RAND PROJECT AIR FORCE

THE ARTS
CHILD POLICY
CIVIL JUSTICE
EDUCATION
ENERGY AND ENVIRONMENT
HEALTH AND HEALTH CARE
INTERNATIONAL AFFAIRS
NATIONAL SECURITY
POPULATION AND AGING
PUBLIC SAFETY
SCIENCE AND TECHNOLOGY
SUBSTANCE ABUSE
TERRORISM AND HOMELAND SECURITY
TRANSPORTATION AND INFRASTRUCTURE
WORKFORCE AND WORKPLACE

This PDF document was made available from www.rand.org as a public service of the RAND Corporation.

Jump down to document

The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world.

Support RAND

Purchase this document
Browse Books & Publications
Make a charitable contribution

For More Information

Visit RAND at www.rand.org
Explore RAND Project AIR FORCE
View document details

Limited Electronic Distribution Rights

This document and trademark(s) contained herein are protected by law as indicated in a notice appearing later in this work. This electronic representation of RAND intellectual property is provided for non-commercial use only. Unauthorized posting of RAND PDFs to a non-RAND Web site is prohibited. RAND PDFs are protected under copyright law. Permission is required from RAND to reproduce, or reuse in another form, any of our research documents for commercial use. For information on reprint and linking permissions, please see RAND Permissions.

This product is part of the RAND Corporation technical report series. Reports may include research findings on a specific topic that is limited in scope; present discussions of the methodology employed in research; provide literature reviews, survey instruments, modeling exercises, guidelines for practitioners and research professionals, and supporting documentation; or deliver preliminary findings. All RAND reports undergo rigorous peer review to ensure that they meet high standards for research quality and objectivity.

TECHNICAL REPORT

An Examination of the Relationship Between Usage and Operating-and-Support Costs of U.S. Air Force Aircraft

Eric J. Unger

Prepared for the United States Air Force

Approved for public release; distribution unlimited

PROJECT AIR FORCE

The research described in this report was sponsored by the United States Air Force under Contract FA7014-06-C-0001. Further information may be obtained from the Strategic Planning Division, Directorate of Plans, Hq USAF.

Library of Congress Cataloging-in-Publication Data

Unger, Eric J.
An examination of the relationship between usage and operating-and-support costs of U.S. Air Force aircraft / Eric J. Unger.
p. cm.
Includes bibliographical references.
ISBN 978-0-8330-4613-0 (pbk. : alk. paper)
1. United States. Air Force—Aviation supplies and stores—Costs. 2. Airplanes, Military—United States—Maintenance and repair—Costs. 3. Airplanes, Military—United States—Parts—Costs. I. Title.

UG1243.U53 2009
358.4'18—dc22

2009002606

The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors.

RAND® is a registered trademark.

© Copyright 2009 RAND Corporation

Permission is given to duplicate this document for personal use only, as long as it is unaltered and complete. Copies may not be duplicated for commercial purposes. Unauthorized posting of RAND documents to a non-RAND Web site is prohibited. RAND documents are protected under copyright law. For information on reprint and linking permissions, please visit the RAND permissions page (http://www.rand.org/publications/permissions.html).

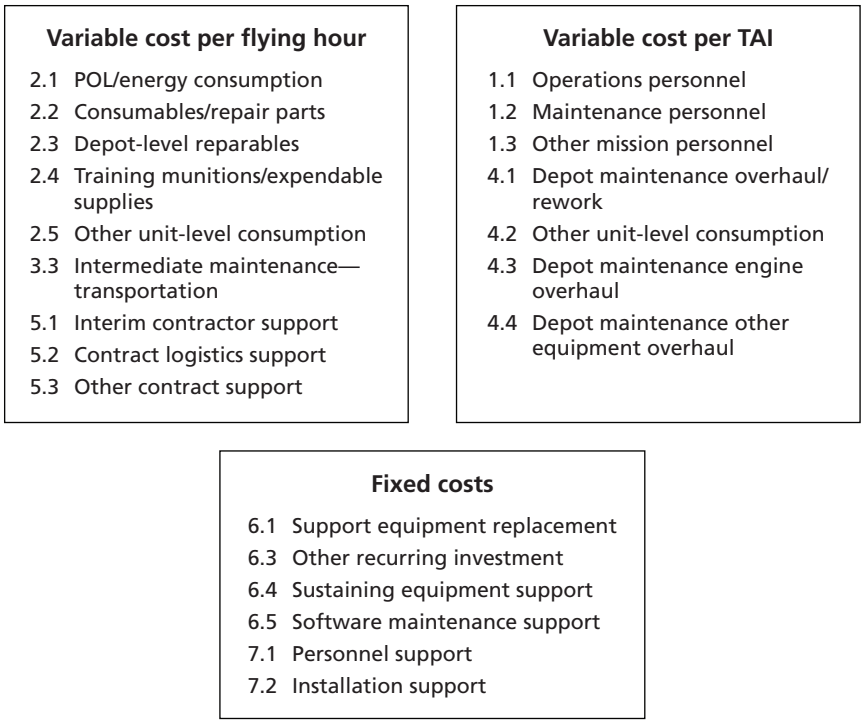
Published 2009 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213-2665
RAND URL: http://www.rand.org
To order RAND documents or to obtain additional information, contact
Distribution Services: Telephone: (310) 451-7002;
Fax: (310) 451-6915; Email: order@rand.org

Summary

A central issue in U.S. Air Force budget preparation is how funding levels need to be adjusted as flying hours and fleet sizes change. To address such challenges, the Secretary of the Air Force, Financial Management directorate (SAF/FM) created the expenditure categorization scheme shown in Figure S.1.

In the figure, Cost Analysis Improvement Group (CAIG) expenditure categories are broken into three groups. Those categories labeled *variable cost per flying hour* are assumed to increase or decrease in proportion to flying hours. Those categories labeled *variable cost per TAI* are assumed to increase or decrease in proportion to fleet sizes (total active inventory or

Figure S.1
SAF/FM Breakout of Cost Analysis Improvement Group Level-Two Costs



SOURCE: Lies and Klapper (2007).
NOTES: "Level-one" costs are most aggregated, e.g., mission personnel, intermediate maintenance, depot maintenance. A greater level of detail is found in "level-two" costs, e.g., different types of mission personnel, different types of depot maintenance.
RAND *TR594-S.1*

tails, TAI). The categories labeled *fixed* are assumed not to vary with flying hours or fleet sizes (though *fixed* does not imply these expenditures could not be reduced or increased).

This report evaluates the validity of Figure S.1 using fiscal year (FY) 1996 to 2006 data on expenditures, flying hours, and fleet sizes for different Air Force aircraft mission designs (MDs) or systems. Our data analysis recommends a somewhat more complicated breakout in which some types of expenses vary partially with flying hours or fleet sizes. For these categories, there appears to be a "fixed-plus-variable" cost structure with incremental costs per flying hour or per tail less than average costs.

Relative to SAF/FM's breakout, we find that a greater proportion of Air Force costs are not variable, especially with respect to flying hours. As a consequence, we are concerned that SAF/FM's approach overbudgets when flying hours increase and underbudgets when they decrease.

Background and Prior Work

CPFH is the primary metric the Air Force uses to create future budgets. Major commands create CPFH factors by mission design series (MDS) or type of aircraft (e.g., F-15C) and multiply the factors by projected flying hours. These projected budget requirements then feed the Air Force's budgetary decisionmaking process.

There is a considerable literature on problems with using flying hours to predict costs.

Hildebrandt and Sze (1990) constructed regression models that relate flying hours to operating and support costs. In general, they found operating and support costs increase less than proportionally with flying hours.

Slay (1995) noted that wartime conditions result in longer sorties and that the number of sorties predicts costs better than the number of flying hours. Sherbrooke (1997) built upon Slay (1995), finding that a disproportionate number of maintenance demands that are unrelated to safety are deferred until the end of a day.

Wallace, Houser, and Lee (2000) found that "removals" (a proxy for cost) are only loosely correlated with flying hours.

Laubacher (2004) examined different forecasting techniques for helicopter budgets. Similarly, Hawkes (2005) studied F-16 costs. Hawkes' primary finding was that last year's CPFH predicts this year's CPFH. Armstrong (2006) studied F-15 CPFH, finding a marginal CPFH would be preferable to average cost.

Data Overview and Estimation Approach

Our analysis is built around two data systems, the Air Force Total Ownership Cost (AFTOC) system and the Reliability and Maintainability Information System (REMIS). AFTOC tabulates expenditures by FY, CAIG cost element category, and weapon system. REMIS tabulates aircraft flying hours and possessed hours.[1] (See pp. 11–12.)

[1] A "possessed hour" refers to the fact that the Air Force *owns* the aircraft, irrespective of whether it is flying or broken.

Our objective is to measure the relationship between expenditures and aircraft flying hours. One could undertake such estimations for each MD separately, but doing so would be hampered by small sample sizes. Instead, we estimated a linear regression of the form

$$\ln(Cost_{it}) = a_i + b * \ln(FH_{it}) + c * Year_t + \varepsilon_{it},$$

where each i is an MD and each t is a year. $Year_t$ is a FY dummy variable. In this estimation structure, each MD gets its own intercept ($\hat{a}_i$) but there is a common $\hat{b}$ that is the most typical empirical relationship between the natural log of flying hours and the natural log of costs. (See pp. 12–14.)

Estimation Results

Using total expenditure data, we estimate an Ln (flying hour) coefficient of 0.56489. This result suggests total spending, on average, increases about 6 percent if a weapon system's flying hours increase 10 percent. (See pp. 15–17.)

In running the analysis of the more-detailed level-one and level-two CAIG categories (see the notes for Figure S.1), the 4.0 (depot maintenance) category shows an unusually large elasticity with respect to flying hours. We believe this finding is spurious and could have been caused by the Air Force changing accounting procedures. (See pp. 17–19.)

For many more-detailed level-two CAIG categories, we find evidence that a category's costs grow with, but not in proportion to, flying hours. The distinct exception is 2.1 (petroleum, oil, and lubricants (POL)/energy consumption) in which, not surprisingly, expenditures closely track flying hours. (See pp. 19–21.)

We also did estimations with both the natural log of flying hours and the natural log of fleet size as independent variables. Such estimations are only feasible because of a post-9/11 increase in flying hours without a commensurate change in fleet sizes. Previously, there was a near-perfect correlation between an MD's fleet size and its flying hours.

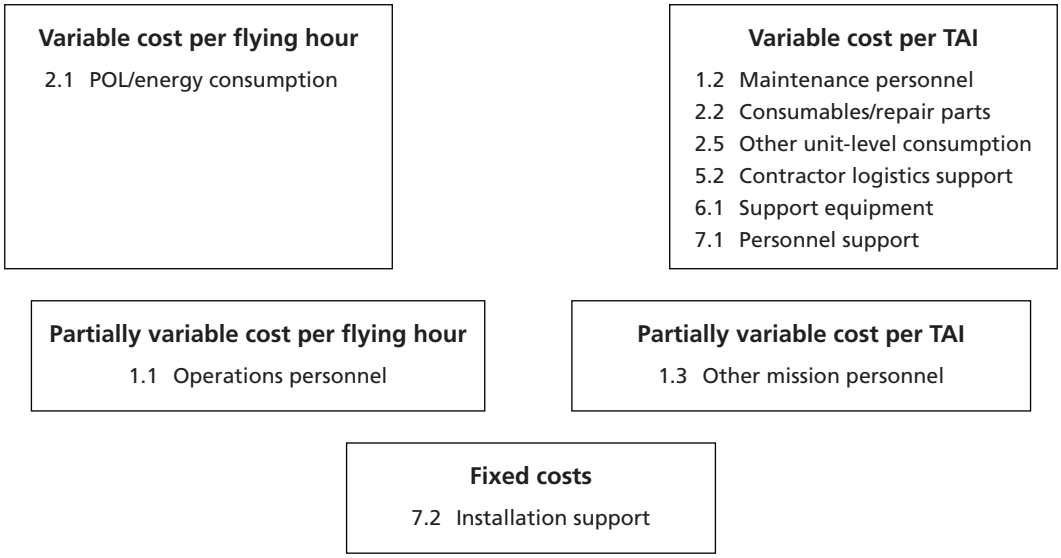
The regressions we undertook with both flying hours and fleet sizes as independent variables had mixed findings. Both flying hours and fleet size appear to partially affect total expenditures. Within specific categories, some types of expenditures—e.g., energy consumption—clearly track with flying hours, but others—including maintenance personnel—track with the number of aircraft. Yet other categories have partial, but not proportional, variability with flying hours or fleet size. Results were difficult to interpret for depot maintenance. (See pp. 21–26.)

Figure S.2 presents our alternative Air Force expenditure categorization scheme.

Policy Implications

Our analysis of FY 1996–FY 2006 expenditure and flying hour data suggests possible improvements to SAF/FM's approach. In particular, the "varying with flying hours" and "varying with fleet size" categorizations are too simplistic. In fact, some expenditure categories appear to

Figure S.2
Alternative Air Force Expenditure Categorization Scheme



NOTE: We cannot determine 2.3 + 4.0 (depot maintenance), 2.4 (training munitions), 3.0 (intermediate maintenance), 5.3 (other contract support), 6.3 (other recurring investment), 6.4 (sustaining equipment support), 6.5 (software maintenance), and 6.6 (simulator operations).

RAND *TR594-S.2*

exhibit fixed-and-variable characteristics, e.g., there is a baseline level of costs in the category and then costs increase with flying hours or fleet size, but not proportionally.

If flying hours are falling, categorizing expenditures as variable when they are actually partially fixed will lead to excessive budget cuts. If flying hours are rising, categorizing expenditures as variable when they are actually partially fixed will lead to excessive budget increases. (See pp. 29–30.)