. Weekend drills, carrier landing qualifications and annual ACDUTRA periods are usually planned months ahead of time.

However, if a reserve squadron suffers a setback to its scheduled operations, it may find it much more difficult to get "back on track" than its active duty counterpart. As an example, with one month left in the quarter, a recurring crack is discovered in the rotor head of a certain T/M/S helicopter, flown by both active duty and reserve squadrons. All affected squadrons are grounded for three weeks while the problem is analyzed and recommended repairs made. With one week of flying remaining in the quarter, active duty squadrons can conduct around-the-clock operations to complete required training and meet flight hour targets, but reserve units would lack the available manpower on short notice to meet the quarterly goals.

D. FIELD COMPTROLLER ROLE IN FLIGHT BUDGET EXECUTION

1. Distribution of Allocated Funds

At the beginning of each fiscal year, the CNARF flight budget office notifies reserve commands of the quarterly dollar amounts and flight hours available to each of their flying activities. This is done using two messages, one for funds authorization and another for the flight hour program. The funds authorization message defines the legal NOA available to the field comptroller for both flight and non-flight programs. The flight hour program message establishes quarterly flight hour targets for each flying unit under a comptroller's cognizance. These dollar amounts and flight hour goals are updated quarterly or whenever a revision occurs. [Ref. 11]

Although the flight hour targets and the funding authorization to achieve them are closely related, an important distinction does exist between the two. While the flight hour targets reflect important training goals, the funding authorization sets strict legal limits on new obligations. Hence the funding authorization may be thought of as a broad budgetary constraint controlling the achievement of the flight hour targets.

Field comptrollers will distribute the authorized funds to the BA accounts of their squadrons and base Aviation Intermediate Maintenance Department (AIMD) and Supply Department using one of two methods. If the reserve airsite is a NAS or NAF, the comptroller's staff will issue funds via a CNARF computer database known as FAST DATA. If the command is a NAR, the comptroller will still use FAST DATA to post funds to squadron accounts, but for AIMD and Supply he must use must a NAVCOMPT Form 2275 (Work Request / Reimbursables Document) in order to allocate funds to the active duty base comptroller [Ref 11]. The effects of this procedure and the lack of a common database for NAR's will be examined in greater detail later in the thesis.

While squadron flight hour totals are broken down into quarterly targets, a unit may exceed its quarterly goal by 5% with comptroller concurrence. This may be done providing funds are available locally and the unit does not exceed its annual total. [Ref. 7: p. IV-4-18]

2. Computation of the Cost Per Flight Hour

a. The Four Cost Pools

For each CNARF and 4th MAW flying activity, cost data for its type/model/series aircraft is collected into four integral cost pools. By integral it is meant that these cost pools are mutually exclusive and collect all costs associated with operating and maintaining the aircraft (with one exception: pay for military personnel). These four cost pools are Fuel, OMA, IMA and AVDLR. They are described below:

- **Fuel** - The cost of aviation fuel and lubricants.
- **OMA** - Organizational Maintenance Activity; the costs incurred at the squadron level to maintain the aircraft. OMA costs are entirely for **consumables**, or items that are more economical to replace than repair.
- **IMA** - Intermediate Maintenance Activity; the costs associated with intermediate level repair and maintenance. These are AIMD costs and are related to both consumables and **repairables**, items for which repair is considered more economical than replacement.
- **AVDLR** - Aviation Depot Level Repairables; the costs of major component rework, repair and replacement beyond the AIMD level of capability. For most aircraft T/M/S, AVDLR represents the largest and most variable cost pool.

[Ref. 7: p. IV-4-17]

b. Consolidation and Verification of Cost Data

An important job of the comptroller's office is to track flight hour data provided by their local squadrons and cost data provided by the squadrons and AIMD/AVDLR billings. At the end of each month, the comptroller sums the accumulated cost data in the four cost pools and comes up with a total monthly cost for operating and maintaining each squadron's T/M/S aircraft. The total is then divided by the squadron's flight hours for the month to achieve a cost per flight hour. As depicted in the following equation:

$$\frac{Fuel+OMA+IMA+AVDLR}{FLIGHT\ HOURS} = Cost\ Per\ Hour\ (CPH)$$

This is done on both a monthly and cumulative year-to-date basis. The updated year-to-date CPH is then compared to both the monthly CPH and the CNARF benchmark CPH to detect any variance direction and magnitude. The cumulative flight hour total is also compared to the projected current plan to see if the squadron is on track to meet its quarterly and annual flight hour goals.

3. Analysis of Flight Hour Program

a. Preparation of Flight Hour Cost Report

The comptroller performs the above procedure for each flying activity under his or her cognizance and consolidates the information into a Memorandum Record Flight Hour Cost Report message which is sent to the CNARF flight budget office. This report contains cumulative totals for all cost data and flight hours and updates a moving CPH which is compared to the CNARF projected CPH in order to detect variances. If the current monthly CPH varies from the year-to-date CPH by more than 10%, the comptroller should also provide an explanation for the variance. [Ref. 7: p. IV-5-4]

In actuality, much of this information is already known by the CNARF flight budget office beforehand since they typically communicate with field comptrollers several times a week via phone, fax machine or message traffic.

b. Positive versus Negative Variances

It is important to note that variances are positive as well as negative and that a positive variance does not necessarily denote something good in terms of flight program execution. Referring back to the example of the grounded helicopter squadrons, the comptroller may find that he has "generated an asset" in terms of funds availability due to decreased fuel and repair costs, but at the unwanted expense of not meeting the squadron's flight hour program.

Positive variances have to be dealt with in terms of annual budget execution as well. If a comptroller foresees that he has generated an asset in a unit, it is imperative that he obligate those funds somewhere else in his local area or turn them back into the CNARF flight budget office for use at another airsite. Hard-fought-for budget dollars that go unobligated in one fiscal year are unlikely to be seen in subsequent years. [Ref. 6]

In short, a significant variance in either direction raises questions that the field comptroller must deal with. Frequently the problems of a negative "deficit" variance mirror those of a positive "asset" one. However, the following general discussion will examine how a comptroller handles a significant negative variance.

c. ***Handling of Significant Variances***

If a comptroller detects a significant negative variance that could become a problem to a flying activity, there are several steps he will follow. First, the comptroller will discuss the emerging problem with the squadron involved. He'll attempt to determine if the variance is a one time "spike" or a potentially recurring situation. [Ref. 12]

If it looks as though the deficit variance, due to either its magnitude or duration, will impact the squadron's flight hour program, the comptroller will then attempt to move funds from among the other flying activities under his cognizance who have generated asset variances in their program. The comptroller is free to do this as long as he has the concurrence of the base commanding officer and the shift of funds will not adversely affect the flight hour program of another unit.

If the comptroller lacks the resources in his other units to alleviate the problem, he'll notify the CNARF flight budget office and request a funding increase for the affected squadron. It is then up to the flight budget office to allocate holdback funds or determine if asset variances generated by other field comptrollers are available. The flight budget office may also seek additional funds from other Naval Reserve Force O&M account via the O&M/NR budget officer. If no funds are available, the funding increase will be denied or delayed.

However, if the situation is serious enough in terms of its impact on the squadron's readiness, the CNARF flight budget office will explain its case to its major staffs in Washington - OP-95 and OP-80 - and request additional obligational authority. Just as it is imperative for a field comptroller to be judicious in contacting the CNARF flight budget office for an increase in funds, queries to OP-95 and OP-80 should be exercised when no in-house alternative is available.

E. SUMMARY

The current force structures of CNARF and 4th MAW were presented. A relatively recent concept, known as the Total Force concept, was examined which evolves around the optimal use and role of reserve forces. The emergent practices of horizontal integration and the creation of SAU's were described. The flight budget funding process was reviewed and the reserve budgetary organization was depicted. The role of field comptrollers and the flight budget office were examined. The computation of CPH, the four cost pools and comptroller reporting requirements were described. A sequential discussion of the handling of significant variances was presented.

This chapter was intended as a broad overview of the Naval Air Reserve narrowing its focus to the role of the CNARF flight budget office and the field comptroller. The description of the flight hour program funding process and the discussion of CPH tracking and reporting procedures serve as the groundwork for the next chapter where the results of an interview process involving headquarters and field level personnel are examined.

III. IDENTIFICATION OF SOURCES OF VARIANCE IN THE CPH

This Chapter will describe the portion of thesis research conducted at the headquarters and field level. It will focus on the interview process used to determine possible sources of CPH variance and the selection of those factors for which cost data exists. It will present a background discussion of each possible source as well as its hypothesized effect on the CPH variance. Finally, it will the describe the database used for investigating the research question.

A. RESEARCH TRAVEL

Thesis research was performed at Naval Reserve Headquarters in New Orleans. A nearby reserve airsite, NAS New Orleans, was also visited in order to collect data and conduct interviews at the field level. This portion of the thesis research consisted of three stages:

1. Bibliography Update

A review of current headquarters directives was conducted to ensure that information gathered from the preliminary bibliography was up to date. Copies of all applicable CNARF reference instructions were obtained as well as an updated copy of the Naval Reserve Force Budget Guidance Manual.

2. Cost Data Collection

This stage consisted of collection and screening of flight hour cost data from the CNARF flight budget office. Budget office personnel had meticulously transferred necessary thesis CPH data onto consolidated spreadsheets prior to commencement of thesis travel. In order to ensure the accuracy of time series data, recent squadron transitions to newer T/M/S aircaft were verified against actual field comptroller reports to pinpoint the exact transition timeframe.

3. The Interview Process

Extensive interviews were conducted with CNARF budget office staff. Interviews were also conducted with other headquarters staff as well as field level personnel at NAS New Orleans.

a. *Personnel Interviewed*

The following personnel were interviewed during the thesis research:

- CNARF Flight Budget Officer
- CNARF Flight Budget Execution Officer
- Naval Reserve Force Comptroller
- Naval Reserve Force Operations & Maintenance Budget Officer
- Director of Flight Operations, Naval Air Reserve
- Director of Flight Operations, Fourth Marine Airwing
- Program Managers (2), Naval Air Reserve
- Aviation Supply Officer, Naval Air Reserve
- NAS New Orleans Comptroller
- NAS New Orleans Budget Officer
- NAS New Orleans Supply Department Master Chief
- VP-94 OPTAR Log Storekeeper

b. *Interview Format*

While the interview process followed a generic format, it was tailored as necessary to match the organizational level and particular expertise of the person involved. The basic tone of the interview was informal and straightforward:

"What do you do ?"

"How do you interact with the flight hour program ?

"What causes variances in the flight hour program ?"

B. POSSIBLE SOURCES OF VARIANCE

During the interview process, a substantial number of variables were cited as possible causes of flight hour variance. Several of these were peculiar to a specific aircraft or reflected a perspective unique to an organizational level or subspecialty. However, as a result of the interview process, four variables were identified and chosen for study in this thesis.

The reasons these variables were chosen are twofold. First, they were repeatedly mentioned as possible cause factors in several different interviews. Secondly, these four variables can be effectively analyzed using available flight hour cost data. This was not the case with other variables cited. The four variables are:

- Flight Hours Per Month
- Primary Mission Area
- Repairables Pipeline
- VP ACDUTRA Detachments

The following is a detailed description of each variable and its hypothesized effect on the CNARF flight hour program:

1. Flight Hours Per Month

How are monthly flight hours related to the cost rate of operating and maintaining the aircraft ? As noted in Chapter One, the CPH is computing by dividing total costs by flight hours. Consequently, a constant CPH in months with different flight hours would indicate a perfectly linear relationship between flight hours and the total cost of fuel, parts and repairs.

While it is logical to assume a fairly linear relationship between flight hours and fuel costs, it is not so clear that the same relationship holds for repair and replacement costs. To understand why, it is important to briefly examine the conceptual framework underlying the maintenance of Navy aircraft using scheduled preventative maintenance as an example.

Different aircraft components "break", or become inoperative in different ways or due to different stresses. Maintenance and replacement procedures are then structured around the measurement that best reflects wear and tear on a piece of equipment. Basically, there are three different measuring units used to schedule preventative maintenance on Navy aircraft:

a. Flight Hours

The wear and tear on some components is primarily affected by aircraft flight hours. Engines are the ideal example of this stress factor. For this reason it is standard procedure to overhaul the engine on an S-3 Viking, for instance, every 1600 flight hours.

b. Calendar Days

Other components need periodic servicing regardless of how often the aircraft is flown. This is true for equipment that has a limited shelf life or is exposed to the corrosive effects of the elements. For example, ejection seats on Navy jets are thoroughly inspected and serviced every 224 days.

c. Occurrences

The stress on some equipment is best determined by the number of occurrences of an event, particularly landings. For this reason the tailhooks on carrier based aircraft are retightened after every 10 arrested landings and replaced after every 100.

d. Intermittent Use Equipment

These three examples of scheduled maintenance do not encompass the wear and tear on many pieces of equipment whose use is dependent on a specific flight condition or mission. An all-weather instrument landing system may be put to use on only a small portion of flights; de-icing systems are normally activated only during the winter.

An armament control panel may be turned on only several times a month when weapons are actually loaded.

e. "Memoryless" Property of Avionics Equipment

This highlights a telling point about many repairs and replacements. A large portion of a squadron's maintenance effort is directed at unscheduled repairs. For any given piece of equipment, an unscheduled component failure is basically a random occurrence which can be depicted statistically by the exponential distribution.

Unlike other random distributions, the exponential distribution is characterized by a unique "lack of memory" property due to the fact that its mean and standard deviation are equal. As an example of application, if an instrument panel light has lasted 100 hours without failure, its chances of lasting one additional hour are the same as when it was installed, for it does not "remember" how long its has already been on. This phenomenon is especially true for electronic components and avionics gear. [Ref 13: p. 288]

f. Theorized CPH/Repair Cost Relationship

The measurement used to capture this whole range of repair and replacement costs is the cost per flight hour (CPH). This is done primarily for convenience sake, for the CPH is considered the easiest of all measures to track and compute. But as the examples above point out, a nearly linear relationship between repair costs and flight hours is inherently unlikely to occur.

However, the interview process indicated that in the long run, the monthly costs for a particular T/M/S will generally stabilize within a moderate range of values, but will fluctuate depending on the number of flight hours logged that month. In other words, the CPH will be affected by variations in the number of monthly flight hours from the long-term average. This thesis will examine the effect of monthly flight hours on the four cost pools and therefore its overall effect on the CPH.

2. **Primary Mission Area**

Aircraft are designed to operate in a variety of flight regimes. While the range of flight operating environments is diverse for some aircraft, for others it is quite homogenous. This section will discuss these differences as a possible source of CPH variance.

a. Diverse versus Steady State Missions

Preliminary research and the interview process identified the primary mission area as another variable to investigate as a possible source of CPH variance. Specifically, compared to relatively "steady state" T/M/S aircraft such as transport or patrol aircraft, those tactical aircraft and helicopters which conduct a diverse range of missions or operate in both the shipboard and land based environment will experience a greater degree of variance in CPH. In order to analyze the relative effects on CPH, it is necessary to assign each T/M/S of aircraft to one of four general mission classifications:

- **Tactical Jet Aircraft** - includes squadrons from East and West coast carrier airwings, all A-4's & F-5's and all 4th MAW tactical jets.
- **Helicopters** - includes all CNARF and 4th MAW helicopter units.
- **Transport Aircraft** - includes all C-9's, DC-9's, C-39's, C-20's and C-12's.
- **Maritime Patrol and Refueling Aircraft** - includes all P-3B's, P-3C's and 4th MAW KC-130 tankers.

In operational terms, it is arguable that these four mission areas are overly broad. However, for purposes of CPH variance analysis, they have been subjectively chosen on the basis of overall function.

b. Constraint on Analysis of Transport Aircraft

There is an important point to note in conducting variance analysis of transport aircraft. The C-9, C-39, C-20 and C-12 are simply military versions of widely used commercial aircraft. Day to day organizational level maintenance is performed by military personnel, but intermediate or depot level servicing and parts replacement is conducted by civilian contractors operating under fixed price annual contracts.

Since these aircraft are not deployed to ships or remote overseas bases, this readily available contract maintenance does not detract from the military missions of these aircraft. More importantly, it is in keeping with the guidelines of OMB Circular A-76 which mandates the use of civilians to perform functions not requiring military personnel if life cycle costs would prove more economical [Ref. 14].

The result of this fixed price contract maintenance is that while there are Fuel and OMA cost pools for transport aircraft, there are no IMA or AVDLR cost pools. These costs are absorbed by the annual contracts. They are not linked to a cost per flight hour nor are they tracked by field comptrollers. Depending on the relative volatility of these cost pools for the other categories, this factor could impact the variance analysis of primary mission area and will be taken into account.

3. Repairables Pipeline

This section will describe the hypothesized difference in the repairables pipeline of different types of CNARF airsites. A brief review of the repairables process is provided below.

a. *Overview of AVDLR Process*

As mentioned in Chapter Two, a repairable is a component that is inoperative and cannot be fixed at the squadron level. Furthermore, the component is considered more economical to repair than replace. It is then "inducted" into the repair and supply system - the pipeline. In theory, the procedure is quite simple:

1) The squadron turns in the inoperative component at its base Aviation Intermediate Maintenance Department (AIMD) and receives a good one in exchange.

2) The malfunctioning component, called a carcass, is examined at the AIMD to determine the extent of repair needed.

3) If the AIMD can, it will repair the part and return it to the supply system for reissue. Costs incurred at this stage are assigned to the IMA cost pool.

4) If the repair is beyond the capability of the AIMD, the part becomes an AVDLR and will be forwarded a specialized Naval Aviation Depot (NADEP) or in some cases to the contractor who originally manufactured the component. Costs incurred in these stages are assigned to the AVDLR cost pool.

In short, the carcass is either repaired at the AIMD, NADEP or contractor level or is replaced with a new piece of equipment. Eventually, the squadron who turned in the component is billed for the cost of repair or replacement via its field comptroller. [Ref.15]

b. Departures from Standard Procedure

However, problems arise in the carcass tracking and billing system for a variety of reasons. First, at the time of the initial exchange by the squadron, there may not have been a one-for-one swap of bad component for good. In some cases the squadron receives a working component without simultaneously turning in a carcass. Perhaps the part is a major structural component which needs replacement immediately after removal. In other cases the malfunctioning part must be kept aboard an otherwise flyable aircraft for weight and balance purposes until a replacement is on hand. In another common example, the inoperative part is aboard an aircraft which is stranded at another base and unable to fly because of the malfunction. These examples point out only a few of the reasons a squadron may receive a good component without a carcass swap.

Even if the squadron does turn in a carcass, the tracking of its whereabouts may fail somewhere in the process of shipment, repair, supply or billing. In either case, this can have enormous consequences for the AVDLR cost pool of the squadron and its field comptroller.

c. Standard versus Net Price

The AVDLR system uses a two-tiered price structure to account for the costs of repairing and replacing parts. If the component is repaired and returned to service, the squadron is assessed a charge via its comptroller. For each component, this fixed charge, called the **net**

price, represents the Navy's average cost to repair that component and is based on technical cost analysis. If a replacement is needed the squadron is billed the full replacement cost, called the **standard price**, for that piece of equipment. Hence for each part there exists one net price and one standard price, both of which are updated annually to account for inflation and other factors. [Ref. 16]

However, if for any reason the carcass tracking system indicates that a carcass was never turned in, the squadron is automatically charged the full standard price. This two-tiered price structure can prove very costly in some cases as the standard price can be two to three times higher than the net price, or perhaps more. Hence AVDLR carcass tracking and the reconciliation of billings become very crucial to reserve squadrons and comptrollers. It is here that the interview process indicated there may be a possible cause of flight hour variance. This is due to the fact that the Naval Air Reserve uses one type of carcass tracking system and active duty NAS's operated by COMNAVAIRPAC and COMNAVAIRLANT use another.

d. *NAR vs NAS/NAF Tracking Ability*

As previously noted, there are three major types of Naval Air Reserve commands - NAS's, NAF's, and NAR's. In terms of the repairables pipeline, the type of command reflects its degree of insularity or interaction with the Naval Air Reserve supply system and accounting structure. For instance, a reserve NAS is basically a stand-alone base operated by Naval Air Reserve so that a component turned in there is automatically inducted into the CNARF repairables pipeline and tracked from there. The same is basically true of a reserve NAF, a self-contained Navy base that is located within the confines of a larger Air Force or National Guard base.

However, a NAR is situated as a tenant command of a larger active duty NAS operated by either COMNAVAIRPAC or COMNAVAIRLANT. There, inoperative components are inducted directly into that respective NAS repairables pipeline. As mentioned in Chapter Two, billing arrangements are made with base AIMD and Supply Departments via a transfer of funds to the active duty base comptroller.

Since the CNARF carcass tracking system uses a different database, it is unable to easily track carcasses through the massive repairables pipelines of either COMNAVAIRPAC or COMNAVAIRLANT. The Naval Air Reserve must wait until billings eventually migrate over to its own accounting structure in order to reconcile standard versus net prices and determine if a discrepancy exists. If a billing error is discovered, it may take an additional six to eight months to correct it and receive an AVDLR credit.

e. *NAR/Repairables Theory Conveyed in Interviews*

During interviews, this factor was cited several times. The hypothesis here is that a NAR's limited ability to effectively account for its repairables may cause a higher CPH variance for a NAR than for a reserve NAS or NAF, especially in the IMA and AVDLR cost pools. Hence the effect of the two tiered pricing structure is amplified in the case of NAR commands.

In the next chapter, the effects of this possible source of variance will be examined. Statistical comparisons will be developed and applied to NAR and NAS/NAF airsites in order to determine if a significant variance difference exists.

4. VP ACDUTRA Detachments

This section will discuss a perceived phenomenon unique to the group of squadrons operating the P-3 aircraft, known as the VP community. The effect involves travel to overseas bases, a markedly increased tempo of flight operations and a shift in the repairables pipeline.

a. *Overview of Reserve VP Operations*

The reserve VP community, operating the P-3 Orion aircraft, represents a substantial portion of the CNARF flight program. With 13 maritime patrol squadrons, it constitutes the single largest aircraft community in the CNARF claimancy. VP squadrons operate from 11 of the 15 CNARF airsites and, in 1990, their 46,000 flight hours accounted for 25% of the CNARF total. Hence significant variance trends in the VP community tend to affect overall budget execution for the Naval Air Reserve.

The VP community is currently undergoing a force modernization of its P-3 T/M/S aircraft to reflect technology updates in its primary mission, antisubmarine warfare. As of 1990, most squadrons have transitioned from the P-3A to the P-3B T/M/S, while two squadrons have transitioned from the P-3B to P-3C series.

b. Effect of ACDUTRA Tempo of Operations

Typically the busiest time each year for any reserve unit is its ACDUTRA period. For most squadrons, ACDUTRA presents the most challenging and valuable training opportunity available during its annual training cycle. It is the culmination of extensive planning and preparation including simulator training, weapon systems reviews and inflight proficiency checks. During ACDUTRA flight operations many required mission qualifications are obtained or renewed by squadron aircrew.

For reserve VP squadrons, ACDUTRA usually entails deployment to an overseas base to conduct antisubmarine warfare and reconnaissance operations in a real world environment. These deployments, or detachments, are normally arranged months in advance. For instance, a West Coast VP squadron may send a detachment to NAF Misawa, Japan while an East Coast unit deploys to NAS Rota, Spain. At the functional wing level, coordinated scheduling takes place to preclude deployment overlaps and ensure that any gaps in active duty commitments are filled.

The ACDUTRA timeframe involves a high tempo of flight operations, resulting in a much higher than average monthly flight hour total. In order to reach remote overseas bases, the transatlantic or transpacific crossings alone account for a sizable number of flight hours. While deployed, P-3 squadrons conduct long-range missions frequently lasting eight to ten hours. It is this concentrated accumulation of flight hours and its possible effect on the CPH that is of interest here.

c. ***Effect of Increase in Monthly Flight Hours***

The marked increase in monthly flight hours during the ACDUTRA period consequently makes the denominator in the CPH computation formula larger. The question is whether or not the actual costs total used in the numerator increases by the same proportion during ACDUTRA and therefore maintains a relatively constant CPH.

The hypothesized effect cited in the interview process is that during the month of actual VP ACDUTRA, the high number of flight hours outpaces the accrual of costs in the IMA and AVDLR cost pools and serves to lower the total CPH significantly from its monthly average. This possible variance effect will be examined in using cost data from P-3 squadrons. However, there is a possible corollary effect which will also be studied involving time lagged impact of ACDUTRA on the repairables pipeline.

d. ***Effect of Shift to Host Repair Base***

During the interview process, a factor was cited regarding VP ACDUTRA detachments which may affect the repairables cost variance. This is due to the fact that when a VP squadron deploys to an overseas base, it comes under the umbrella of the host base repairables pipeline. The host base has its own flight budget to contend with and cannot absorb the additional activity without an increase in funding.

Before ACDUTRA commences, the reserve comptroller for the deploying VP squadron will usually arrange a transfer of funds to the comptroller of the host base. This amount is based on an estimate of upcoming ACDUTRA flight hours multiplied by a pre-agreed CPH. Later, if the actual billings indicate a shortage or overage, another transfer will take place to reconcile the accounts of both bases [Ref. 12].

This is a practical technique which provides the flexibility for VP reserve squadrons to deploy to a number of remote sites. However, the billing process involved is subject to many of the same constraints as depicted with the NAR's - lack of control of funds, different data bases for tracking and the burden of time lags due to billings from overseas bases.

e. *Overall ACDUTRA Effect on CPH Variance*

Given the intensity of VP ACDUTRA operations and the fact that the unit is deployed away from its normal base of supply support, do ACDUTRA detachments have a significant effect on cost per flight hour variance ?

There is flight hour cost data available to help answer this question. For the 11 VP squadrons currently operating the P-3B aircraft, CPH variance outside of the ACDUTRA timeframe can be compared with the ACDUTRA variance. Additionally, the possible time lag effects of delayed billings can be examined.

C. DATA COLLECTION, SANITIZATION AND INPUT

In order to perform statistical tests on the four possible sources of variance, it was necessary to establish a valid database of flight hour cost information from which to draw samples. The following section will describe the procedures used to collect and screen data for inclusion in the database, as well as an overview of data input and file organization. Finally, for each possible source of variance, applicable data fields which can be drawn from the database for statistical sampling will be identified.

1. Data Collection

Flight hour cost data was originally collected for 108 flying units in the Naval Air Reserve and the Fourth Marine Airwing. For each unit, cost data submitted by field comptrollers in the monthly Flight Hour Memorandum Record messages was consolidated into a single spreadsheet for the 30 month period from July 1987 through December 1989. If a unit transitioned to a new T/M/S aircraft during the 30 month timeframe, a new unit spreadsheet was created. Due to overlaps caused by these transitions, the number of spreadsheets initially collected totalled 131.

The 30 month period was chosen in order to provide sufficient cost data on as many newer T/M/S aircraft as possible given the ongoing modernization of the CNARF force structure. In analyzing current force structure and recent aircraft transition phases several major T/M/S changes are noted which have a marked effect on overall CNARF force composition. Notable among these are:

- F-4 Phantom to F-14 Tomcat (4 squadrons)
- A-7 Corsair to F/A-18 Hornet (3 squadrons)
- P-3A to P-3B Orion (9 squadrons)
- E-2B to E-2C Hawkeye (2 squadrons)
- EA-6A to EA-6B Prowler (2 squadrons)

For each flying unit, the spreadsheet notes the T/M/S aircraft it operates and its airsite location. It then presents in column format the unit's cumulative annual flight hours, the monthly CPH for each of the four cost pools, a total CPH, the number of barrels of fuel consumed per flight hour and the monthly travel costs if applicable.

2. Data Sanitization

The 131 unit spreadsheets initially available were screened, or sanitized, in order to ensure data integrity prior to testing of the hypotheses. The criteria for inclusion of a unit's spreadsheet into the database for hypotheses testing was straightforward; a unit should be included in the database if its cost data provided sufficient, relevant information for analysis and excluded if it does not.

The following three criteria were chosen as guidelines in order to exclude unit spreadsheets whose cost information was irrelevant or insufficient for hypotheses testing:

- **T/M/S Retired from Service**: Flight hour cost data for T/M/S aircraft which have been deleted from service with CNARF and 4th MAW units as of 1 October 1990 are of no value for a current analysis and were excluded from the database. This criterion resulted in the exclusion of 11 T/M/S's.

- **Recent T/M/S Transition**: Aircraft T/M/S transitions which occurred during the 30 month data collection period may not provide a sufficient time series from which to reflect seasonal effects such as ACDUTRA periods, for which one year of data is the absolute minimum. For this reason, units having a partial time series of 12 months or less were excluded. This criterion resulted in the exclusion of four new T/M/S's.

- **Squadron Augmentation Units** : As described in Chapter Two, SAU's have no aircraft assigned to them. Rather, SAU personnel operate with active duty or reserve squadrons within their aircraft community. When SAU fly in aircraft belonging to one of these squadrons, the squadron receives a CNARF reimbursement based on a predetermined CPH rate. Since the CPH is preset, it exhibits no variance and hence provides no value for this analysis. Therefore, cost data for all SAU units was excluded. This criterion resulted in the exclusion of three T/M/S's not encompassed by other exclusions.

Table III

UNIT SPREADSHEETS EXCLUDED FROM DATABASE BY DATA SANITIZATION PROCESS

Initial Number of Spreadsheets:	131
Criterion	# of Units Excluded
T/M/S RETIRED FROM SERVICE	23
RECENT T/M/S TRANSITION	18
SQUADRON AUGMENTATION UNITS	20
UNITS INCLUDED IN DATABASE	70

As depicted in Table III, 61 of the original 131 unit spreadsheets were excluded from the database using the above criteria. The remaining 70 units included in the database represent 22 different aircraft T/M/S operated by CNARF and 4th MAW and are listed in Table IV.

3. Input of Cost Data into Computer Database

Using the MINITAB statistical software package, a separate file was created for each different T/M/S aircraft. Within each file, separate blocks were used to input cost data from individual units which operate a

Table IV

DATABASE COMPOSITION FOR HYPOTHESIS TESTING

Type/Model/Series	# of Squadrons or Units
A-4F	3
A-4M	4
TA-4F	2
TA-4J	2
UC-12B	10
CT-39G	2
C-9/DC-9	11
C-20D	1
P-3B	8
P-3C	2
KC-130T	2
F-14A	4
F/A-18	2
EA-6A	1
E-2C	2
RH-53D	1
CH-53A	3
CH-46E	2
UH-1N	3
AH-1J	1
SH-2F	3
SH-3D	1

Total Number of T/M/S Aircraft Included in Database: 22

Total Number of Squadrons or Units included in Database: 70

common T/M/S. For instance, within the file for the SH-2F helicopter, a separate data block was created for each of the three reserve squadrons which operate that T/M/S, HSL-74, HSL-84 and HSL-94. For each squadron, the following information was available to test the four possible sources of variance:

- **Flight Hours Per Month** - monthly flight hours, monthly CPH for each cost pool, actual costs for each cost pool, above or below average monthly flight hours and corresponding CPH.
- **Primary Mission Area** - total cost variance by squadron, AVDLR cost variance by squadron, average total variance and AVDLR variance by primary mission category.
- **Repairables Pipeline** - AVDLR cost variance and IMA cost variance for NAR squadron, AVDLR cost variance and IMA cost variance for corresponding NAS/NAF squadron.

- **VP ACDUTRA Detachments** - monthly flight hours, monthly CPH, monthly travel costs, monthly IMA costs, monthly AVDLR costs (both current and time-lagged)

D. SUMMARY

This chapter provided an overview of thesis research, including travel to CNARF headquarters and a field level activity. It described the procedures involved in the interview process and presented a detailed examination of the resultant variance factors developed from interviews. The methodology used to collect and screen cost data for suitability was discussed. The database to be used for testing the effect of the possible sources of variance was established and its file format was explained.

In the next chapter, the research question will be investigated. The four possible sources of variance will be examined by applying statistical analysis techniques to database samples. Each test measure will be described and its results interpreted. The goal will be to determine which possible sources of CPH variance, if any, are statistically significant and therefore merit special consideration during annual flight budget execution.

IV. ANALYSIS OF THE POSSIBLE SOURCES OF VARIANCE

Chapter Three described an interview process in which four possible sources of cost per hour variance were identified for investigation. In this Chapter, each of the four possible variance factors will be evaluated to determine if it has a significant impact on the CPH. For each potential variance source, a statistical test will be developed and applied to a sample from the database. The significance of test results will be interpreted and the possible ramifications on flight budget execution will be explored.

A. OVERVIEW OF METHODOLOGY

1. Hypotheses

Hypothesis testing procedures will be used to investigate the effect of the four possible sources on CPH variance. It is important to precisely define the testable relationship between each variance factor and CPH. The expected relationships are restated in hypothetical form as follows:

- **Flight Hours** - The null hypothesis is that a squadron's monthly flight hours will have no association with it's monthly CPH. The correlation coefficient **r** will be used to test this hypothesis.
- **Primary Mission Area** - The null hypothesis is that there is no significant difference in the degree of CPH variance based on primary mission area. The t-statistic will be used to test this hypothesis.
- **Repairables Pipeline** - The null hypothesis is that there is no significant difference in the degree of CPH variance due to the different type of repairables pipeline existing at NAR commands and NAS/NAF commands. The t-statistic will be used to test this hypothesis.
- **VP ACDUTRA Detachments** - The null hypothesis is that VP ACDUTRA detachments will have no effect on the CPH of maritime patrol squadrons. The t-statistic will be used to test this hypothesis.

2. Cost Variance versus Statistical Variance

A clarification of terms is in order here. The average CPH variance, as stated in the hypotheses above, refers to a cost variance. Specifically, a CPH variance refers to the deviation of a monthly CPH from the average CPH for the 30 month sampling period. Average CPH variance is simply the average of those 30 monthly deviations. It is important to note that CPH variance is not the statistical variance, that is, the average of the squared deviations. The following section discusses whether or not CPH cost variance should be measured using statistical variance or another method.

3. Measure of Dispersion Desired

The tests in this chapter are designed to investigate the deviations of monthly CPH's from an average. The degree of deviation, or dispersion, can be measured using one of two methods: absolute values or squared deviations. The average obtained from absolute values is known as the mean absolute deviation (MAD) and the average of the squared deviations is statistical variance, with its square root being standard deviation.

For this thesis, the absolute deviation was chosen as the desired measure of dispersion. The primary reason for this selection is that with squared deviations, large deviations from the mean are given disproportionately greater weight due to the exponential effect of squaring, whereas with absolute values all deviations are assigned proportional weights in the computation of the average CPH variance. In the case of CPH variance analysis, squared deviations may obscure relatively small but significant factors at the expense of large irregular deviations.

In short, two measures related to CPH are investigated, depending in the test. They are:

- **CPH Variance**: The deviation of a monthly CPH value from the 30 month average. This measure is used when investigating causes of month by month CPH variability.

- **CPH Dispersion**: The average of the 30 monthly variance values (absolute values). This measure is used as a summary indicator of the overall degree of CPH variability for a given squadron.

4. The Probability Value p

For each statistic, its corresponding p-value will be used to determine the significance of the test at the 95% level of confidence. Broadly defined, the **p**-value is a measure of doubt cast upon the validity of a null hypothesis. For any statistic used, its corresponding **p**-value is the probability that, if the null hypothesis is true, another sample could be taken which contradicts the null hypothesis more than the observed sample. It therefore expresses the strength of the decision to reject the null hypothesis. [Ref. 13: p. 459]

The lower the **p**-value, the more the validity of the null hypothesis is called into question and the alternate hypothesis is favored. Since this analysis will use a confidence level of 95% , a **p**-value of .05 or less indicates that the null hypothesis should be rejected.

5. Use of Standardized Measure

Various aircraft can exhibit drastically different CPH rates depending on a host of factors. These include fuel usage, parts availability and the technological complexity of the weapon system. For example, the twin turboprop C-12 transport generally operates at a cost of less than $100 per flight hour, while the CPH for the F-14 Tomcat is frequently over $1500.

In order to conduct a comprehensive analysis of the relationship between monthly flight hours and CPH rates among 15 different units, a standardized measure was needed. This standardization of scale was achieved by the use of an adjusted CPH value and an adjusted monthly flight hour value. These are described as follows:

- **Adjusted CPH** - For each CPH data point, its adjusted CPH is the actual CPH divided by the average CPH of its 30 month data set, resulting in ratio values near one. This procedure was performed for each cost pool of each squadron analyzed. Hence CPH variances were restated as standardized ratios, regardless of the actual CPH rate.
- **Adjusted Monthly Flight Hours** - This value was likewise computed by dividing each monthly flight hour total by the squadron's monthly flight hour average for the 30 month period. Again, this scaling effect resulted in ratio values near one.

B. ANALYSIS OF THE FLIGHT HOURS HYPOTHESIS

The null hypothesis is that a unit's monthly flight hours will have no effect on its CPH. In the following section, tests will be performed in order to detect any significant correlation between monthly flight hours and monthly CPH. While this analysis is the primary goal of the section, the sample data will also be "wrung out" in several respects. This additional examination will provide a broad insight into the overall cost structure of the flight hour program. Besides the correlation of monthly flight hours with the CPH, the following areas will also be briefly investigated:

- The relationship between flight hours and actual costs.
- The effect of each cost pool on the total cost per hour.
- The presence of first order autocorrelation in the cost per hour.

The initial test performed correlated monthly flight hours and the CPH as described below.

1. Test of Significant Correlation

The correlation coefficient **r** was selected to measure the impact of monthly flight hours on variance in the CPH. The **p**-value for this statistic will be used to determine if the hypothesized effect of flight hours on CPH variance is statistically significant. For each test performed in this section, **r**-coefficients and their respective **p**-values will be listed in the table of results.

a. *The Correlation Coefficient r*

The relationship between monthly flight hours and the CPH was tested using the Pearson product-moment correlation coefficient function. This function computes **r**, a measurement of the linear association between two random variables. The range of **r** is from -1 to 1. Values of **r** which approach 1 or -1 indicate a strong linear relationship between the associated variables, so that points plotted on a X-Y graph using the two variables would fall close to a straight line. If **r** is positive, the slope of the line is positive. If **r** is negative, the slope of the line is negative, thus indicating an inverse relationship between the variables. Values of **r** near 0 indicate little or no linear relationship between the variables. [Ref. 17: p. 9]

b. *Selection of Sample Data*

Chapter Three described the process by which a database was established from which to draw samples. In the first step of the analysis

Table V

FLYING UNITS SELECTED FOR TESTING
THE EFFECT OF MONTHLY FLIGHT HOURS ON MONTHLY CPH

Unit	T/M/S	Location
MACG-48	KC-130T	Glenview
MAG-49A	TA-4F	South Weymouth
MAG-46	CH-46E	San Diego
HS-85	SH-3D	Alameda
VAW-88	E-2C	San Diego
VP-90	P-3B	Glenview
MAG-49A	UH-1N	South Weymouth
HSL-94	SH-2F	Willow Grove
HM-18	RH-53D	Norfolk
VR-46	C-9B	Atlanta
MAG-42B	A-4M	Memphis
VFA-305	F/A-18	Pt. Mugu
VP-93	P-3B	Detroit
CFLSW Det	CT-39G	Washington
VR-52	C-9B	Willow Grove

of flight hours as a possible source of CPH variance, a sample of 15 flying units was drawn from the database. This sample size was selected based on a judgement that these units were a representative sampling of units from the CNARF and 4th MAW force structure. The sample includes units operating from all four primary mission areas. This procedure ensured that recommendations developed will be applicable to overall forcewide budget execution. The 15 units selected are shown in Table V.

2. Correlation of Monthly Flight Hours and Cost Per Hour

Adjusted CPH's and adjusted flight hours values were obtained for

Table VI

CORRELATION COEFFICIENTS (r-values):

CORRELATION OF MONTHLY FLIGHT HOURS WITH:

	Fuel CPH	OMA CPH	IMA CPH	AVDLR CPH	Total CPH
Tactical Jets	**.335** (.000)	**.139** (.136)	**.061** (.517	**.167** (.074)	**.196** (.035)
Helicopters	**-.197** (.018)	**-.372** (.000)	**-.252** (.002)	**-.044** (.596)	**-.152** (.067)
Maritime Patrol	**-.168** (.121)	**-.061** (.572)	**.025** (.820)	**-.097** (.372)	**-.135** (.212)
Transports	**.227** (.034)	**-.442** (.000)	N/A	N/A	**-.050** (.643)
All Units	**.168** (.002)	**.011** (.843)	**-.045** (.400)	**.070** (.194)	**.067** (.211)

Note: p-values in parentheses

all units in the sample. Once this standardization of scale was complete, the 30 month data sets for all 15 units were pooled. This resulted in data sets of adjusted CPH's for each of the four cost pools - Fuel, OMA, IMA and AVDLR - as well as adjusted monthly flight hours, each containing 450 data points. These cost pools were then individually correlated with adjusted flight hours. The correlations for all 15 units combined, as well as broken down by primary mission area, are depicted in Table VI.

a. *Results of Correlation*

The overall findings indicate generally low correlations between monthly flight hours and the cost per hour. Even for those correlations whose p-values are significant, the correlation coefficient is relatively weak. For the combined sample, monthly flight hours did not have a significant association with the total CPH.

For the combined sample, the association of monthly flight hours with individual cost pools was significant only for the Fuel cost pool. However, even for fuel costs, the correlations for separate mission areas were weak and inconsistent, correlating positively for two primary mission areas and negatively for a third.

The breakdown of correlations by primary mission area indicates a weak but significant positive correlation between the monthly flight hours of tactical jet units and total CPH. This correlation is due primarily to the effect of the Fuel cost pool. One plausible explanation for this significant relationship is that when the monthly flight hours for a tactical jet unit go up markedly, it is usually because the unit has gone somewhere and participated in an exercise or conducted aircraft carrier operations. During such periods, the unit will fly a greater degree of the so-called "gas-guzzler" sorties, such as air combat maneuvering or carrier landing qualifications, than it would during normal operations at its home base. Hence the rise in monthly flight hours correlates positively with an increase in the Fuel CPH.

Another phenomenon noted was the weak but significant negative correlations for three of the cost pools associated with helicopters, indicating that as flight hours increased, the CPH rates for those cost pools decreased slightly. The possible reason for this effect is not obvious.

In summary, monthly flight hours do not have a strong or consistent effect on the CPH. Even for notably significant exceptions, correlation values were low. The remainder of this section will expand on several associated areas which may provide additional insight.

3. Correlation of Monthly Flight Hours and Total Costs

a. Relationship of Flight Hours and Costs

The previous correlation analysis focused on the relationship between monthly flight hours and the CPH. As discussed in Chapter Two, the monthly CPH is a rate achieved by dividing actual monthly costs by monthly flight hours. Therefore, CPH variances result from disproportionate changes in flight hours and costs from month to month. Either costs do not change at the same rate as flight hours, or costs and flight hours change in different directions.

Since monthly hours are used as the denominator in the CPH equation, the lack of consistent correlation between flight hours and the CPH suggests the possibility of a moderate to strong correlation between monthly hours and actual costs. The cost pool of fuel can be used to illustrate this point. An increase in flight hours will cause a corresponding increase in fuel costs. However, the fuel CPH rate derived by dividing fuel cost by flight hours may remain constant. The positive correlation will be reflected between hours and actual fuel costs.

Therefore, in order to determine those cost pools which are most affected by changes in monthly flight hours, monthly flight hours were correlated with the total costs actually incurred in each cost pool.

b. Results of Correlation

The monthly cost pools for Fuel, OMA, IMA and AVDLR were correlated with monthly flight hours, again using adjusted measures to provide a uniformity of scale. The results are listed in Table VII. The following is an analysis of the correlations.

Total Costs - For all units sampled, monthly flight hours are a strong predictor of the total dollar costs. The p-values indicate that

Table VII

MONTHLY FLIGHT HOURS VS. ACTUAL COSTS

CORRELATION OF MONTHLY FLIGHT HOURS WITH:

	FUEL COSTS	OMA COSTS	IMA COSTS	AVDLR COSTS	TOTAL COSTS
Tactical Jets	.97	.85	.79	.78	.92
Helicopters	.93	.80	.44	.66	.79
Maritime Patrol	.98	.81	.86	.82	.96
Transports	.95	.88	N/A	N/A	.93
All Units	.96	.83	.70	.75	.89

Note: p-values for **all** correlations are zero to three decimal places.

flight hours are significantly related to the total costs and to all four cost pools at the 95% confidence level. In fact, for all correlations the p-value was zero to three decimal places.

Fuel and OMA - Not surprisingly, the strongest correlation is between flight hours and fuel costs. The next strongest flight hour correlation is with actual OMA costs, or the cost of consumable items at the squadron level. This confirms the intuitive assumption that the most direct impact of changes in operating tempo and flight hours are borne at the squadron level.

IMA and AVDLR - The association of flight hours with the IMA and AVDLR cost pools is significant, but is not as strong as with Fuel and OMA costs. This finding seems to reflect the discussion of Chapter Three regarding the different types of component stress factors - flight hours, calendar days, occurrences and the unique properties of avionics gear failure.

The use of flight hours alone to capture this diverse set of factors tends to dilute or weaken the correlation somewhat with the IMA and AVDLR cost pools. The results indicate that monthly flight hours are significantly related to repairables costs, but in any given month the behavior of the AVDLR cost pool is only loosely related to monthly flight hours and is therefore relatively unpredictable. In pragmatic terms, the more removed a maintenance level is from the aircraft flight line, the less direct the effect flight hours will have on its cost pool.

4. The Effect of Each Cost Pool on Total Cost

A computation was also performed in order to determine the relative influence of each of the four cost pools on the total cost sum for the sampled units. The results are summarized below:

- Fuel cost as percentage of total cost: 36%
- OMA cost as percentage of total cost: 8%
- IMA cost as percentage of total cost: 10%
- AVDLR cost as percentage of total cost: 46%

The percentages above point out that OMA and IMA costs are relatively small. Of the two large cost pools, Fuel is highly correlated with monthly flight hours (.96) and its behavior is therefore quite predictable. For the sampled units, AVDLR costs comprised virtually half (46.3%) of total costs and its correlation with flight hours was only (.75).

5. The Cost Driver Effect of AVDLR's

If flight hours were a very strong predictor of the behavior of all four cost pools, CPH variance would be nil. Flight hours would determine costs, and those same flight hours would be divided into costs to maintain a relatively steady CPH. Since that phenomenon does not generally occur, it is because flight hours do not serve as a consistent, reliable predictor of the behavior of a dominant cost pool, specifically the AVDLR cost pool.

The moderate correlation of flight hours with the dominant AVDLR cost pool means there are fluctuations in total costs which flight hours do not reliably predict. Hence flight hours do not serve as a very strong predictor of costs for all four cost pools, and CPH variances result.

This establishes the major component rework and repair effort (AVDLR's) as the **cost driver** in determining total costs each month because of its dominant size and erratic correlation with flight hours. In other words, CPH variance hinges largely on the behavior of the AVDLR cost pool.

This analysis is not intended to discount the importance of monthly flight hours in the determination of costs, for they are perhaps the best single predictor of overall costs. But the correlation confirms that the inability of monthly flight hours to steadily predict immense AVDLR costs serves as a major source of CPH variance.

6. Autocorrelation of Total Cost Per Hour Values

In theory, the accrual of costs for each month is an independent event, unrelated to the costs or flight hours of a previous period. However, when observations are taken over time, such as costs and flight hours, they frequently tend to exhibit a dependency on the values of previous periods in the time series. This is known as **autocorrelation**. If each observation is highly correlated with the one before it, this is called first order autocorrelation [Ref 18: p. 335].

In order to determine if first order autocorrelation existed for units in the database, each total CPH value was correlated with its predecessor. This was done by regressing the total CPH's for each unit on the total CPH's from the previous month, also known as a lagged regression. The **p**-value for the predictor coefficient was then checked to see if it was significant at the 95% level of confidence. This procedure was conducted for all units. The results are broken down by primary mission area and are listed below, showing the percentage of units that exhibited first order autocorrelation:

- **Tactical Jets**: 70%
- **Helicopters**: 64%

- **Transports:** 100%
- **Maritime Patrol:** 78%
- **All Units:** 76%

These results indicate that significant first order autocorrelation exists for approximately three out of four units. The possible causes and effects of this autocorrelation will be examined in the next chapter.

C. ANALYSIS OF THE PRIMARY MISSION AREA HYPOTHESIS

This section will study the primary mission area of an aircraft as a possible source of CPH variance. The null hypothesis is that there is no significant difference in the degree of CPH variance of a squadron based on the primary mission area of the aircraft it operates. By examining this hypothesis, the effect of diverse operating environments on CPH for some squadrons may be isolated and evaluated. A comparison of CPH dispersion was conducted in order to analyze the relative volatility of CPH variance for different primary mission areas.

1. Statistical Procedure

In order to examine the possible CPH variance effect of the primary mission area, the following procedure was performed:

- All units in the database were grouped according to the four primary mission areas outlined in Chapter Three: tactical jets, helicopters, transports and maritime patrol aircraft.
- The CPH dispersions for all units in each category were obtained, resulting in four samples.
- A two sample **t**-test was performed for each paired comparison. For example, a two sample test was conducted using tactical jets versus helicopters.
- The **p**-values for the resulting **t**-statistics were checked to determine if the difference in CPH dispersion was statistically significant at the 95% level of confidence.

The results of this statistical technique are depicted in Table VIII.

Table VIII

TEST RESULTS: PRIMARY MISSION AREA AS A POSSIBLE SOURCE OF CPH VARIANCE

Primary Mission Area Comparison	t-statistic	p-value
Tactical Jets vs Helicopters	2.55 (2.040)	.0160
Tactical Jets vs Transports	7.18 (2.093)	.0000
Tactical Jets vs Maritime Patrol	4.95 (2.086)	.0001
Helicopters vs Transports	5.58 (2.160)	.0001
Helicopters vs Maritime Patrol	2.53 (2.145)	.0240
Maritime Patrol vs Transports	5.46 (2.179)	.0000

Note: Critical table values from the t-distribution are given in parentheses.

2. Results of Variance Comparison

The comparison of CPH dispersion indicates that a significant difference exists depending on the primary mission area of the aircraft involved. The CPH dispersion of tactical jet aircraft was the highest, followed in order by helicopters, maritime patrol and transport aircraft. The CPH of transport aircraft exhibit very little dispersion, probably due to the absence of IMA and AVDLR cost pools due to fixed price maintenance contracts. This resulted in relatively large t-statistics when compared with other primary mission areas.

The markedly high CPH dispersion in tactical jet aircraft and the high dispersion in helicopters highlight important areas of focus during annual budget execution. These will be explored in detail in the next chapter.

D. ANALYSIS OF THE REPAIRABLES PIPELINE HYPOTHESIS

As discussed in Chapter Three, the hypothesized effect of the repairables pipeline involves the AVDLR cost pool and is related to the different types of CNARF airsites - NAS's, NAF's and NAR's. The null hypothesis is that NAR airsites will have a greater degree of AVDLR cost pool CPH dispersion than NAS or NAF commands. This effect is primarily due to differences in tracking databases and accounting structures. For purposes of this study, NAS and NAF airsites will be considered the same since their repairables pipelines share a common accounting structure.

1. Statistical Procedure

All units in the database with AVDLR cost pools were analyzed in order to test the hypothesized effect. Statistical comparison was conducted using the t-statistic technique similar to that used to compare primary mission area fields:

- All units in the database were sorted into two groups, those that operate from NAR airsites and those that operate from NAS/NAF airsites.
- Using adjusted CPH data to ensure a uniformity of scale, CPH dispersion values were obtained for the units in each group, resulting in two samples.
- A two sample t-test was performed on the two samples.

A one-tailed test was used because the postulated effect is that NAR units will experience a higher degree of CPH dispersion, rather than that NAR and NAS/NAF dispersions will simply be unequal.

2. Results of Analysis

The outcome of this statistical procedure for the AVDLR cost pool is highlighted in Table IX. The results of this test indicate that on average, units operating from NAR commands do not experience a greater degree of CPH variance than units which operate from NAS or NAF commands. Therefore, the differences in the repairables pipeline cannot be considered a significant source of CPH variance.

Table IX

NAR vs NAS/NAF AIRSITES: COMPARISON OF AVDLR COST POOL VARIANCES

Two Sample t-test for NAR vs NAS/NAF:

	n	mean dispersion
NAR Units	21	.331
NAS/NAF Units	21	.245

TTEST MU NAR = MU NAS/NAF (VS NE): T = 1.66
p-value = .100
DF = 38

Note: Average dispersions were calculated using adjusted CPH values.

Although the average dispersion for NAR units was higher than for NAS/NAF units, the difference was not considered meaningful at the 95% level of confidence. This highlights an important point - within each group a high degree of dispersion exists. Indeed, the intra-group dispersion was enough to rebut a finding that the difference between the two types of commands is significant. Therefore the key difference may not depend on the type of command, but rather on the AVDLR cost allocation procedures between individual commands. This issue will be addressed in the next chapter regarding the non-standardized methods of AVDLR overhead allocation between the two coasts and among various commands.

E. ANALYSIS OF VP ACDUTRA DETACHMENTS HYPOTHESIS

The following section will examine the possible CPH effects of ACDUTRA detachments by P-3 squadrons to overseas locations. As discussed in Chapter Three, this type of reserve operation is unique to the VP community and has been cited as a possible source of variance. Therefore it merits separate attention. The null hypothesis is that VP ACDUTRA detachments will have no effect on the CPH of the P-3 squadron involved. The analysis will seek to isolate and examine the combined effect of a high tempo of flight operations and a shift in the repairables pipeline away from the home base, both of which accompany VP ACDUTRA operations.

1. Selection of Sample Data

As noted in Chapter Three, reserve VP squadrons have been methodically transitioning to newer updates of the P-3 Orion aircraft. Most squadrons which once operated the P-3A have transitioned to the P-3B. Some P-3B squadrons have progressed to the P-3C. In terms of completeness, the best sample data available from the database is for the P-3B T/M/S. The database contains full 30 month P-3B sample data for nine VP squadrons. Review of travel cost data and interviews with headquarters staff pinpointed exact timeframes of ACDUTRA periods.

2. Initial Analysis of Sample Data

For each of the nine P-3B squadrons, both the 1988 and 1989 ACDUTRA timeframes were identified, resulting in eighteen initial data sets. Each data set consisted of ACDUTRA month flight hours, average monthly flight hours and the resultant percent increase in flight hours due to ACDUTRA operations. Table X depicts the initial analysis of data.

The ACDUTRA month CPH's were compared to the average CPH's for each unit in order to detect any significant difference among the nine VP squadrons. Since the hypothesized effect of ACDUTRA on CPH variance is primarily through the AVDLR cost pool, it was the focus of examination.

3. Analysis of CPH Changes During ACDUTRA

In order to provide a graphic illustration of the effects of VP ACDUTRA operations on the cost per hour, time series plots of flight hours, CPH's and AVDLR costs are presented in Tables XI, XII and XIII.

To effectively measure the effect of ACDUTRA on the AVDLR CPH rate, the key issue is the relative change between the numerator and denominator of the CPH formula. In order to establish the change in the numerator, actual AVDLR costs during ACDUTRA were compared with the average monthly AVDLR costs. To establish the change in the denominator, flight hours during ACDUTRA were compared to the average of monthly flight

Table X

P-3B SQUADRONS SAMPLED TO MEASURE EFFECT OF VP ACDUTRA DETACHMENTS

Squadron	ACDUTRA Date	Average Hours	ACDUTRA Hours	ACDUTRA Increase
VP-60	APR 88	339	645	90%
VP-60	MAR 89	340	668	96%
VP-65	JUL 88	356	522	47%
VP-65	JUL 89	360	521	45%
VP-67	JUN 88	273	512	88%
VP-67	MAY 89	268	517	93%
VP-68	MAR 88	341	604	77%
VP-68	MAY 89	376	659	75%
VP-90	MAR 88	337	785	133%
VP-90	APR 89	344	614	78%
VP-91	MAY 88	316	777	146%
VP-91	JUN 89	303	603	99%
VP-92	JUL 88	285	731	156%
VP-92	JUN 89	284	570	100%
VP-93	APR 88	293	449	53%
VP-93	MAR 89	286	462	62%
VP-94	APR 88	300	536	79%
VP-94	FEB 89	310	696	125%
Average		317	604	91%

hours. Two-sample t-tests indicated that these differences in ACDUTRA month data were significantly different from the average yearly data. The relative changes in these parameters are shown in Table XIV.

The results indicate that during the ACDUTRA period, flight hours will accumulate at a faster rate than AVDLR costs and will cause a decrease in the CPH during the ACDUTRA month. In fact, VP squadrons nearly double their average monthly flight hours during ACDUTRA while their AVDLR costs increase by only 77%. The resultant CPH for the ACDUTRA month then dips significantly lower than average, causing a positive CPH variance.

Perhaps the accrual of costs in the AVDLR cost pool is only delayed by the effects of overseas ACDUTRA. If so, the impact on the CPH may manifest itself in the ensuing months as AVDLR billings arrive at CNARF airsites. As discussed in Chapter Three, this may be the result of the shift in the repairables pipeline away from the squadron's home base

Table XI

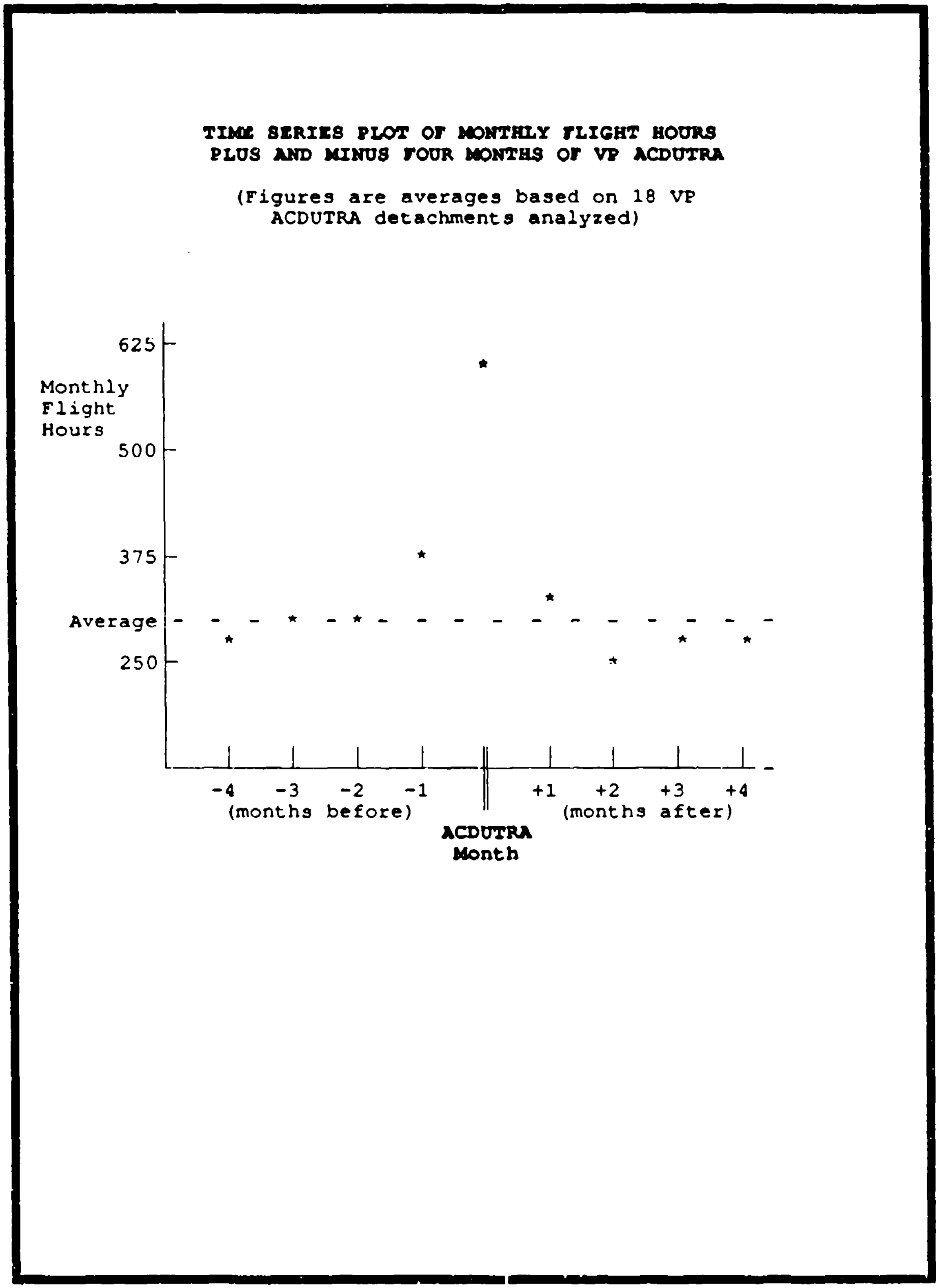
TIME SERIES PLOT OF MONTHLY FLIGHT HOURS
PLUS AND MINUS FOUR MONTHS OF VP ACDUTRA
(Figures are averages based on 18 VP
ACDUTRA detachments analyzed)
625
Monthly
Flight
Hours
500
375
Average
250
-4
-3
-2
-1
+1
+2
+3
+4
(months before)
(months after)
ACDUTRA
Month

Table XII

TIME SERIES PLOT OF COST PER HOUR
PLUS AND MINUS FOUR MONTHS OF VP ACDUTRA

(Figures are averages based on 18 VP
ACDUTRA detachments analyzed)

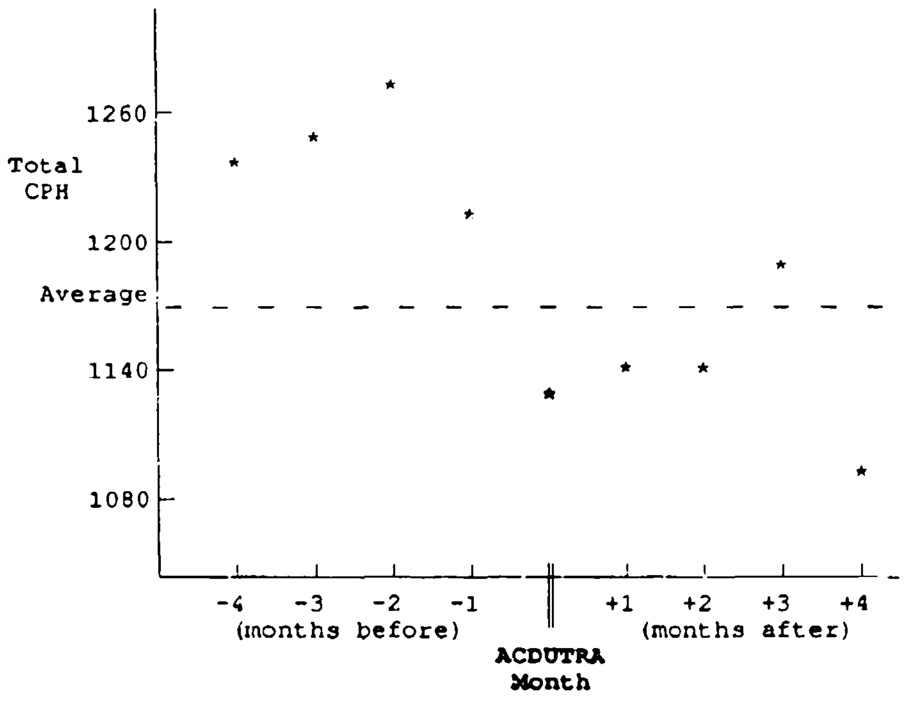

Table XIII

TIME SERIES PLOT OF AVDLR COSTS PLUS AND MINUS FOUR MONTHS OF VP ACDUTRA

(Figures are averages based on 18 VP ACDUTRA detachments analyzed)

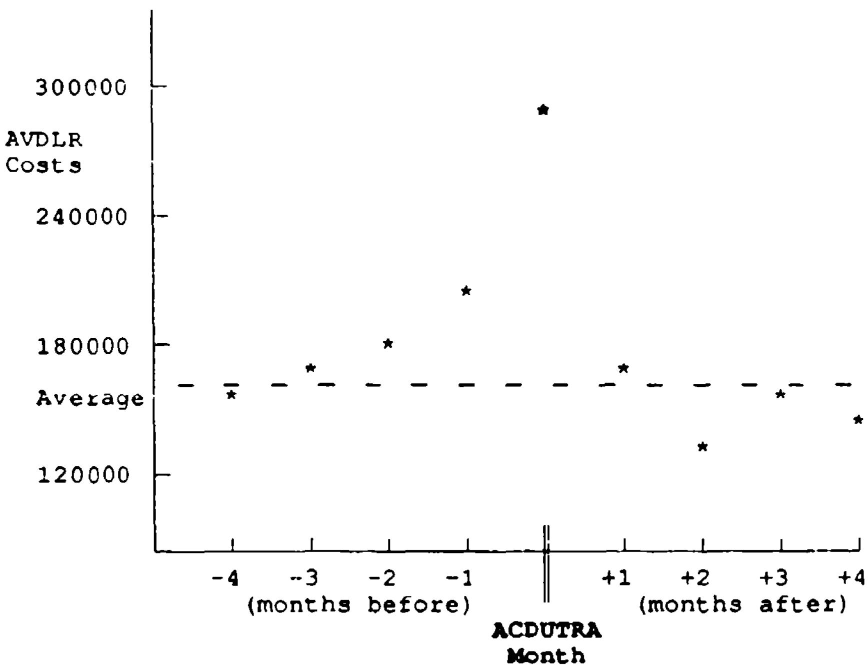

Table XIV

EFFECT OF VP ACDUTRA DETACHMENTS ON AVDLR CPH RATES

(Figures are averages based on 18 VP ACDUTRA detachments analyzed)

	Annual Average	ACDUTRA Month	Percent Increase
DENOMINATOR CHANGE:			
Actual AVDLR Costs	163898	290103	77%
NUMERATOR CHANGE:			
Monthly Flight Hours	317	604	91%

Finding: A 91% increase in flight hours occurs during ACDUTRA with a 77% increase in AVDLR costs, causing a decrease in the CPH for the ACDUTRA month.

during ACDUTRA. The next section will examine the time lagged effects of ACDUTRA on the AVDLR cost pools of reserve P-3B squadrons.

4. Analysis of Shift in Repairables Pipeline

This section will focus on the possibility of time lagged increases in a VP squadron's AVDLR cost pool in the months following an ACDUTRA detachment. The same basic methodology employed in the previous section is used here; the relative change in the AVDLR cost pool is compared to the relative change in flight hours. However, in this case the comparison is between the second and the third month following ACDUTRA. This selection was based on a review of P-3B spreadsheets and interviews with field comptrollers regarding the estimated receipt of billings from overseas bases. The interviewees indicated that this time frame may show the most substantial impact of the receipt of delayed AVDLR billings. The results of this comparison are depicted in Table VIII.

a. Results of Time Lagged Analysis

A cursory inspection of time lagged data using graphs and cost data did reveal a discernible shift in the behavior of the AVDLR cost pool in the months following VP ACDUTRA detachments. It appeared that from the second to the third month following ACDUTRA, flight hours increased by eight percent while AVDLR costs rose by nineteen percent, causing a noticeable increase in the total CPH. This effect can be seen in Tables XI, XII and XIII.

However, these differences were not significant at the 95% confidence level using a two sample t-test. Therefore, the effect of time lagged increases in the CPH is considered inconclusive.

The preceding analysis leads to two conclusions. First, the large number of flight hours accumulated by VP squadrons during ACDUTRA detachments will cause a significant decrease in the CPH for the ACDUTRA month. Secondly, there is no detectable pattern of time lagged increases in the AVDLR cost pool in the months following ACDUTRA.

It does appear that the CPH for VP squadrons follows a sine wave pattern - rising in the months prior to ACDUTRA, dropping markedly in the ACDUTRA months and then rising slowly again in the ensuing months. This pattern, due primarily to AVDLR costs, poses an interesting question. Is the rise in the months prior to the ACDUTRA due to the delayed effects of the previous ACDUTRA, a gear-up effort for the upcoming ACDUTRA or a combination of both? While available cost data is not sufficient to answer this question, it does present an area of possible further study.

F. SUMMARY

In this chapter the four possible sources of variance developed from the interview process were tested and evaluated. Statistical procedures were established and applied to selected samples. For each variance factor, the results of hypothesis testing are summarized below.

Flight Hours - Flight hours are significantly related to all four cost pools. Monthly flight hours are a good indicator of expected fuel costs and a fair indicator of OMA costs. However, as an indicator of IMA and AVDLR costs, monthly flight hours are relatively moderate and erratic. The AVDLR cost pool is typically the cost driver in the determination of the total CPH rate. The failure of flight hours to serve as a reliable predictor of AVDLR cost pool behavior precludes the use of flight hours alone as a strong predictor of CPH variance.

Primary Mission Area - In the analysis of primary mission area, significant differences in the degree of CPH variance were found between each category of aircraft studied. Tactical jet aircraft experience a high degree of fluctuation in AVDLR costs and hence the largest CPH variances. To a lesser degree, the same effect is true of helicopters. Maritime patrol squadrons appear to achieve a more consistent CPH range, perhaps reflecting a relatively steady state operating environment. Transport aircraft exhibit minimal CPH variance due to the lack of IMA and AVDLR cost pools. Therefore the primary mission area of a squadron will in large part determine the degree of CPH variance it exhibits.

Repairables Pipeline - Test results did not establish a significant variance difference between the repairables cost pools of NAR and NAS/NAF airsites. The degree of variance in NAR AVDLR CPH was not higher than that for NAS/NAF commands. This finding indicates that the nature of the repairables pipeline at NAR commands (lack of tracking ability and common database) cannot be considered a significant source of increased CPH variance.

VP ACDUTRA Detachments - The deployment of reserve VP squadrons to overseas bases causes a significant positive variance in the CPH during the month of ACDUTRA. This consistent dip in the CPH is due to the rapid accumulation of flight hours during ACDUTRA operations which is not matched by a corresponding rise in the AVDLR cost pool. Tests to detect possible delayed increases in AVDLR costs could not detect any discernible pattern in AVDLR cost pool behavior. Therefore, VP ACDUTRA detachments are a source of CPH variance in the months they occur but their effect on the CPH variance in ensuing months is unclear.

The next chapter will focus on conclusions and recommendations drawn from the findings of these analyses.

V. CONCLUSIONS AND RECOMMENDATIONS

This thesis investigated flight hour cost variance in the Naval Air Reserve. Its goal was to conduct an analysis of cost data and determine relevant areas of focus during annual flight budget execution. For two of the four possible sources of variance identified in the interview process, the findings were significant. Although the effect of monthly flight hours on CPH variance was not considered significant, important findings concerning the cost driver effect of the AVDLR repairables pipeline were documented during the testing process. These may translate into specific guidelines to enhance the success of the CNARF flight program. This section will synthesize in a concise format the overall findings from the testing of the research question.

A. ANALYSIS OF THE TESTING OF POSSIBLE SOURCES

In Chapter Four, the four possible sources of variance developed from the interview process were tested and evaluated. Significant findings were achieved from the analysis of three of the four variance factors. The following is a breakdown of findings and conclusions for each variance factor studied.

1. Flight Hours

For any unit, monthly flight hours are not a good predictor of cost per hour. From month to month, changes in the number of flight hours do not cause the cost per hour to fluctuate consistently or substantially.

Obviously, diseconomies of scale would result if the number of units produced (in this case flight hours) were very small. As an extreme example, if a squadron were to fly only ten hours in a month, the cost per hour would probably rise dramatically. This is because the ten hours would absorb the relatively fixed costs associated primarily with the AVDLR cost pool.

However, this thesis focused on the relevant range of monthly flight hours generated by normal operations during a thirty month sampling period. Within this relevant range, flight hours were not highly associated with the cost per hour.

The investigation of monthly flight hours was expanded to study the relationship between flight hours and actual costs. Here, significant correlations were found between monthly flight hours and each of the four cost pools; however, the strength of the correlations varied.

The weakest correlation was with the largest cost pool, AVDLR. The fact that total AVDLR cost does not move consistently with changes in flight hours leads to variance in the AVDLR CPH. Due to the dominant effect of AVDLR on total cost, this then leads to variance in the total CPH. In effect, the analysis of the remaining sources of variance focused on enhancing the ability of field comptrollers to more accurately predict the behavior of the AVDLR cost pool.

2. Primary Mission Area

Cost per hour variance is partially a function of the primary mission area of the squadron under study. As a category, tactical jet aircraft exhibited the greatest degree of CPH dispersion, followed in order by helicopters, maritime patrol aircraft and transport aircraft.

This dispersion ranking closely mirrors the range of flight operating environments from very diverse to relatively steady state. Consider this: On any given day, a tactical jet such as the F/A-18 Hornet may conduct training for any of the following missions:

- Air-to-air combat
- Bombing, mining and missile strikes
- Overwater surface surveillance
- Low-level and formation flight
- Inflight refueling
- Aircraft carrier landing qualification

- Cross-country instrument flight training
- Electronic warfare range training

At the other end of the spectrum, the C-9B transport aircraft could be expected to consistently perform missions in a single operating arena - high altitude medium range transport. The findings of Chapter Four indicate that the wear and tear of a diverse operating environment for certain categories of aircraft are reflected in a higher degree of CPH variance.

3. Repairables Pipeline

A significant difference does not exist in the AVDLR cost pool dispersion of a unit depending on whether or not it operates from a NAR airsite or a NAS/NAF airsite. The dispersion for units operating from NAR airsites is not higher due to differences in tracking databases and accounting structures.

4. VP ACDUTRA Detachments

During the month of actual VP ACDUTRA operations, the cost per hour of a reserve P-3 squadron can be expected to drop markedly from previous months. The accrual of costs, especially AVDLR costs, in the numerator of the CPH equation cannot keep pace with the rapid accumulation of flight hours in the denominator, resulting in a lower than average CPH. This phenomenon is unique to the VP community in that ACDUTRA involves long transits to overseas bases, sizable increases in the number and length of sorties and a shift in the repairables pipeline to the host base.

However, the effects of time lagged accruals in the AVDLR cost pool after ACDUTRA are unclear. No one particular post-ACDUTRA month tends to exhibit a significant rise in its CPH. Perhaps time lagged effects are fairly evenly spread among the ensuing months and therefore provide no discernible trend.

B. AREAS FOR FURTHER STUDY

During thesis research, several notable issues related to the Naval Air Reserve flight hour program were encountered which merit further study concerning the Naval Air Reserve flight hour program. These topical areas may provide a more detailed insight into some of the sources of CPH variance evaluated in this study. These are briefly described below.

1. AVDLR Overhead Allocation

While conducting a review of spreadsheet data, several observations were noted which may effect the average cost level of the AVDLR cost pool. These have to do with possible differences in AVDLR overhead cost allocation and billing arrangements between the Atlantic and Pacific fleet type commanders, COMNAVAIRPAC and COMNAVAIRLANT. For example, listed below are the average CPH rates, based on the 30 month sample period, for the CH-46E helicopter operated by the Fourth Marine Aircraft Wing on both coasts:

- MAG-46 (San Diego) Average CPH: $490
- MAG-46A (Norfolk) Average CPH. $942

In the case of the San Diego unit, billing is performed by COMNAVAIRPAC via the active duty 3rd MAW and thence to the reserve field comptroller. In the case of the Norfolk unit, costs are totally captured by the NAR comptroller without any intermediary effect. These significant differences are due to dissimilar cost allocation procedures between the type commanders and reflect non-standardized billing arrangements with different airsites.

Interviews with several field comptrollers indicated that, at the individual comptroller level, different and sometimes divergent techniques were being tried in order to alleviate cost allocation problems. While their results are unclear, these efforts present an opportunity for further research which may provide an enhanced understanding of the sources of CPH variance.

2. AVDLR Shipping Costs

One interesting phenomenon was observed during the analysis of VP ACDUTRA detachments which may merit further study. The average monthly AVDLR cost for the reserve VP squadron at NAS Alameda was significantly lower than for other VP squadrons located throughout the country. Not coincidentally, the Naval Aviation Depot which handles major component rework and repair for all P-3's is located at NAS Alameda. Perhaps part of the difference in the AVDLR costs could be due to reduced shipping costs for a squadron co-located with the Naval Aviation Depot. Hence the impact of AVDLR shipping costs on the CPH may merit closer investigation.

3. Intra-T/M/S Differences

In some cases, even for units operating the same aircraft at the same airsite, there were significant differences in average CPH rates (based on a two sample t-test at the 95% confidence level). For example, the following is the average CPH for the two F-14 squadrons administered by NAR San Diego for the 30 month sample period:

- VF-301 Average CPH: $2247
- VF-302 Average CPH: $1894

While the above units represent a NAR airsite, the same incidence of significant intra-T/M/S differences was found at NAS and NAF airsites. For instance, for the two F-14 squadrons operating from NAS Dallas, the averages for 30 months are as follows:

- VF-201 Average CPH: $2008
- VF-202 Average CPH: $1633

Since in each case the two squadrons share the same airsite comptroller, the differences above are not a result of comptroller level tracking or reporting procedures. Rather, they are a function of individual squadron level phenomena which, although beyond the scope of this thesis, are certainly worthy of closer examination.

4. "Stickiness" in Flight Hour Program

In Chapter Four, it was noted that approximately three-fourths of the units in the data base exhibited significant first order autocorrelation in total CPH trends. In economics, the statistical concept of autocorrelation is known as "stickiness". A variable may be slow to deviate from its established value even when the function that determines the variable indicates a change is required. Wage rates, for example, are frequently referred to as "sticky downward", especially if they are the result of labor union negotiations. [Ref. 18: p. V-5]

This phenomenon may affect flight budget execution at the field comptroller level. For each unit, a moving year-to-date CPH average is established in the first few months of the fiscal year. Thereafter, the goal of successful budget administration is to manage significant deviations from the moving average, thereby introducing "stickiness" as a system control. In fact, the requirement for comptrollers to explain any deviation greater than ten percent in their monthly reports serves to incentivize autocorrelation and emphasizes stability as a primary budgetary objective.

Further study may prove useful in this area. From a standpoint of systems controls, perhaps alternative reporting procedures could be examined which effectively blend the twin goals of budgetary stability and functional accuracy.

C. CONCLUSION

This analysis has attempted to provide a deeper insight into the sources of cost per hour variance in the Naval Air Reserve. In some areas, significant findings confirmed existing preconceptions regarding CPH variance. In other areas, new ground was broken and areas of further research were identified. While variances are, and will continue to be, a fact of life in ongoing budget execution, any effort to refine knowledge concerning their source will prove beneficial.

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