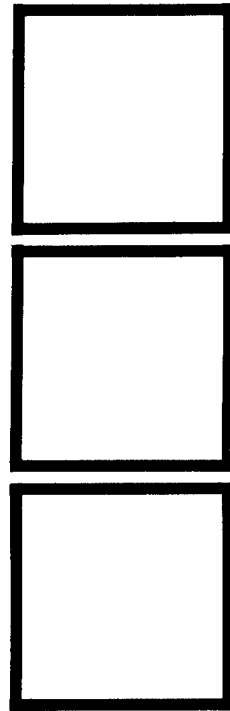
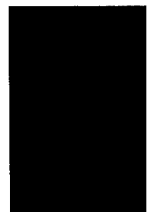


AIR FORCE JOURNAL ^{of} LOGISTICS



WINTER
1980



DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

20040601 087

BEST AVAILABLE COPY

AIR FORCE JOURNAL of LOGISTICS

Dr. Robert J. Hermann
Assistant Secretary of the Air Force
Research, Development and Logistics

General Bryce Poe, II
Commander
Air Force Logistics Command

Lieutenant General Billy M. Minter
Deputy Chief of Staff
Logistics and Engineering
HQ USAF

Editorial Advisory Board

Mr. Lloyd K. Mosemann II
Deputy Assistant Secretary of the Air Force
Logistics
Department of the Air Force

Lieutenant General John G. Albert
Commander
Air Force Acquisition Logistics Division

Lieutenant General Richard E. Merkling
Vice Commander
Air Force Logistics Command

Lieutenant General George Rhodes
USAF (Retired)

Major General Martin C. Fulcher
Assistant Deputy Chief of Staff
Logistics and Engineering
HQ USAF

Major General Rufus L. Billups
Director of Logistics Plans & Programs
HQ USAF

Major General Jay T. Edwards III
Deputy Chief of Staff, Logistics
United States Air Forces in Europe

Major General Cecil E. Fox
Commander
Oklahoma City Air Logistics Center

Major General William D. Gilbert
Director of Engineering & Services
HQ USAF

Major General Earl T. O'Loughlin
Deputy Chief of Staff, Maintenance
Air Force Logistics Command

Major General Jack W. Waters
Deputy Chief of Staff, Logistics Operations
Air Force Logistics Command

Brigadier General Joseph H. Connolly
Director of Contracting & Acquisition Policy
HQ USAF

Brigadier General Lawrence D. Garrison
Deputy Chief of Staff, Logistics
Air Training Command

Brigadier General Leo Marquez
Deputy Chief of Staff, Plans & Programs
Air Force Logistics Command

Brigadier General Waymond C. Nutt
Director of Maintenance & Supply
HQ USAF

Brigadier General George B. Powers, Jr.
Director of Transportation
HQ USAF

Colonel Lewis M. Israelitt
Dean, School of Systems and Logistics
Air Force Institute of Technology

Colonel William R. Tauzel, Jr.
Commander
Air Force Logistics Management Center

Editor

Major Pember W. Rocap
Air Force Logistics Management Center

Contributing Editors

Mr. Joseph E. DelVecchio
Associate Director, Logistics Plans & Programs
HQ USAF

Colonel Joseph E. Boyett, Jr.
Director of Plans and Programs
Air Force Logistics Management Center

Colonel Jerry J. Kean
Chief, Materiel and Logistics Management Studies
Air War College

Colonel David H. Schweigerdt
Director of Management Sciences
HQ AFLC

Lieutenant Colonel Jarrett B. McGehee, Jr.
Chief, Logistics Career Management Section
Air Force Manpower and Personnel Center

Lieutenant Colonel John M. Vosse
Chief, Logistics Management Branch
Directorate of Curriculum
Air Command and Staff College

Lieutenant Colonel William J. Weida
Tenure Associate Professor of Economics and
Management
United States Air Force Academy

Major Joseph L. Britelli
Department of Contracting Management
School of Systems and Logistics
Air Force Institute of Technology

Mr. Mel Waldgeir
Chief, Logistics Career Program Branch
Office of Civilian Personnel Operations

Graphics

Mr. Bob Ryan
Ms. Jane Snyder

AFRP
400-1

VOL IV
NO 1

WINTER
1980

AIR FORCE JOURNAL *of* LOGISTICS

CONTENTS

SPECIAL

2 Four Letters of Introduction

*General Lew Allen, Jr.
Dr. Robert J. Hermann
General Bryce Poe, II
Lieutenant General Billy M. Minter*

ARTICLES

4 The Impact of the Freedom of Information Act on the Contractor's Technical Proposal Major Van R. Muhn

11 An Assessment of the Benefits of Reliability Centered Maintenance on the C-141 Nozer D. Singpurwalla and Captain Carlos M. Talbott, Jr.

18 Opportunistic Base and Depot Maintenance Policies for F100 Engines in F-15 Aircraft John L. Madden and Virginia L. Williamson

24 Air Force Logistics Doctrine Major James D. Gorby

DEPARTMENTS

- 9 *USAF Logistics Policy Insight*
- 16 *Career and Personnel Information*
- 31 *Current Research*

ITEMS OF INTEREST

- 8 *Aircraft Tire Pressure Maintenance*
- 23 *MISTR Program Enhancements*
- 23 *Differential Item Management*

Purpose

The *Air Force Journal of Logistics* is a non-directive quarterly periodical published in accordance with AFR 5-1 to provide an open forum for presentation of research, ideas, issues and information of concern to professional Air Force logisticians and other interested personnel. Views expressed in the articles are those of the author and do not necessarily represent the established policy of the Department of Defense, the Department of the Air Force, the Air Force Logistics Management Center, or the organization where the author works.

Distribution

Distribution within the Air Force is F through the PDO system based on requirements established for AFRP 400-1 on the basis of 1 copy for every 15 logistics officers, top three NCO's and professional level civilians assigned.

Subscription

Subscription to the *Air Force Journal of Logistics* can be made for \$6.00 per year domestic (\$7.50 foreign) through the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Single copies are \$2.00 domestic (\$2.55 foreign). Back issues are not available.

The *Air Force Journal of Logistics* became AFRP 400-1 on 1 Jan 1980 and incorporated *The Pipeline* beginning with Volume IV, No. 1. Authority to publish this periodical automatically expires on 3 Aug 1981 unless its continuance is authorized by the approving authority prior to that date.

4 LETTERS OF INTRODUCTION

From the Chief of Staff, United States Air Force

Alexander the Great was a brilliant logistician as well as a superb strategist. He had to be both in order to give his command the ability to move rapidly over great distances and inflict decisive defeats over enemies outnumbering him by as much as ten to one. Had Alexander not had a thorough understanding of the relation between logistics and success in battle, his name would be unknown today and the history of the western world would be far different.

Since the time of Alexander, the equipment of warfare has changed markedly, but superior logistics remains critical to victory. Today, when we are faced with worldwide challenges to our security, it is of paramount importance that Air Force logistics be capable in peace and ready for war. I expect the *Air Force Journal of Logistics* to contribute to this necessary end. It will provide a forum for the professional discussion of efforts to improve the Air Force ability to deploy, support and fight wherever our nation needs airpower. The Journal will be valuable for logisticians and for users of logistics.

*LEW ALLEN, JR., General, USAF
Chief of Staff*

From the Assistant Secretary of the Air Force, Research, Development and Logistics

By any standard, logistics is big business and critical to the accomplishment of our Air Force mission. Approximately 30 percent of the entire Air Force budget and 40 percent of the manpower are allocated to logistics functions. The readiness and sustaining power of the operational forces are directly related to the amount and effectiveness of logistics support.

The establishment and publication of this journal is further recognition of our vital logistics role. The journal will produce a needed forum for open dialog about the major issues facing the Air Force and, in particular, the logistics community. This open dialog should provide new insights into the way we do our job and, equally important, increase our level of professionalism.

I am proud to be present at its beginning.

*DR. ROBERT J. HERMANN
Assistant Secretary of the Air Force
Research, Development & Logistics*

**From the Commander,
Air Force Logistics Command**

I have the great pleasure to introduce to you the first issue of the *Air Force Journal of Logistics (AFJL)*. It is one of the more satisfying moments of my career.

The *AFJL* is published in recognition of the complexity and vital essentiality of the job logisticians do. More importantly, it recognizes that

- effectively operating current Air Force logistic systems depends on a thorough understanding of those systems by logisticians,
- making sound decisions for future changes and operations must identify and consider all aspects of logistics related issues, and
- achieving this kind of understanding, effectiveness, and decision-making requires the full-time, career-length commitment of many highly talented people.

This journal is designed to publish the thinking of and information for those members of the Air Force logistics community—officers, enlisted people, civilians—who have made that commitment.

In short, the *Air Force Journal of Logistics* is your professional journal. Read it, use it, contribute to it. With your participation, it can reflect not only where Air Force logistics is today, but where we should be tomorrow.

BRYCE POE, II, General, USAF
Commander
Air Force Logistics Command

**From the Deputy Chief of Staff,
Logistics and Engineering**

Publication of a professional journal concerning Air Force logistics has finally become a reality. There has been a long standing requirement for a medium which would provide logisticians a forum to communicate practical and academically sound arguments and concepts. Considering the many challenges facing us in the coming decade, it is most appropriate for the *Air Force Journal of Logistics* to begin, now.

Almost daily we are finding better ways to do our jobs in support of the Air Force, other service and allied operational units charged with deterring any adversary. The articles appearing in this journal will provide needed insight into various issues and surface possible alternatives or new approaches to our work. The *AFJL* can ensure this information is shared and applied wherever possible, as we all have a common purpose. More importantly, this journal can serve as a vehicle to stimulate the professional thinking in our logistics community.

Through active support and participation by Air Force logisticians in this forum, we will all better understand the interrelation of the entire logistics system and be more aware of how our efforts are related to broader Air Force and national objectives.

I wish the Journal and its staff the highest success possible.

BILLY M. MINTER
Lieutenant General, USAF
DCS/Logistics and Engineering
HQ USAF

The Impact of the Freedom of Information Act on the Contractor's Technical Proposal

Major Van R. Muhn
Defense Mapping Agency Topographic Center
6500 Brookes Lane
Washington, D.C. 20315

Abstract

The Freedom of Information Act (FOIA), passed in 1967, provides anyone the right to request and obtain documentation from the Government (there are certain exceptions, however). Even material that is exempted, such as a contractor's trade secrets, may be released by the Government in response to a FOIA request. The Government considers the impact on the contractor's competitive position and the likelihood that the Government will be able to receive the necessary information in the future before it decides on a case by case basis whether or not to release a contractor's proprietary information. This paper addresses the possibility that the threat of losing state-of-the-art technology (proprietary information) via an FOIA request for a contractor's technical proposal has caused contractors to withhold such information from proposals submitted to Air Force Program Offices. There could be a serious impact on the outcome of source selections if contractors are withholding technical information from their proposals. The most technically capable contractors may not be identified as such.

Introduction

An Aerospace contractor may spend thousands, perhaps millions, of dollars of its independent research and development (IR&D) funds developing the technology required to prepare a proposal it hopes will win a government contract. Following the award of the contract, any of the proposals submitted could be requested and obtained by anyone making a Freedom of Information Act (FOIA) request for them. Suddenly, the contractor has lost the competitive advantage his IR&D efforts had provided. He may lose the next competition because of it.

Contractor technical information is being requested and obtained via the FOIA. Consider, for example, the experience gained by Air Cruisers Co., a producer of inflatable life rafts for commercial aircraft (1:1). Air Cruisers developed a 42-person raft and submitted to the Federal Aviation Administration (FAA) the appropriate technical data along with its application for approval. Six months later the company heard that the FAA was about to release the technical information to a competitor, Switlik Parachute Co. Switlik had merely telexed a FOIA request to the FAA for the information. The FAA felt it had to comply with the request and was about to do so when Air Cruisers filed suit in federal court to prevent release of the information. Before the case could be resolved, Air Cruisers had to agree to the release of some of its technical information. Switlik used the information to successfully design its own raft and subsequently won a large contract. Air Cruisers was one of its competitors for that contract.

The Aerospace contractor is in the same position as Air Cruisers. When responding to the specifications and requirements set forth in a Government Request for

Proposal (RFP), the contractor applies his latest, most advanced technology to the solution of the design engineering problems he encounters. The technical proposal is one way the contractor convinces the Government Source Selection Evaluation Board (SSEB), and ultimately the Source Selection Authority (SSA), of his ability to meet the requirements of the sought after contract. Thus, the technical proposal may contain a synopsis of the contractor's state-of-the-art technical capability, a capability he may consider proprietary and wish to keep to himself. His competitive position in the future could be jeopardized if the technical proposal were to fall into competitors' hands. A recent article in the *Wall Street Journal* makes this point abundantly clear (2:1). Sikorsky Aircraft, a division of United Technologies Corp., withdrew from competition for a Coast Guard Helicopter. Sikorsky said that in order to bid they would have been required to submit proprietary data to the Government. Other companies and countries could then have obtained the data via a FOIA request. Sikorsky elected to protect its competitive position and, in so doing, lost a chance at a potential \$135-180 million contract.

Technical proposals come under control of the U.S. Government when submitted to the Air Force for evaluation. (Of course, the Air Force is only one of many Government agencies that evaluate proposals, but it is the only Government agency considered in this paper.) Following contract award any person may request and obtain a copy of a technical proposal from the Air Force under the FOIA (unless the proposal is exempted from disclosure; exemptions will be discussed below). There are indications that contractors are concerned about their loss of control of technical know-how through the FOIA request (3:19). Contractors, in at least one instance have been encouraged to withhold at least a portion of their technical capability and design approach from their technical proposals (4:35). If contractors are concerned about the possibility of revealing technical information contained within their technical proposals via the FOIA, and they are actually withholding information, the value of the technical proposal in the source selection process may be reduced. And, as a result, the SSEB may not be able to identify the most technically capable contractor.

If it is true that the Air Force has more confidence in the contractor who adequately supports his technical approach in the proposal, the contractor is put in a difficult position. If he withholds technical information, his proposal may not generate the desired confidence in the Air Force evaluators. On the other hand, he risks losing that same information to competitors through FOIA requests. To understand how a contractor's proprietary technical information can be released to the public by a Government agency, a more detailed look at the FOIA is required.

Air Force Journal of Logistics

The Freedom of Information Request

The FOIA became effective on 4 July 1967 (5). It provides any person the right to obtain Government records unless the Government can justify withholding the information under one of nine specific exemptions. The original act required a requestor to identify the record desired. If the requestor did not know the exact title of the record, or could not provide identifying numbers, the Government could refuse the request. Other methods were used by some Government agencies to deny access to documents that should have been available through a FOIA request.

Government agencies would sometimes charge excessive search and reproduction fees to discourage requests. (Fees are allowed under the FOIA, but, the original Act did not set reasonable limits.) Some requests were also handled at a leisurely pace, with some being fulfilled only after several months had passed. A 1972 Congressional Committee report identified these abuses and prompted the 1974 (and still the most current) Amendment to the FOIA.

The most significant changes were that:

1. The FOIA request need only reasonably describe the requested document.
2. Uniform search and reproduction fees have been established to compensate the Government.
3. FOIA requests must be processed under rather strict time limits.

The effect of the 1974 Amendment has been to make requests for Government documents much easier and more likely to succeed. However, there are still limitations on the categories of information the Government may release. The FOIA identifies nine categories of documents the Government may refuse to release under FOIA requests.

Two of these exemptions are most likely to be invoked by the Government to prevent the release of technical proposals. The number 1 exemption for classified information is obvious; yet it does allow for release of unclassified portions of the documents unless they are subject to another exemption. Exemption number 4, the only one likely to prevent disclosure of unclassified technical proposals should it be invoked by the Government, exempts:

Documents containing trade secrets or commercial or financial information which a (Government) component receives from a person with the understanding that it will be retained on a privileged or confidential basis in accordance with customary handling of such records. Such records are those the disclosure of which would cause substantial harm to the competitive position of the person providing the information; impair the Government's ability to obtain necessary information in the future; or impair some other legitimate Governmental interest.

Whether the Air Force will invoke exemption 4 in an effort to deny a FOIA request is subject to a number of considerations, including the basic FOIA, a DoD Directive, recent court cases, Air Force Regulations, and the Air Force's perception of the impact of releasing technical proposals.

Department of Defense (DoD) Directive 5400.7 ("Availability to the Public of Department of Defense Information") implements the FOIA. It reiterates the disclosure exemptions contained in the FOIA. The exemptions describe the kinds of records which *need not* be made available to the public. It is important to note that the Directive does not *require* exempted material to be withheld from the public. This point is clarified by AFR 12-30, "Disclosure of Air Force Records to the Public", paragraph 8b, where it states "... even when such nondisclosure is so authorized, the request for disclosure may be granted, at the sole discretion of the Air Force, if no significant and legitimate Governmental purpose is served by withholding them." This is consistent with the FOIA, which neither authorizes nor prohibits the disclosure of such information.

A careful reading of the fourth exemption reveals that the Government may exempt documents containing trade secrets (a contractor's state-of-the-art technical know-how may be considered trade secrets if he is a leader in the specific field) if there is the understanding that the information will be retained on a privileged or confidential basis. This understanding is frequently conveyed by the contractor by marking the proposal's title page and other appropriate pages with a legend as described in section 3-507.1(a) of the Defense Acquisition Regulatory System (DARS):

(a) A proposal, whether solicited or unsolicited, may include data, such as a technical design or concept or financial and management plan, which the offeror does not want disclosed to the public for any purpose or used by the Government for any purpose other than evaluation of the proposal. If an offeror wishes so to restrict his proposal, he shall mark the title page with the following legend:

This data, furnished in connection with Request for Proposal No. . . . , shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part for any purpose other than to evaluate the proposal; provided, that if a contract is awarded to this offeror as a result of or in connection with the submission of this data, the Government shall have the right to duplicate, use, or disclose the data to the extent provided in the contract. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction is contained in Sheets . . . (1966 DEC)

It would appear that if the proprietary portions of a proposal are marked with a legend it will not be released to the public without written permission of the offeror (contractor). Paragraph 3-507.1(c), however, indicates that there is an exception: "(c) Records of data, other than the types of items listed in 1-329.1(b), bearing such a legend may be otherwise subject to release under the terms of the Freedom of Information Act."

The Air Force Systems Command Program Office survey (conducted by the Author) and telephone discussions with program office personnel have revealed that most individuals are not aware of this exception and feel that as long as a proposal is marked proprietary it is not releasable to the public. In fact, whether or not the legend

is honored is a matter addressed by the Government agency on a case by case basis. Exemption 4 states that documents containing trade secrets are those the disclosure of which would either cause substantial harm to the competitive position of the person providing the information or impair the Government's ability to obtain necessary information in the future. Recent federal court cases involving contractors suing to prevent disclosure of proprietary information by Government agencies cite a 1975 case which strongly reinforces these two conditions (6). Government agencies that attempt to prevent the release of proprietary information may be required to prove the condition or conditions of exemption apply, should the requestor bring suit in a federal court.

The contractor may be notified by a Government agency that that same agency has received an FOIA request for information submitted by the contractor. Within the Department of Defense, DoD Directive 5400.7 requires prompt notification of the source of information intended for release "when there is reason to believe that the source . . . may object to release and may have an enforceable right to prevent release, . . ." The contractor's first step to block release is to seek an injunction from a Federal Circuit Court. To obtain the injunction, and block the release under exemption 4, he must reasonably demonstrate that the requirements of exemption 4 are met. If granted, the injunction is usually good for ten days. During the ten day period the contractor and the Government prepare their cases for presentation to the court. The resulting decision may be appealed to the next highest federal court, the Circuit Court of Appeals. Appeals of Circuit Court decisions could receive a final hearing before the US Supreme Court.

The Chrysler Corporation has recently taken the Federal Court Appeal route to the Supreme Court (7). In compliance with federal regulations pertaining to government contractors, Chrysler had provided the Defense Logistics Agency (DLA) with equal employment opportunity information. The DLA received an FOIA request from a third party and prepared to release the information. Chrysler filed suit (a "reverse-FOIA" suit) to block release and was partially successful in District Court. In the opinion of that court some of the information was not releaseable. Both the DLA and Chrysler appealed to the Supreme Court. On April 18, 1979, the Supreme Court decided that Chrysler had no right under the FOIA to prevent DLA disclosure of the information. The impact of this decision is yet to be appreciated. However, it does appear that contractors seeking to prevent future governmental agency disclosure of corporate information will have to base their arguments on some other point of law (such as the Administrative Procedures Act). But, if the contractor fails to learn of the intended disclosure he may never get a chance to prepare his case.

If the Government agency receiving a FOIA request for a contractor's technical proposal does not notify the contractor of the request, the contractor, of course, has no opportunity to influence the agency's consideration of the request. The Government agency then considers the impact of releasing the information (which may be proprietary); i.e., will the disclosure cause substantial harm to the competitive position of the contractor or impair the Government's ability to obtain necessary information in the future. This is a decision the Government agency may not be qualified to make because

it requires a knowledge of the future and the contractor's competitive environment. Thus, when the contractor submits his technical proposal to the Government, he is placing it into an environment over which he may have very little control. Furthermore, those who decide whether the technical proposal will be released via FOIA requests may not have the competitive interests of the contractor in mind, nor be in a position to understand them. The contractor's motivation to delete state-of-the-art technology from his technical proposal is not difficult to understand.*

The Surveys

The actual impact of the FOIA on contractors' technical proposals cannot be determined merely by studying court cases or applicable Air Force regulations. The most cost effective and efficient method of measuring the FOIA impact is to survey a sample of the contractors who prepare technical proposals and the program offices who evaluate them.

The purpose of the surveys was to determine the military /contractor perceptions of the impact of the FOIA on contractor technical proposals. Two surveys were actually constructed, one tailored to the program offices' view of the subject, and a similar one tailored to the contractors' view. It was anticipated that interesting and unpredictable comparisons could be drawn from nearly opposite views of the same potential problem.

The selection of the contractors to be surveyed was based on the dollar value of the contract awards they received in FY 1978 (8). The nine largest contractors were selected to participate in the survey because it was felt that they would have the most experience in the preparation of technical proposals, and they represent a significant pool of state-of-the-art technology. In addition, if the FOIA is having an impact on the content of technical proposals, the effects could be translated into a significant dollar impact on a contractor and/or the potential Government award to a less technically competent contractor.

Two basic criteria were used to select the program office to be surveyed: (1) the program office dealing with each contractor's largest program (as measured by total cost of the program), and (2) the program office selected would be an Air Force Systems Command Program Office if possible. (It was necessary to select a Navy Plant Representative Office and an Air Force Logistics Command Air Logistics Center Office where Air Force Systems Command Program Offices were not available.) The eighteen selected survey respondents (nine major contractors and the program office responsible for managing each contractor's major Air Force program) are shown in Table 1.

*Ed. Note: The following comments are included to complement this article's contribution in providing a better understanding of the impact of one of the most complex and debated issues in government today. The Air Force is very much aware of the competitive interests of the contractor and of the potentially harmful results of any release. As a result, it is the practice of the Air Force to notify the originator of a proposal when an FOIA request for that proposal is received. Air Force contracting personnel are knowledgeable of current FOIA practices and procedures and are extremely careful not to release proprietary technical information to third parties. In fact, HQ USAF has indicated to the AFJL that no proprietary data, as distinguished from technical information, has been released by the Air Force.

None of this alters the author's survey findings which follow.

Table 1. Contractors and Program Offices Surveyed

CONTRACTOR	DOLLAR VALUE OF AIR FORCE SYSTEMS COMMAND CONTRACTS AWARDED IN FY 78	PROGRAM OFFICE RESPONSIBLE FOR MAJOR PROGRAM
1. General Dynamics	\$2,201,182,943	Aeronautical Systems Division (ASD)/YP (F-16 Fighter)
2. McDonnell Douglas	1,363,282,930	ASD/YF (F-15 Fighter)
3. United Technologies	1,188,219,565	Navy Plant Representative Office, Stratford (UH-60A Helicopter)
4. Boeing Aerospace	808,788,494	Space and Missile Systems Organization (SAMSO)/MN (Minuteman)
5. General Electric	709,484,585	ASD/YZ (F404 Engine)
6. Rockwell Industries	497,231,482	SAMSO/LV (Space Shuttle)
7. Fairchild Industries	467,368,506	ASD/YX (A-10 Aircraft)
8. Lockheed Aircraft	289,745,217	Warner Robins Air Logistics Center/ MMSF (C-130 Aircraft)
9. Northrop	283,719,623	ASD/SD30K (F-5E Aircraft)

The nature of the surveys was such that the contractors and program offices were able to draw on their total experience with program offices and contractors, respectively. For example, when answering the survey, the program offices could report their experience with any contractor, not just the one they are paired with in this study. They were unaware that contractors were also being surveyed. The same holds true with the contractors and their experience with various program offices. Thus, the survey drew upon a large cross section of contractors and the Air Force Program Offices doing business with them.

Survey Analysis and Findings

The surveys sent to the selected contractors and program offices generated some interesting responses (14 of the 18 surveys were returned; two contractors and two program offices abstained). A review and analysis of those responses led to the formulation of several general findings that reflect the current contractor/program office perception of the technical proposal and the FOIA. These findings are summarized in Table 2. Finding number 3 is clearly the most significant of those resulting from the study. The FOIA *has* affected the amount of the

Table 2. Survey Findings

1. The major aerospace contractors surveyed submitted over 500 competitive proposals last fiscal year.
2. All contractors have taken measures to protect technical know-how in their proposals. Their efforts may or may not be successful, since the Government may release proprietary information after consideration on a case by case basis.
3. Some of the major aerospace contractors are withholding state-of-the-art technology from their proposals to prevent release via the Freedom of Information Act.
4. The program offices having developmental responsibility for some of the Air Force's major programs have not detected (with one exception) an increased reluctance on the part of contractors to include their latest technology in a proposal.
5. Program offices have not released a significant number of technical proposals in response to Freedom of Information requests.
6. Some aerospace contractors are discussing, with the program offices, the problem of release of proprietary information via a Freedom of Information request.
7. The program offices have experienced no problems evaluating contractor proposals that they would attribute to a contractor withholding technical information. They would lose confidence in a contractor's ability to perform a contract if it was obvious he was withholding information from his technical proposal. The possible withholding of technical information by contractors has *apparently* not affected the outcome of any source selections.
8. Program offices are generally unaware that contractor proprietary technical information may be released by the Government in response to a Freedom of Information request.

state-of-the-art technology contractors are willing to include in their technical proposals. Several contractors indicated that the threat of a FOIA request for their proposals has resulted in their withholding some of their sensitive (competitive) technology from them. Finding number 7 indicates that the program offices have not detected this reluctance to reveal technology in the contractor's proposals. Nor, according to the program offices, has this impacted a source selection. The withholding of technical information has apparently not reached such proportions that it has become obvious to the program offices surveyed. It may be only a matter of time before they detect it.

Recommendation

The FOIA is becoming a major concern of the aerospace contractors. More and more reference is being made to the technology transfer facilitated by the Act. Some contractors have responded to the threat by withholding technical information. No one can be certain that the outcome of source selections are not being affected as a result. The conclusions set forth in this paper support the following recommendation: It is imperative that the DoD and the aerospace contractors engage in a dialog that will, as a minimum:

1. Inform DoD agencies of the threat the FOIA poses to the content of contractor technical proposals.
2. Keep all participants informed on the latest developments (for example, new regulations and court decisions) in the FOIA areas.

3. Provide a forum for the presentation of contractor/DoD concerns regarding the FOIA and contractor technical proposals.

4. Promote new or revised DoD directives that would clarify and standardize the DoD's approach to handling FOIA requests for contractor technical proposals.

5. Develop new procedures for controlling contractor's technical information subsequent to the source selection process. For example, if the proprietary portions of the technical proposals were returned to the contractors just prior to announcement of contract award, they would never be susceptible to a FOIA request.

Without the type of interface recommended above, the FOIA may be more responsible for the outcome of source selections than the source selection authorities. And the irony of it is that they and the program offices may never realize it.

References

- (1) "How Law Is Being Used to Pry Business Secrets From Uncle Sam's Files", *The Wall Street Journal*, 9 May 1977.
 - (2) "United Technologies Cancels Bid to Make Helicopters for U.S.", *The Wall Street Journal*, 27 March 1979.
 - (3) Kozicharow, Eugene, "Information Act Invoked in Contracting", *Aviation Week and Space Technology*, 7 February 1977.
 - (4) American Institute of Aeronautics and Astronautics, *Third Annual Conference on Contract Management*, Washington, D.C.
 - (5) Freedom of Information Act, U.S. Code, sec. 552 (1967).
 - (6) Charles River Park "A", Inc., et al. v. The Department of Housing and Urban Development et al., 519 F.2d 935 (1975).
 - (7) Chrysler Corporation v. Harold Brown, Secretary of Defense, 99 Supreme Court Reporter 1705 (1979).
 - (8) Austin, C. L., Pricing and Financial Services Division, Air Force Systems Command, Andrews AFB, Maryland, telephone conversation of 19 January 1979.
- (This article has been adapted from Air Command and Staff College research report 1685-79 by the author.)

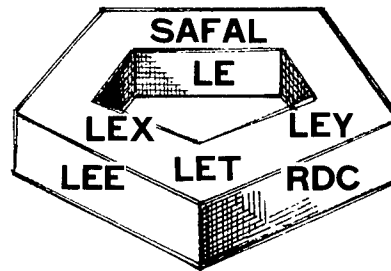
Air Logistics Center Item of Interest

Aircraft Tire Pressure Maintenance

The Air Force invests 11 million dollars annually in aircraft tires. If some of those tires are among the logistics resources you manage, you need to know that:

- Natural rubber used in aircraft tires will not hold air 100 percent effectively. Air leakage of 5 percent in a 24 hour period is authorized.
- Most tires fail because they have been operated in an underinflated condition. This improper operation allows excessive sidewall flexing which generates excess internal tire temperature, resulting in blowout or tread separation.
- One takeoff or landing on an underinflated tire or even taxi to runway under extreme climatic conditions can cause failure damage. The tire may not fail on this flight, but under continued use, it will fail.
- Overinflation to compensate for the natural leakage is also hazardous, not so much for tire failure as for causing the entire wheel to fail.
- Increased ambient temperatures will increase the need for closer monitoring of aircraft tire pressure.
- No amount of experience can qualify "kicking the tires" or "eyeballs only" as a satisfactory method of determining correct tire pressure. For example, an F-4 main tire inflated to the proper 265 pounds per square inch (PSI) does not look much different on a fully loaded and stationary aircraft than a tire underinflated to only 205 PSI. When measured from the top of the wheel flange to the concrete, there is 3 tenths of an inch difference. Even to a highly trained eye, under ideal conditions, 0.3 inch would be very difficult to determine. The only satisfactory method is the use of a recently calibrated tire gauge.

(Ogden ALC/QEI, Ray Crouch, AUTOVON 458-6971.)



USAF LOGISTICS POLICY INSIGHT

SAFAL Major Logistics Policy Goals for 1980

- ☐ Development of a corporate long range logistics planning structure. This structure will be used to articulate major logistics issues and strategies.
- ☐ Expansion of the Air Force's logistics research and development capabilities. This includes development and application of technology to improve logistics processes as well as designing more supportable hardware systems.
- ☐ Increased consideration of supportability in resource decisions affecting the force structure and the acquisition of individual hardware systems.

Logistics Long-Range Planning

In September of this year, the DCS/L&E approved an organizational structure at HQ USAF that would formally look at logistics long-range planning. The overall purpose of the Logistics Long-Range Working Group, in conjunction with the MAJCOMs, is to identify the major issues and concerns of our senior Air Force logisticians and establish the necessary goals to resolve these issues. At the same time, the Working Group will attempt to influence the Planning portion of the Planning, Programming and Budgeting System (PPBS) by including these issues/goals into several of the planning documents. To influence the logistics system of tomorrow, we need to start with the guidance and plans of today.

Establishment of Logistics Budget Integration in HQ USAF/LE

The Logistics Integration Office (HQ USAF/LEX-I) has been established as the DCS/Logistics and Engineering contact point for Planning, Programming, Budgeting System (PPBS) matters and will be responsible for overall procedural guidance. The DCS/L&E Programming Divisions (AF/LEXP/LEXW/LEEP) will maintain responsibility for actions regarding specific budget programs. AF/LEX-I will function as the primary DCS/L&E point of contact for all communication regarding the following: PPBS Policy, Procedures and Guidance; Program/Budget Exercises; Program Objective Memorandum (POM); Issue Papers; DPS, Consolidated Guidance, Congressional Transcript Review; Inserts for the Record and Congressional Appeals. Majors William M. Newsom and Victor A. Hill staff this new function.

C-Day Replaces D-Day in Joint Planning

As a result of a recommendation from the July 1979 Joint Operational Planning System (JOPS) Users Group Conference at Norfolk, Virginia, all future Time Phased Force Deployment Lists (TPFDL) developed for joint plans will be based on C-Day rather than D-Day beginning July 1980. The general consensus was that an OPLAN TPFDL is more related to C-Day (commencement of deployment) rather than D-Day (commencement of hostilities). An additional factor supporting the decision was that for deployment operations, a D-Day may not be known. Consequently, TPFDLs built with C-Days would be more logical and less confusing to the forces required to implement the plan.

Aircraft Maintenance Training

The effectiveness of aircraft maintenance training is affected and influenced by numerous factors. Among the more significant are: the work environment, declining skill levels, support of numerous different weapon systems, and austere funding levels. To fully recognize these factors, and to formalize and structure an Air Force aircraft maintenance training program, a set of basic principles have been adopted and provided to all major Air Command functional managers. These principles or objectives are to be translated into policy so as to optimize aircraft maintenance training effectiveness within the given constraints.

European Vehicle Procurement Program

As part of the DOD Rationalization, Standardization and Interoperability Program, a program has been authorized which permits the procurement of select types of non-tactical motor vehicles from European manufactures. The program, first approved by DEPSECDEF in January 1978, encompasses three procurement regions, consists of 22 vehicle types (light cargo vehicles, buses and forklifts) and potentially totals over 15,000 vehicles valued in excess of \$225 million. In Germany, the program has been formalized through a Memorandum of Understanding and the initial vehicles purchased under the Memorandum have been delivered. In the United Kingdom, a Memorandum of Understanding was recently signed and the initial vehicles will be placed on contract this year. In Italy, the signing of the Memorandum of Understanding is imminent, and procurement contracts will be negotiated immediately following the signing.

Contractor Equal Employment Opportunity Requirements

A significant policy change in the Contractor Equal Employment Opportunity (EEO) requirements was recently developed and is reflected in Defense Acquisition Circular 76-20, dated 17 Sep 79. Prior to this change, contracting officers were required to withhold contracts from contractors which *appeared* to be in violation of the EEO requirements. This caused serious impact to Air Force mission when major sole source contractors were involved. The new policy allows for contract award until a *formal* determination has been made that a contractor is not awardable. Since the formal procedures require a substantial amount of lead time, it is anticipated that we will now have sufficient warning of any major problem to avoid serious impact.

Base Level Service Contracts

Air Force Regulation 400-28 issued on 26 September 1979 prescribes the means for developing a Statement of Work (SOW) and a quality assurance surveillance plan for service contracts. It describes how to write and use the documents. It tells how to write performance into a SOW and is written for mid-level managers who write the documents and for contracting personnel who review and administer service contracts. Parts of it apply to quality assurance evaluators who use these documents.

Logistics Checkmate

Buried deep in the bowels of the Pentagon is a unique cadre of Logisticians. They are a select team of officers with backgrounds that span all aspects of Air Force logistical support; they are known as Logistics CHECKMATE. The group's physical location in the basement, however, in no way reflects the importance of their mission. Logistics CHECKMATE was established by the Chief of Staff to take an "unconstrained" look at the support necessary to wage war today. The team's charter requires an in-depth analysis of current operational plans and postulated scenarios. Their efforts have uncovered shortfalls in supportability that have, in turn, generated near and long term improvement initiatives. Enhancing force preparedness is the bottom line, and the free-thinking efforts of Logistics CHECKMATE will continue to support an essential objective: readiness now.

An Assessment of the Benefits Due to Reliability Centered Maintenance on the C-141

Nozer D. Singpurwalla
Professor of Operations Research and
Research Professor of Statistics
The George Washington University
Washington, D.C. 20006

Captain Carlos M. Talbott, Jr.
AFIT Graduate Student
Doctoral Program in Operations Research
The George Washington University
Washington, D.C. 20006

Introduction

In January 1976, the U.S. Air Force undertook an experiment which entailed several modifications of the existing maintenance policies, for a fleet of the C-141 aircraft. These modifications were motivated by, and patterned after, similar actions taken by the commercial airlines, and termed by them as the "MSG-2 Concept". Essentially, the modifications involved an *extension* of the maintenance interval and a *reduction* in the amount of effort ("work content") devoted to each inspection. Based upon the claimed encouraging results of this experimental program, the U.S. Air Force, in June 1977, decided to institute it on a permanent basis. The modified maintenance policy was termed by the U.S. Air Force as the "Reliability Centered Maintenance (RCM) Policy". Since RCM was effectively instituted as of January 1976, the date is often referred to as the "date of intervention" or "date of RCM initiation."

Our objective in undertaking the analysis that is reported here is to assess the effects, beneficial or otherwise, of RCM on several variables which describe the logistics performance of the fleet. Accordingly, a selected group of variables were chosen, and their monthly values before and after the date of intervention were studied. The monthly values of these performance variables considered by us constitute a natural time series. Furthermore, the observed values of the nineteen variables are autocorrelated, that is, related to each other; they are not independent. Thus the *correct* method of analysis should be one which accounts for this lack of independence. The approach taken by us is the one described in Box and Jenkins for the analysis of time series. Basic data used in the analysis was taken from "G098, Maintenance Requirements Data Systems" and "K051-B, System Availability Model" reports and the Air Force Inspection and Safety Center's "Aircraft Mishap File."

THE VARIABLES

Nineteen variables pertaining to the availability, maintainability, reliability and safety of the system were analyzed. These are:

Alert Availability - The probability that a typical aircraft is available to react to an execution order. Its monthly value is computed by dividing the cumulative fleet operational hours by the cumulative fleet available hours.

System Effectiveness - The probability that a weapon system is capable of performing all assigned missions. It is estimated by multiplying the Alert Availability by the ratio of successful sorties to attempted sorties.

Aircraft Availability - The sum of the proportion of the fleet which is fully mission capable and the proportion which is partially mission capable.

Unscheduled Maintenance Actions - The number of weapon system defects or deficiencies discovered at times other than scheduled maintenance inspection times.

Unscheduled Maintenance Manhours - Direct labor consumed in performing unscheduled maintenance.

Unscheduled Remove and Replace Actions - A part (subset) of unscheduled maintenance actions.

Scheduled Maintenance Actions - The number of scheduled inspections plus the number of defects or deficiencies discovered during those inspections.

Scheduled Maintenance Manhours - Direct labor hours consumed in scheduled maintenance activity.

Scheduled Remove and Replace Actions - A subset of Scheduled Maintenance Actions.

Enroute Departure Reliability - The monthly ratio of on-schedule departures to total departures at enroute locations.

Home Operations Departure Reliability - The monthly ratio of on-schedule departures to total departures at home base locations.

World-Wide Departure Reliability - The monthly ratio of on-schedule departures to total departures world-wide.

Training Departure Reliability - The monthly ratio of on-schedule departures to total departures, for the purpose of training missions.

Before Flight Aborts per 10,000 Sorties - The number of monthly before flight aborts per 10,000 sorties.

Inflight Aborts per 10,000 Sorties - The number of monthly in-flight aborts per 10,000 sorties.

Inflight Failures - The number of component failures occurring during flight; a subset of the Unscheduled Maintenance Actions.

Aborted Missions - The total monthly aborts and deviations from programmed missions.

Requests for Depot Assistance - The monthly total of field requests for assistance from the depot in accordance with Technical Order 00-25-107 which governs such requests. This variable loosely measures the ability of scheduled maintenance inspections to catch structural failures before they become significant.

Safety Incidents - Events caused by maintenance of material failure which result in a hazard to life or property.

**Table 1. Linear Correlations
Between Pairs of Variables in Each Category**

FLEET AVAILABILITY				
	AA	SE	AC	
Alert Availability (AA)	1	*		
System Effectiveness (SE)	.995	1		
Aircraft Availability (AC)	.395	.426	1	
UNSCHEDULED MAINTENANCE**				
	UMA	UMH	URR	
Unsched Maint Actions (UMA)	1			
Unsched Maint Manhours (UMH)	.8913	1		
Unsched Removals (URR)	.9106	.9168	1	
SCHEDULED MAINTENANCE**				
	SMA	SMH	SRR	
Sched Maint Actions (SMA)	1			
Sched Maint Manhours (SMH)	.4156	1		
Sched Removals (SRR)	.5793	.7357	1	
FLEET DEPARTURE RELIABILITY				
	ENR	WWR	HOR	TRN
Enroute Reliability (ENR)	1			
World-Wide Reliability (WWR)	.9475	1		
Home Ops Reliability (HOR)	.5669	.7945	1	
Training Reliability (TRN)	.4785	.6165	.6702	1
FLEET ABORTS				
	BFA	IFA	IFF	AM
Before Flight Aborts (BFA)	1			
Inflight Aborts (IFA)	.7447	1		
Inflight Failures (IFF)	– .0363	– .2153	1	
Aborted Missions (AM)	.1889	.0264	.6858	1

*Note that the correlation between AA and SE is the same as that between SE and AA, and hence is omitted; similarly for the other missing entries.

**Correlations exclude data for May & June 1975 which were either missing or were grossly in error.

An advantageous feature of some of these variables is that they tend to be significantly positively correlated with each other as shown in Table 1. For example, Alert Availability is strongly, and positively, correlated with System Effectiveness. Consequently, we can perform a detailed time series analysis on Alert Availability, and arrive at similar conclusions for System Effectiveness as well. In general, we can analyze any particular variable in detail, and, with some caution, extend the same conclusions to all the other variables which are highly positively correlated with this variable.

In Table 1, the correlation coefficient describes the degree to which two variables are linearly related to each other. If the correlation coefficient is close to +1, then the two variables tend to behave in a similar manner, whereas, if the coefficient is close to -1, then the two variables behave in an opposite manner to each other. Values of the correlation coefficient close to 0 indicates the absence of any linear relationship between the two variables.

The correlations given in Table 1 are *simple linear correlations*. Since the observed values of the variables are serially correlated, the appropriate correlations between variables should be the *cross correlations*. In the interest of keeping our analysis simple, the cross correlations were not considered.

ANALYSIS OF THE VARIABLES

Time Series Plot and Visual Analysis

Time series plots of the variables were made and visually inspected. This type of an analysis is intuitive, and does not require any specialized skills of the reader; further, it *reinforces*, and often gives some guidelines for, a more formal analysis.

On each of our plots we also indicate the date of intervention, January 1976; thus each plot can be viewed as being broken down into two phases: pre-RCM and post-RCM. Representative plots of six of the variables are shown in Figures 1 through 6. Plots of the other variables are given in (3). Our qualitative assessment of the behavior of each variable based on a visual inspection of its time series plot was as follows:

Alert Availability -As can be seen in Figure 1, this plot certainly *does not reveal an improvement* due to RCM; in fact, quite the opposite is true.

System Effectiveness -The plot *did not reveal any improvement* due to RCM. Furthermore, since System Effectiveness is highly correlated with Alert Availability (see Table 1), we would expect that our remarks for these two variables would be similar.

Alert Availability

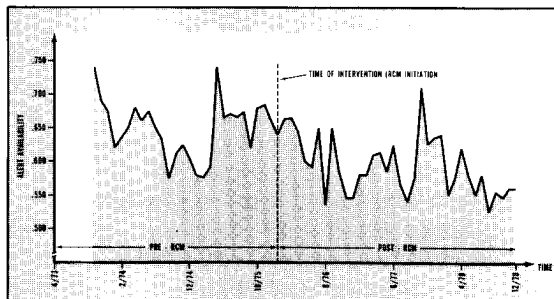


Figure 1.

Aircraft Availability -Data for this series was not available prior to 1975. With only 12 data points in the pre-RCM period, we prefer not to make any comparisons.

Unscheduled Maintenance Actions -In the post-RCM part of the series (see Figure 2) there is a reduction in variability which, we conjecture, may be the result of reduced variability in monthly flying activity. We further note that, prior to the date of intervention, Unscheduled Maintenance Actions fluctuate about a constant level. However, during the period Jan 76 -Jun 77, they trend upward and then downward. We also observe that even though there is a downward trend in the later part of the post-RCM series, the overall operating level of the post-RCM series is generally higher than that of the pre-RCM series.

Unscheduled Maintenance Manhours -As seen in Figure 3, the behavior of the time series plot for this variable was analogous to that for Unscheduled Maintenance Actions. Furthermore, the two variables are highly correlated (see Table 1). Thus, our comments for Unscheduled Maintenance Actions should be analogous to those for Unscheduled Maintenance Manhours.

Unscheduled Remove and Replace Actions -The series for this variable also behaves in a manner similar to the series for Unscheduled Maintenance Actions; we note a reduction in variability and an increasing and then decreasing trend in the post-RCM series.

Scheduled Maintenance Actions - Figure 4 is a plot of this series. In the post-RCM period, we note an upward trend in activity which, based on the time series plot of only the "look" actions, appears to be the result of increases in the number of defects discovered during inspections. We remark that this increased *scheduled* repair activity has apparently not reduced *unscheduled* maintenance activity.

Scheduled Maintenance Manhours - As Table 1 indicates, this series is correlated with Scheduled Maintenance Actions. Hence, we observed an increasing trend in the post-RCM period.

Scheduled Remove and Replace Actions -A subset of Scheduled Maintenance Actions, scheduled removals showed an increasing trend in the post-RCM period similar to behavior in the other scheduled maintenance activity.

Enroute Departure Reliability -A slight increasing trend prior to the date of intervention and a declining trend thereafter was observed.

Unscheduled Maintenance Actions

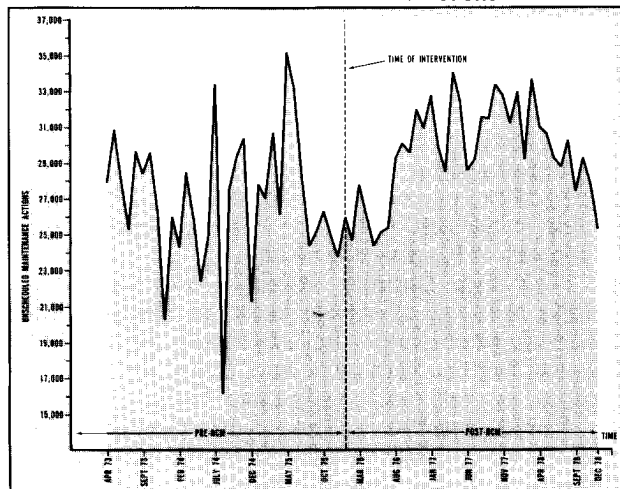


Figure 2.

Unscheduled Maintenance Manhours

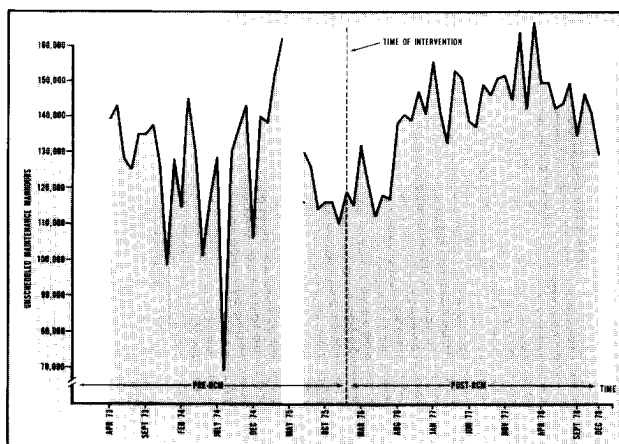


Figure 3.

Scheduled Maintenance Actions

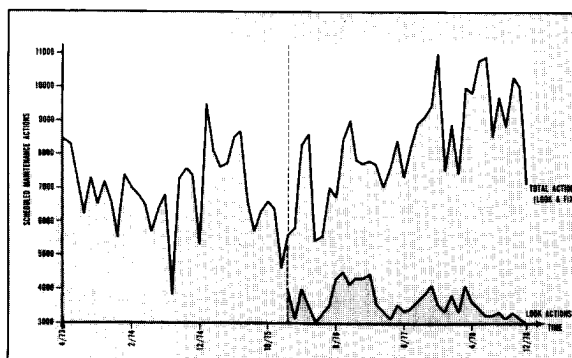


Figure 4.

Home Operations Departure Reliability -A plot of this variable is shown in Figure 5. This variable is perhaps more strongly influenced by RCM than Enroute Departure Reliability because of the larger variety of scheduled inspections performed at home stations as compared with those performed at enroute locations. We note an upward trend in the pre-RCM period followed by a downward trend in the post-RCM period. We also observe more variability in the post-RCM series.

World-Wide Departure Reliability -This variable is highly correlated to Enroute Departure Reliability (see Table 1). We observed a declining trend in the post-RCM period; however, because of scant data in the pre-RCM period, we prefer not to make comparisons.

Training Departure Reliability -A declining pattern was seen in the post-RCM period which may be due in part to changes in reporting criteria. However, since we have only 12 data points in the pre-RCM period, we again elect not to make any comparisons.

Home Operations Departure Reliability

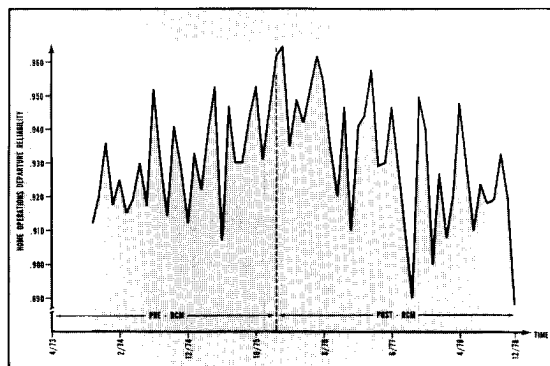


Figure 5.

Time Series Analysis of the Variables

Subsequent to the above visual inspection of each performance variable, we formally analyzed them using time series analysis techniques. Such techniques are used to perform statistical analyses of data which evolves over time and which features successive observations which are related to each other. The lack of independence precludes the use of standard statistical techniques such as a 2-sample 't' test and analysis of variance.

The key step in performing a time series analysis is to develop a model which describes the behavior of the observed data. Several non-stochastic and stochastic models have been proposed for time series analysis (see references 1 and 2). Box and Jenkins (2) emphasize the detailed use of stochastic models; as a result, such models are also called Box-Jenkins type models.

A summary of our analysis employing a Box-Jenkins model is as follows:

Alert Availability -The appropriate time series model for the pre-RCM and post-RCM series indicate that Alert Availability had been trending slightly upward prior to the date of intervention and is trending downwards after the

date of intervention. We determined that the spike in Oct-Dec 1977 is caused by a change in data collection procedures. We remark that the decline in Alert Availability could be the result of increases in scheduled and unscheduled maintenance activity in the post-RCM period. Although it is not of interest for our present objectives, our analysis revealed an evidence of periodicity in both the pre- and the post-RCM series.

Unscheduled Maintenance Actions -In the pre-RCM series, we identified a downward trend with a period of 4. In the post-RCM series, we identified an upward trend in the period Jan 76 -Jun 77 followed by a downward trend throughout 1978. We also noted a seasonal pattern of period 2 in the post-RCM series and a marked reduction in variability. We conjecture that this reduced variability may be the result of reduced variability in monthly flying activity. As for the concavity in the behavior of the post-RCM Unscheduled Maintenance Actions, we conjecture it to be a manifestation of an extended learning experience. We suspect that the RCM intervention may have initially caused Unscheduled Maintenance Actions to increase and that in due course the process may go below pre-RCM levels. However, this is merely a conjecture.

Scheduled Maintenance Actions - We found the pre-RCM Scheduled Maintenance Actions data to be without trend but with seasonal patterns of period 2. The post-RCM series has an increasing trend without periodicity. Thus, we confirm our earlier impression that Scheduled Maintenance Actions are on the rise in the post-RCM time frame.

Enroute Departure Reliability - Notwithstanding our visual impressions of this series, we did not detect any trend or periodicity in either the pre-RCM or post-RCM series. Accordingly, we conclude there is no apparent RCM effect in this data.

Before Flight Aborts per 10,000 Sorties -A slight downward trend in the pre-RCM period and a decrease in variability in the post-RCM period was observed.. We noted two abnormal data points in the series at April 76 and July 76 which we suspect may have resulted from an anomaly in data collection.

Inflight Aborts per 10,000 Sorties -Again, a slight downward trend in the pre-RCM period and two abnormal data points at April 76 and July 76 were noted. Since Inflight Aborts is correlated with Before Flight Aborts (see Table 1), the similar behavior of the two series in question is not surprising.

Inflight Failures -This variable revealed a pattern similar to the Unscheduled Maintenance Actions variable of which it is a subset: a reduced variability in the post-RCM period as well as an increasing and then decreasing trend.

Aborted Missions -There was no apparent trend noticed in the post-RCM series and, because of scant data in the pre-RCM series, we do not make any comparative statements.

Requests for Depot Assistance - No apparent trend in the post-RCM period was observed. With only six data points in the pre-RCM period, we elect not to make any comparisons.

Aircraft Safety Incidents Due to Maintenance or Material Failure

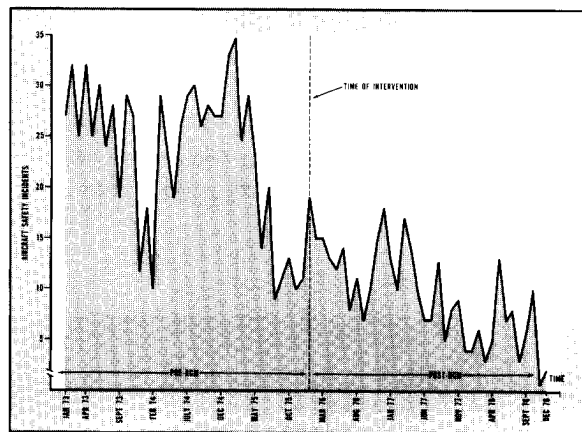


Figure 6.

Safety Incidents -This variable is depicted in Figure 6. We noted a declining trend in the data beginning in early 1975 and continuing in the post-RCM period. However, the variability in the post-RCM period appears to be reduced.

Home Operations Departure Reliability -We confirmed an increasing trend in the pre-RCM series with a seasonal effect of period 4. We also confirmed a decreasing trend in the post-RCM series. Accordingly, we conclude that Home Operations Departure Reliability was improving prior to the date of intervention and has been declining since then.

Before Flight Aborts per 10,000 Sorties -In the pre-RCM series, we found evidence of a seasonal effect of period 6 but no evidence of trend. This seasonal effect disappears in the post-RCM series. We note that the general level of Before Flight Aborts and its variability are slightly lower in the post-RCM series than in the pre-RCM series.

Safety Incidents -The pre-RCM series has a distinct peak in February 1975. Although there was no term for describing a downward trend in our best time series model, we suspect that there was probably another intervention at this point (the deletion of single engine shutdowns as a reportable safety incident). In the post-RCM series, we found that the best time series model had a seasonal component of order 6 but no significant term to describe a downward trend. We remark that the slight decline in safety incidents is described by a particular autoregressive integrated moving average process.

SUMMARY AND CONCLUSIONS

In summary, we sought to identify evidence of changes in C-141 logistics performance and to describe the nature of these changes. Although management had expected a decrease in Scheduled Maintenance Activity (with no change in Unscheduled Maintenance Activity) and an increase in availability, there is no evidence of any such RCM benefits. There have been observable changes in logistics performance shortly after January 1976;

however, these changes were adverse. A substantial amount of the adverse effect was in the Unscheduled Maintenance Activity; however, this variable is now showing improvement and may lead to substantial benefits over time.

These findings permit two possible conclusions: (1) RCM as applied on the C-141 fleet has not yet produced results as expected, or (2) RCM effects were masked by other offsetting influences. Additional study is warranted to eliminate possible confounding factors and determine which conclusion is correct.

Our analysis considers the RCM effect to be present as of January 1976. USAF management recognizes that this effect may not have been consistent through time. For instance, the Jan 76 -Jun 77 time period is characterized by unrepresentative maintenance activity caused by inspection cycle tests roughly equivalent to the RCM concept. Also, the Jun 77 -Feb 78 time period, which followed formal RCM implementation, is considered unstable due to the "maintenance and management learning curve." We also know that substantial activity occurred in the post-RCM period relating to training of maintenance technicians. Such activity could have had a significant impact on logistics performance aside from RCM. Notwithstanding these issues, our analysis assumes that RCM is the only factor responsible for a change, and hence, that changes in logistics performance are caused by this factor. We recognize that such an assumption may be restrictive. For example, maintenance training could have had some detrimental influence on logistics performance in the post-RCM period which could mask any benefit due to RCM. Recognizing this limitation, we ask the reader to temper any criticism of our analysis with the realization that there was no experimental design in the RCM program to evaluate benefits, and that limitations in such analyses are often inherent in the utilization of historical data.*

References

- (1) Anderson, T.W., *The Statistical Analysis of Time Series*. New York: John Wiley & Sons, Inc., 1971.
- (2) Box, G.E.P., and Jenkins, G.M., *Time Series Analysis: Forecasting and Control*. San Francisco: Holden-Day, 1976.
- (3) Singpurwalla, N.D., and Talbott, C.M., *An Assessment of the Benefits Due to Reliability Centered Maintenance on the C-141*. AFLMC Report 780206-1, USAF Logistics Management Center, July 1979.

*Ed. Note: Some initial responses to the results of the analysis discussed in this article have centered on the possibility that, as the authors themselves recognized, "RCM effects were masked by other offsetting influences." Changing C-141 utilization rates and areas of operation during the period covered by the study could have been accompanied by mission stress factors - such as high gross weight, hot weather, reduced runway lengths, low level operations, multiple cycles without return to home station - that, in turn, could have influenced the apparent effect of RCM on the variables.

As a result of this study, follow-on efforts are underway to continue tracking C-141 performance, examine the logistics performance of the B-52, KC-135 and T-38 fleets, examine the varied methodologies for establishing periodic maintenance intervals on various aircraft, and analyze the relation between logistics performance and operational activity.



CAREER AND PERSONNEL INFORMATION

LOGISTICS CIVILIAN CAREER ENHANCEMENT PROGRAM

The birth of this new journal coincides with the birth of a new program offering significant changes for civilian logisticians within the Air Force. In this first issue we shall cover some background on the Logistics Civilian Career Enhancement Program (LCCEP) and in future issues will speak to specific areas of concern to civilian logisticians. We solicit questions which you may have for direct response or answer within future journal issues.

The LCCEP is a new program designed to encourage and manage the development of USAF civilian logisticians to enable them to achieve more of their potential. As described in AFR 40-110, Volume IV, the LCCEP is extremely comprehensive. The program covers both positions and personnel in specified "exclusive" logistics occupational series and "potential" logistics occupational series. Through a concerted effort, certain positions in the management structure at the GS-12 through GS-15 grades have been designated as "Career Executive" positions and will be filled through Air Force competitive procedures, administered by the Office of Civilian Personnel Operations (OCPO), Logistics Career Program Branch, Randolph AFB, Texas. These "Career Executive" positions are further categorized as "Career Essential," "Cadre Reserved," or "Career Broadening." Basically, a civilian logistician qualifies for these positions by becoming part of the "Logistics Executive Force Inventory." This inventory is composed of personnel who are qualified for GS-12 through GS-15 logistics positions and register into the LCCEP. Registration is accomplished through any local Central Civilian Personnel Office (CCPO) in accordance with existing procedures.

Today the LCCEP inventory encompasses some 1200 "Executive Force" positions with approximately 400 of these positions further identified as "Career Essential" and the other 800 positions identified as "Cadre Reserved." Initial registration into LCCEP began last

THE DYNAMICS OF INEXPERIENCE

One of our officer resource managers...prone to understatement...introduced a briefing with, "The challenges facing today's logisticians are of infinite variety and complexity." Elaboration of that simple understatement would fill volumes. This article will narrow the scope of elaboration to one challenge - an analysis of the officer personnel subsystem.

When analyzing any "people" system, subjectivity tends to overwhelm objective assessment. Thus, long range assessments are interesting intellectual exercises with little foundation for proper decision...at least on the part of functional managers. Instead, in this article we will take a shorter range, pragmatic look at facts about the support officer force. In future editions of the "Journal," we will specifically address the logistics subset of the support force.

fall. The next key event in the Cadre selection process is the convening of command panels to assess candidates in March 1980.

LCCEP is a program conceived by senior USAF logisticians, developed by civilian logisticians and personnel specialists, designed to meet the needs of the civilian logistician. A key element to the success of the program will be active participation by all qualified individuals. Future articles in this publication will detail how individuals may participate; how standard promotion patterns, standard career patterns and master development plans are used; and what individuals may do in the area of self-development to further their LCCEP potential. In the meantime, we encourage all civilian logisticians to stay in touch with their servicing CCPO for LCCEP information. OCPO Program Administrators for specified logistics are as listed: (AUTOVON 487): Plans and Programs, Acquisition Logistics and International Logistics - 6388; Supply/Distribution - 5351; Transportation - 5351; Maintenance - 6464; and Materiel Management - 6259.

Before the Vietnam conflict, the line force was essentially composed of rated officers as we accessed very few nonrated lieutenants. As a result, over 18,000 rated officers were holding down full or part-time support duties. We were living with the "Korea hump." As the Vietnam conflict expanded, rated officers were pulled back to rated duties to support the flying effort. With an insufficient nonrated base to compensate, the doors opened to nonrated lieutenants to back fill rated withdrawals. Eventually, rated accessions were increased but never really caught up with the demand.

After Vietnam, as after all wars, authorizations (end strength) decreased rapidly. There were a number of options considered for reducing force size. The Air Force position was that we should surgically balance each line force year group through RIF action. Though costly in the short term, this option would have obviated the peaks of wartime year groups and the valleys of peacetime year groups that have always plagued force managers. Inherent in this option was keeping rated and nonrated second lieutenant inputs (accessions) at a level to not only sustain a properly structured force but to allow for rapid expansion at minimum cost. The logistics corollary could be the application of D to P funding for WRM with inventories consumed at a rate supporting maintenance of a warm production base.

Unfortunately, factors outside the Air Force forced us to forego that option and a minimization of RIF was imposed shortly after implementation. Thus, the only

Supplement/Accession Dynamics

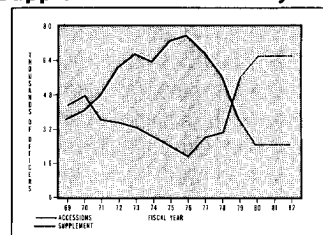


Figure 1.

Air Force Journal of Logistics

option left was to put the inventory at the source. We decreased Undergraduate Flying Training (UFT) as well as nonrated accessions. To save the hard earned combat experience, rated officers were again "banked" in support duties.

These actions continued through the early and mid-seventies. Today, we are again faced with a situation similar to early Vietnam, that is, *rated shortages*. The reasons are many and could be a subject of future articles. The basic impact on the support force is that rated officers are returning to flying duties and the Force is being backfilled with nonrated second lieutenants.

Figure 1 graphically explores these dynamics over the post-Vietnam years. The obvious conclusion is that with the relatively stable authorization base we have experienced since the mid-seventies, rated supplement inventories drive the nonrated accession program. Past FY80, the variables of loss rates, force sizing, requirements changes, force management philosophy, and many others make sensitivity analysis of possible officer inventories far too complex for presentation in this article. Thus the factors are simply straight-lined after FY80.

The dynamics have created today's support force as shown in Figure 2. The peaks in the one to three year groups reflect the increased nonrated accessions discussed previously. The valley in the four to eleven year groups (basically captains) is simply the result of not accessing nonrated officers after Vietnam. This will be aggravated by loss of rated officers in these same year groups. The twelve to seventeen year groups (basically majors) are fairly balanced with a valley in the fifteen year group representing the results of RIF action taken prior to minimization. The eighteen to twenty-three year groups (basically lieutenant colonels) will be severely

Support Force by Year Group

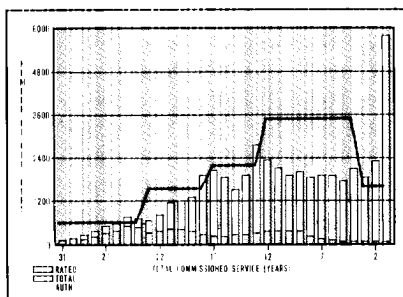


Figure 2.

Overall Support Force Manning End FY80

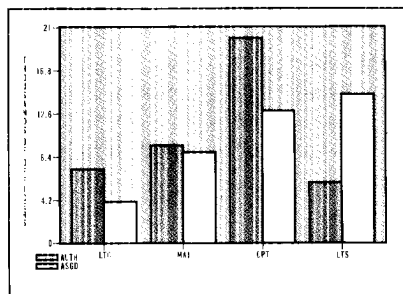


Figure 3.

impacted by rated losses. Many of these officers are the core: our middle and senior support experience with more time in support than operations duties. The Air Force may decide to leave most rated lieutenant colonels in support duties. This will obviate the senior management shortages, but could force even higher withdrawals in the captain and major grades.

If we age the support force using current loss, promotion and continuation rates, as well as the supplement and accessions rates shown in Figure 1, the end of FY80 support force status will be as shown in Figure 3. This projection is in terms of effective assigned (permanent party) officers. It does not count lieutenants in basic technical training, either in terms of authorizations or assigned. More finitely, during FY80 about 14,000 support jobs are coming open. The DOD and Air Force rules are such that only a little over half of these jobs can be filled without processing waivers to DOD and Air Force regulations, a time consuming staffing process.

From this discussion we can draw a number of conclusions. From the 'available for assignment' perspective, our response to your requests for a particular officer could be delayed by the time required to process waivers. The reverse holds true also. It could mean premature loss of a key officer in your organization via waiver to fill higher priority requirements.

From a total manning perspective, we can develop further conclusions. The DOD and Air Force directives require that we man Joint and Departmental positions at 100%. If we do so... by grade... and grade substitute into all other positions using the inventories outlined in Figure 3, then from a purely mathematical context we conclude the following: 60% of the other (non-Joint/Departmental) lieutenant colonel positions will be filled with majors, 50% of the other major positions will be filled with captains, 60% of the other captain positions will be filled with lieutenants, and 40% of the other lieutenant positions will be vacant... soon to be filled with basic technical school graduates. In reality grade substitution is not always possible. For example in most career fields, lieutenants should be assigned to squadron or equivalent level to learn the business from the bottom. Thus, instead of 60% of captain positions filled with lieutenants it could be 90% to 95% at unit level. In most cases, younger officers will be filling our key support force positions. The lieutenant colonel rotating from one of our commander or key staff

positions is likely to be replaced by a major or captain. Further, inventory and availability realities result in a coming situation where overlap is a third of the past and lower priority positions could remain unfilled.

Thus, the dynamics of inexperience have created a new challenge for supervisors throughout the support force, as well as logistics. From the perspective of the supervisor or commander, this simply means that no one organization or group of organizations can be allowed to corner the market in support experience or quality. This must be spread throughout the commands and agencies on as equitable a basis as possible in order to maintain the Air Force's readiness posture. The greatest challenge for supervisors, however, comes in two areas. First, we must recognize that the force is younger. Thus, we must be more tolerant of mistakes and somehow create environments whereby our young officers are capable of learning from mistakes and applying the lessons learned. Second, in these times of experience short falls, the ability of the personnel resource managers to satisfy the personal desires of the individual officer are limited. All officers must understand and be counselled in this regard. As resource managers, we will do our part in our many communication vehicles. However, the help of commanders and supervisors throughout the Air Force is necessary to insure that each officer understands the requirement and understands why we cannot always specifically satisfy his or her personal desires. Thus, we suggest squadron commanders and staff equivalents periodically contact appropriate resource managers to discuss the current and future status of officers within your organization.

The above discussion looks at the short range in the entire support force. The inference shown is in fact true. This is a short term problem. Referring back to Figure 2, the large lieutenant inventories in the lower year groups if properly trained, supervised and motivated, will solve the experience problem in the longer term as they progress in their specialties. The challenge to supervisors throughout the next few years is to create the environment necessary to foster proper experience and development.

Thus, we have explored the dynamics of officer force management and the resulting total support force posture. The next article will build upon this one in analyzing in more specific detail the logistics subsystem of the overall support force.

AIR FORCE INSTITUTE OF TECHNOLOGY SCHOOL OF SYSTEMS AND LOGISTICS GRADUATE PROGRAM

You may be eligible for a 12-15 month graduate program held at Wright-Patterson AFB for DOD military and civilian personnel leading to a Master of Science Degree in Logistics, Facilities, or Systems Management. This fully accredited program enhances skills needed by many AF managers and offers specific majors in the following areas: Logistics Management, International Logistics Management, Acquisition Logistics Management, Contracting and Acquisition Management, Maintenance Management, Facilities Management, R&D Management, Engineering Management, and Systems Management. Prerequisites and application procedures are stated in AFM 50-5, available in your base education office. For program information call AUTOVON 785-4437.

Opportunistic Base and Depot Maintenance Policies For F100 Engines in F-15 Aircraft

John L. Madden and Virginia L. Williamson
Logistics Systems Laboratory Division
Directorate of Management Sciences
DCS/Plans and Programs
Headquarters, Air Force Logistics Command
Wright-Patterson Air Force Base, Ohio 45433

Abstract

The problem is to find the least cost combination of base and depot screening intervals to apply opportunistically during the maintenance of F100 PW100 engines in F-15 aircraft so as to minimize long run system-wide logistics support costs subject to constraints on the final expected total engine removal rate per thousand hours and on the final engine NRTS (not reparable this station) rate. A simulation model was developed for use in solving this problem. It forecasted removals of complete engines, modules, and life-limited parts and related logistics support costs for given life limits on the internal parts and for given input unscheduled engine and module removal rates and NRTS rates. Separate forecasts were produced for each maintenance policy (set of input screens) specified by the user. Output costs, removal rates, and NRTS rates were graphed, and preferred solutions were selected by graphic methods. Resource impacts of the various sets of inputs alternatives are discussed.

Background

The F100 PW100 engine used in the F-15 aircraft consists of six modules which can be separately removed and replaced at base level to repair an engine. The modules are repaired at a later time at either base or depot depending on what needs to be done. The six modules are the input fan, high pressure core, high pressure turbine, fan drive turbine, gear box, and the augmentor. In addition, there are several external life-limited accessories that can cause an engine removal for repair.

Each of the modules contains one or more internal life-limited component parts. These parts are subject to catastrophic failure if they are used too long, so life limits have been established. Whenever one of these parts ages enough to reach its life limit, the engine must be removed and the module containing that part must be replaced. The module is then sent to the depot where that part is replaced.

There are about 50 internal life-limited parts in the F100 engine. Some of the limits are given in cycles and some in total operating hours. A cycle is related to how often and for how long the part is heated above a specified temperature. Cycles accumulation is related to the number of times an engine is started up as well as how often the throttle is advanced during flight. In general, there is a different life limit for each part.

The Problem

The management problem is to try to group the replacements of the life-limited parts so that several parts will be replaced each time the module is repaired. This grouping should allow fewer engine and module removals

to occur per thousand hours than would have occurred without grouping. One way to do this grouping is to establish a "screening interval" for each part. A screening interval defines how close to the life limit a part's age must be before the part can be replaced economically. The screening interval is applied opportunistically—that is, whenever an engine is removed for maintenance, there is an opportunity to replace a life-limited part provided that its age is within a screening interval of the life limit for the part. Thus, at each engine removal, all the life limited parts are reviewed, and those old enough to be within the screening interval are replaced at that time.

This paper describes a simulation approach for finding the set of screening intervals to be used for all the life-limited parts within the engine so as to minimize the long run logistics support costs. Two separate screens are to be identified for each part—one for use at base level to determine whether additional modules should be removed at a given engine removal, and one for use at the depot for identifying which life-limited component parts should be replaced when the module is repaired. The problem can be stated formally as follows: Find the combination of base and depot screens per part so as to minimize the total logistics support cost subject to constraints on the final engine removal rate per thousand hours and on the final engine NRTS rate.

The total logistics support cost includes maintenance manhours, pipeline spares, transportation, and parts consumption costs. Maintenance manhours include engine remove and replace actions from the airplane, module remove and replace actions from the engine, and module repair. Totals include both base and depot actions. Pipeline spares costs include both complete engines and individual modules. Since the screening intervals affect the removal rates for both the engine and the separate modules, the spares quantities required to fill the total cost equation. Base level screening intervals affect the number of modules that need to be repaired and, in turn, affect the decision as to whether or not to ship a whole engine to depot for repair. Thus, transportation costs for both the complete engine and the separate modules are also included in the total logistics support costs. The parts consumption costs include the cost of replacing the life-limited parts that are removed for expiration of life limits or are screened out for early replacement due to the screening interval policy. These costs are calculated using the stock list price of the part.

Simulation

A simulation model, called OMENS for Opportunistic Maintenance Engine Simulator, was used to calculate

Air Force Journal of Logistics

expected engine, module, and parts replacement actions; all the logistics support costs for the objective function; and the final engine removal and NRTS rates. OMENS is a Monte Carlo simulation model writing in FORTRAN. See reference 1. The OMENS model was designed to forecast expected repair actions and costs at steady state for mature engines. Steady state implies the period of time after the first replacement of all of the modules and parts. Mature implies that input removal rate factors were based on the assumption that all known and planned engineering improvements had been incorporated into the engine fleet. The final selection of the screening intervals will be applicable for long run application on a mature fleet.

The model tracks all modules on the engine and all life-limited component parts within each module. In addition, "dummy" components and "dummy" modules were included to drive removal actions for unscheduled repairs due to expected failures of internal components other than the life-limited components being tracked. Input removal rate factors were specified at input time to drive unscheduled removals through Monte Carlo sampling from given life distributions. The Weibull distribution was used in this study.

The model was initialized by specifying two numbers for each component part, including the dummies. The first number was the time until unscheduled removal. This value was obtained by making a random draw from the Weibull distribution using appropriate shape and scale parameter values specified for that component. The other number was the time remaining until the life limit would be reached. This was obtained by table look up and conversion of cycles or total operating time units into engine flying hour units.

The model also permitted a warmup option in which the ages of the components could be mixed before the model was started. This was accomplished by subtracting the beginning age of the module from both the time remaining until unscheduled removal and the time remaining until life limit for each component.

The model identified when in simulation time the engine would be removed next by searching for the smallest life remaining across all modules and parts. When found, the system clock was advanced that far, and all life remaining counters were updated. Given "screen" intervals were applied to determine whether the time remaining until the life limit on each unfailed component was less than or equal to the allowed early removal interval. If so, that component and its parent module were both coded for replacement. Removal actions were recorded, by reasons for removal, for each component, for each module, and for the complete engine. In addition, the logic for determining repair level was applied for each module requiring separate repair to see whether it would be fixed at base or depot. Likewise policy logic was applied to see whether or not the complete engine must be shipped to the depot for repair.

Following this process, all removed components were replaced by selecting new times until unscheduled removal and until life limit exactly as was done during initialization. The model then searched for the next engine removal time, as before. The whole process was repeated until a specified simulation run period was reached.

At this point the model calculated all the costs, and

produced a lengthy, detailed, edited output which was used for manual preparation of charts and tables. The model was then reset for the next policy combination to be examined and another run was made. This process was repeated until all policy combinations to be examined by the analyst had been completed.

The model was written in FORTRAN for use on a Honeywell 635 time-sharing computer. Each run took less than .02 of an hour of CPU time. This study required about 30 computer runs to generate the points plotted in the graphs. Each run contained 10 replications of the 20-year life cycle evaluation period.

The module used a Monte Carlo technique for determining which module and engine usage removals would require depot level repair based on input NRTS factors. In addition, the model identified which engine removal required shipping the whole engine to the depot rather than breaking it down into modules for repair at base level. The decision to ship the whole engine was made whenever four modules required repair and at least three of them were the inlet fan, high pressure core, high pressure turbine or fan drive turbine. Reasons for repair included premature failure, reaching a life limit, or being screened out opportunistically. This decision rule was called the "Rule of Four." The constant "four" was used in this study. However, other constants such as three or five, or six can and should be studied since they may greatly impact the final engine NRTS rate and the total system costs. Other studies have shown that in general, the larger the constant the lower the total cost. See reference 2.

The Experiment

An experiment was set up to compare a relatively large number of base and depot screening interval combinations. For each combination of screening intervals identified, the OMENS model was run to generate expected engine removal rates and engine NRTS rates and to calculate costs for a 20-year life cycle evaluation period. The output from each simulation run was plotted on a graph to facilitate the comparisons and to help identify preferred base and depot screening intervals. Base level screens were used to identify modules that should be replaced opportunistically based on the ages of the internal life-limited parts. Depot level screens were used to identify which life-limited parts to replace opportunistically during depot repair of the module.

Depot screen options ranged from 0 to 2000. A given option, such as 2000, meant that a screen interval of 2000 cycles (or hours if appropriate) was used for the accessories, inlet fan, high pressure core, and high pressure turbine and a 2500 screen was used for the fan drive turbine. Zero was always used for the augmentor and the gear box. If the option was 1000, then all the screens were cut in half resulting in four modules using 1000 and the fan drive turbine using 1250. The screen interval for the fan drive turbine was always set at 125% of the screen used for the other four modules.

Base level screens were expressed as percentages of the respective parts life limits. For example, if 10% was the option selected, then the screen for each part was calculated in the model by multiplying the life limit for that part by 10%. Base screen options used in the study were 0%, 5%, and 10%.

Results

Figure 1 shows the final removals per thousand engine flying hour rates for the complete engine as a function of both the base and depot screens used. There are three curves: one for 0% base screens, one for 5%, and the third for 10% base screens. Each of the curves varies with changes in the depot level screens with lower depot screens resulting in higher removal rates on each curve. None of the curves changed much over the depot screen range from 1000 to 2000. High percent factors used for base screens provided low engine removal rates. There was a diminishing returns effect with large decreases in removal rates between the 0% and 5% curves, and much smaller decreases between the 5% and 10% curves.

Having low engine level removal rates is desirable for several reasons. Aircraft readiness would be higher for a given spares posture, and maintenance manhours to accomplish engine changes would be lower. Of the curves plotted here, the engine removal rate could be minimized by following a 10% base screen policy coupled with a depot screen policy of 500.

Figure 2 shows the engine NRTS percent as a function of both the base and depot screening choices. High engine NRTS rates occurred whenever low depot screens were used for base screens greater than 0%. The larger the base screen percent, the higher the NRTS. This occurred because of the Rule of Four since larger base screens were

more likely to cause four or more modules to be screened out simultaneously at each engine removal. The effect was enhanced at lower depot screens, because less operating time would remain on each part following each module repair since modules were returned to service with only 400 or 500 hours (cycles) remaining until life limit, rather than 1500 or 2000 hours (cycles) remaining for larger depot screens. This condition made it more likely that a part's age would fall within the screening interval at the next engine removal. The NRTS rates were lowest for the zero percent base screen case.

Figure 3 shows the total logistics support costs as functions of joint base and depot screening policies. These costs reflect expected total costs per unit engine for an arbitrary 20-year life cycle evaluation period. Each curve has a low point: at 500 depot screen for the 0% base screen curve; at 1000 depot screen for the 5% base screen curve; and at 1800 depot screen for the 10% base screen curve. In addition, for any given depot screen, total costs increased as the base screen percent was increased. Each cost curve decreased with increasing depot screen over low values of the depot screen, and increased with increasing depot screen for high values. The decreases were due primarily to reductions in engine and module removal rates and the related reductions in maintenance, pipeline, and transportation costs. The increases were due to increases in parts replacement costs for the higher screening intervals.

F100 PW100 F-15 Removals Per 1000 Engine Flying Hours (EFH)

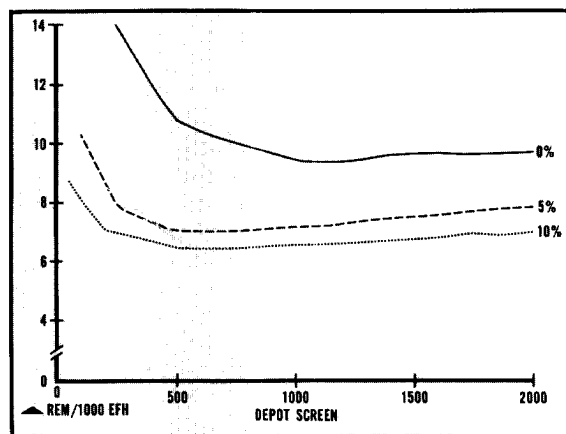


Figure 1.

F100 PW100 F-15 Not Repairable This Station (NRTS) Percentage

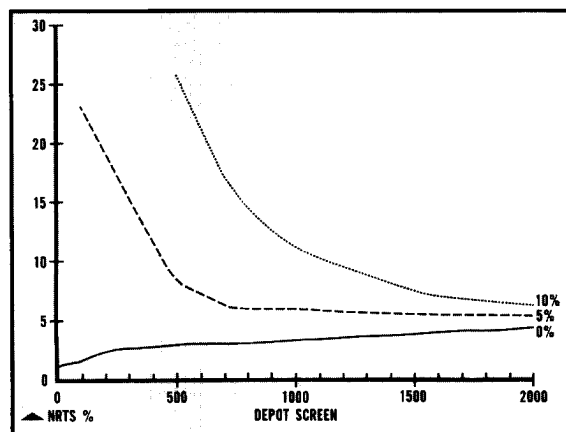


Figure 2.

Unconstrained Solution

If there were no constraints, and if a total cost criterion were acceptable to all the commands involved (TAC, AFLC, and AFSC) then the preferred solution would be to have a depot screen of 500 and a base screen of zero. See Figure 3. At this combination, the expected engine level removal rate would have been nearly 11 per thousand hours (from Figure 1) and the NRTS rate would have been about 3% (Figure 2). Maintenance costs, pipeline costs, and transportation costs were all about at their minimum values while the parts cost would have been slightly greater than its minimum at a zero depot screen.

Constrained Solution

Now let us suppose that there were constraints on the engine level removal rate and NRTS rate. This condition would occur when spare engines and modules had

F100 PW100 F-15 Total Costs

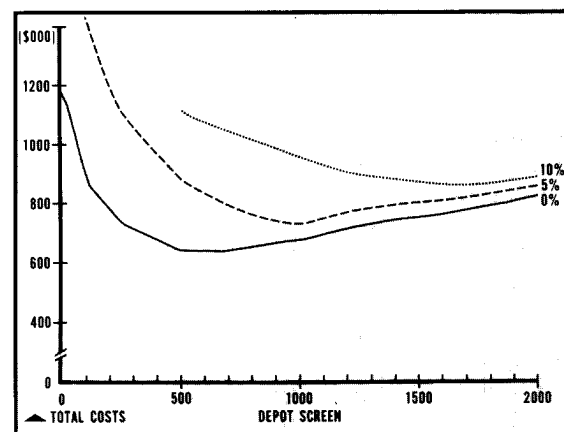


Figure 3.

Screening Intervals Within Constrained F100 PW100 F-15 Removals Per 1000 Engine Flying Hours Rates

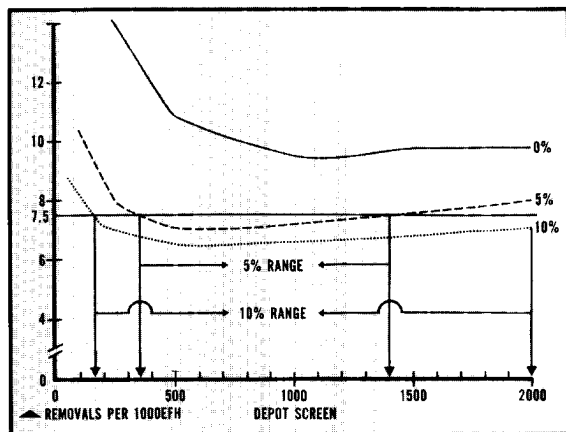


Figure 4.

Screening Intervals Within Constrained F100 PW100 F-15 Not Repairable This Station (NRTS) Percentages

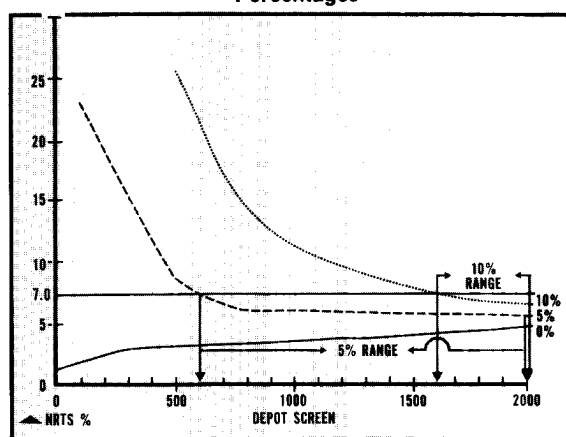


Figure 5.

already been bought using specific given values for these rates and no more buys were planned. Let us assume that a maximum removal rate of 7.5 was imposed along with a maximum NRTS rate of 7.0.

To solve the constrained problem, we would return to the engine removal rate chart (Figure 1) and draw a horizontal line at 7.5. See Figure 4. Any part of any curve below this line would indicate a feasible policy choice. For example, with the 10% base screen, any depot screen between 150 and 2000 would be acceptable. With a 5% base screen any depot screen in the range 3500 to 1400 would have produced acceptable removal rates per thousand hours.

Returning to the NRTS percent chart (Figure 2) and drawing a horizontal line at 7.0 (see Figure 5) we see that feasible choices again are defined by the parts of each curve which fall below the line. Thus, any depot screen would have been acceptable when a zero base screen was used. For 5% base screens, any depot screening interval larger than 600 would have been acceptable. For 10% base screens, a depot screen greater than 1600 was satisfactory.

Table 1 identifies the acceptable depot screening interval ranges for both removal and NRTS rates. Table 1 also identifies the joint constraints that meet both removal and NRTS rate constraints simultaneously.

Solutions which satisfy both constraints exist for both

Constrained Screening Intervals and F100 PW100 F-15 Total Costs

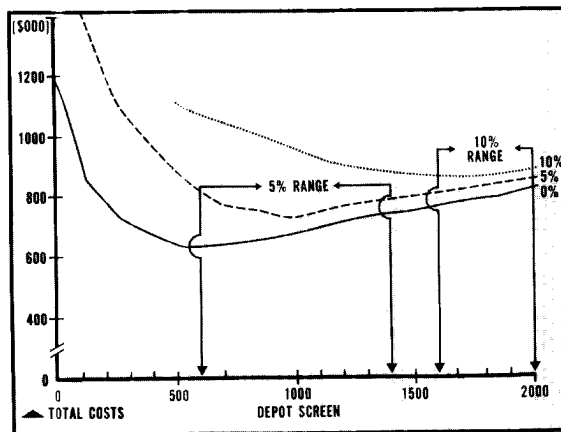


Figure 6.

the 5% and 10% cases in Table 1. Figure 6 shows the curves from Figure 3 with these ranges identified. Within these ranges, the 5% cost curve has a minimum at a depot screen of 1000, and the 10% cost curve has a minimum at 1800. Since the minimum cost is lower for the 5% curve, the solution, 5% base screen and 1000 depot screen, appears to be the preferred one provided that it does not cause excessive costs in any major cost category.

There would be no appreciable increase over minimum values for maintenance, pipeline, or transportation costs. There would, however, be a big effect on parts costs.

Table 2 compares the two preferred feasible solutions over a number of measures covering both rates and costs. The third column, the 5% base 1000 depot solution, is compared to the second column, the 10% base 1800 depot solution. The 5% base 1000 depot solution was \$139,000 cheaper in total costs per engine unit, mostly due to the parts costs reduction. This solution resulted in a slightly higher removal rate and a slightly lower NRTS rate. This table also breaks several of the costs down to engine- and module-related costs. It also breaks the maintenance costs down to base and depot. There appears to have been no really significant differences in any costs other than for parts.

It, therefore, appears that the 5% base, 1000 depot screening policy would be the final preferred policy for the constrained case.

Assessment

Referring again to Figure 6, it is clear that lower costs could have been obtained had there been no constraints on the removal rates and NRTS rates. This seems to imply that the best opportunistic policy, the unconstrained one, would apply screens only at the depot repair site. It also implies that the base would repair engines by replacing only those modules containing defective parts or containing parts which have reached their life limits. In other words, an "on-condition" maintenance policy would be applied at base level. Screening would be done only during the actual repair of each module, since this is the only time that the life-limited parts can be replaced. However, following this policy would have produced a larger engine removal rate that might not have been supported with the spares that had already been bought. To prevent this type of situation on future applications, the analysis should be done as early as possible in the

Table 1.
Acceptable Depot Screen Ranges

Base Screen Percent	CONSTRAINED REMOVAL RATE		CONSTRAINED NRTS RATE		JOINT CONSTRAINT	
	Min Depot Screen	Max Depot Screen	Min Depot Screen	Max Depot Screen	Min Depot Screen	Max Depot Screen
0	-	-	0	2000	-	-
5	350	1400	600	2000	600	1400
10	150	2000	1600	2000	1600	2000

acquisition and development stages of a weapons system program, since applying the technique later in the life cycle might have constraints imposed that would prevent achieving the lowest possible long run costs.

With additional computer runs, it might also have been possible to improve upon the choice of the final preferred policy. For example, a policy of 3 or 4 percent base screens with corresponding depot screens might have produced still lower costs while keeping the removal and NRTS rates within acceptable limits.

In addition, other constraints might have been applied. For example, if there are long term parts shortages, a line could have been drawn on a parts cost curve to further restrict the range of feasible solutions. These constrained solutions could then be followed for the duration of the parts shortage.

This paper has attempted to demonstrate how simulation modeling and operations analysis could be used to help identify decision rules for maintenance

management which would have been feasible and which could produce reasonably low costs. The approach was objective, straightforward, and was relatively easy to brief for higher levels of review. Application of the approach required access to a large scale time sharing computer, identification of a relatively large set of input factors and costs, and time necessary to set up and make the computer runs, prepare the tables and graphs, and analyze the results.

Experience has shown that the curves developed using the standard 10 replications are generally satisfactory for the analysis. However, increasing the number of replications helps to establish the curves with greater confidence when required. In those parts of the curves where the screening policy effect is less dominant, such as at moderately high depot screens, more replications are required to locate the curves with enough precision. One must also be careful to do additional runs in the vicinity of the low point for each curve to assure that the minimum indicated is actually the low point. Judgment is the final criterion for deciding whether enough runs have been made. Whenever there is doubt, make more runs.

Opportunistic "screening" policies described in this paper are currently being considered for implication by the USAF for the F100 engines in both the F-15 and F-16. Initial application of this method indicates a potential for large savings. The model, data, and recommendations are all being critically reviewed and coordinated among the involved major commands with a view toward implementation as soon as possible.

References

- (1) J.L. Madden, P.A. Persensky, V.L. Williamson, R.A. Novak, "Opportunistic Maintenance Engine Simulation Model, OMENS-II," Working Paper XSR-79-137-1, Logistics Systems Laboratory Division, Directorate of Management Sciences, Headquarters Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio 45433, June 1979.
- (2) J.L. Madden, "F-100 Opportunistic Maintenance Policy Analysis," Working Notes and Papers XRS-77-7-1 through 14, Logistics Systems Laboratory Division, Directorate of Management Sciences, Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio 45433, 1978-79.
- (3) J.L. Madden, "Opportunistic Maintenance Policies for Economic Replacement of Internal Life-Limited Components in Modular Aircraft Engines", Working Paper XRS-77-7-15, Logistics Systems Laboratory Division, Directorate of Management Sciences, Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio 45433, September 1979.

Table 2.

Comparison of Preferred Feasible Solutions

RATE OR COST (\$000)	10% BASE 1800 DEPOT SCREENS	5% BASE 1000 DEPOT SCREENS	DIFFERENCE
REM/1000FH	7.1	7.4	+ 0.3
NRTS %	5.8	4.4	- 1.4
Total Cost	860.	721.	- 139.
Maint. Cost	175	170	- 5
Base	60	62	+ 2
Depot	115	108	- 7
Engine	77	73	- 4
Modules	98	97	- 1
Pipeline Cost	91	89	- 2
Engine	48	45	- 3
Modules	43	44	+ 1
Trans. Cost	34	32	- 2
Engine	9	6	- 3
Modules	25	26	+ 1
Parts Costs	860	430	- 130

Air Logistics Center Items of Interest

MISTR Program Enhancements

The organic Management of Items Subject to Repair (MISTR) program is the cornerstone of the jet engine component parts repair program at Oklahoma City Air Logistics Center (OC-ALC). All engine parts as well as numerous airframe and accessory items are repaired under the MISTR program. In January 1978, a Task Group of managers and technicians from the Directorates of Maintenance and Materiel Management was formed to study, develop, test, and implement program enhancements. Several important enhancements were started, including the Engine MISTR Adjustment and Requirements Computation System (EMARCS). This computer system helps determine realistic engine line repair requirements for all the major component parts of a particular jet engine. Previously, all engine line repair requirements were calculated manually for 550 separate stock numbers for each quarter. EMARCS now accomplishes this task in a fraction of the earlier required time. Also, the system can adjust the repair requirements previously negotiated between Maintenance and Materiel Management whenever the engine schedule changes. This system is being prototyped on a computer and has been tested on two engine schedule changes and two quarterly repair negotiations with excellent results. Other procedural enhancements, when implemented, will result in separation of the negotiated repair requirements and actual production for the field support (worldwide mission support) and the OC-ALC engine line. These logistics enhancements will result in improved efficiency and support readiness for the Air Force. (OC-ALC/MMEA, Ron Wallis, AUTOVON 735-2513.)

Differential Item Management

During 1978 and 1979, OC-ALC service tested a Differential Item Management concept which involved the aggregation of investment (reparable) items into five Selective Management Groupings. The concept is similar to the program currently implemented throughout AFLC on expense (consumable) items. Simply stated, each item is not managed to the same degree of intensity with the same degree of item detail data. In contrast to the grouping of expense items according to annual dollar value of the item issues, investment items are grouped according to the number of customer demands per annum. This program will significantly reduce the workload on the item manager, technician and data processing personnel allowing more time and management attention for the more active critical items. An improved program has made it possible to include the Security Assistance Program and inter-service workloads in the pre-selection process. OC-ALC management by Selective Management Groupings is a reality in 1980. An estimated \$100,000 per year can be saved in paper alone with the full implementation of this system throughout AFLC.

(OC-ALC/MMI, Denise Chouteau, AUTOVON 735-3275.)

Air Force Logistics Doctrine

Major James D. Gorby
Commander, 317th Transportation Squadron
317th Tactical Airlift Wing
Pope AFB, North Carolina 28308

There is a need to develop and publish a new, comprehensive logistics doctrine for the Air Force. Granted, logistics doctrine is outlined in the February 1979 version of Air Force Manual (AFM) 1-1, *Air Force Basic Doctrine*. But it is only an outline. Much more is written about logistics in AFM 400-2, *Air Force Logistics Doctrine*, published in 1968. But that manual reflects theory popular then and needs complete revision today.

The purpose of this paper therefore is to stimulate the development of a new logistics doctrine for the Air Force. The pages that follow present a logistics doctrine to serve as a target for the Air Staff and the major commands to focus on, to discuss, and to change—thus creating a document that is understood and valued by students and practicing logisticians alike.*

THE NEED

Why should any time be spent developing logistics doctrine? The answer is clear if we look at the purpose of logistics, what logisticians must do to accomplish that purpose, and how doctrine might help us in that task.

Air Force logistics supports the buildup, readiness, and operations of combat forces, including strategic and tactical mobility; determines what resources are needed; procures, transports, stores, allocates, and maintains these resources to make the forces efficient and effective. In addition, logistics supports certain foreign air forces through security assistance.

This defines what logistics must do, its basic purpose for being. On this foundation we can build our doctrine. Additionally, since doctrine is usually associated with a profession, we shall consider logistics as a profession—at least for the purposes of this paper.

Webster defines a profession as “a vocation or occupation requiring advanced training. . . usually involving mental rather than physical work. . .”. It is characterized by a long apprenticeship under the tutelage of some experienced practitioner and is usually seen as a service to the larger community (26:5). Such is Air Force logistics, although the closer we get to aircraft, the more physical work is required.

*Ed. Note: Current activities within the logistics community include a complete new look at logistics Doctrine—what it is, its purpose and its relationship to our Basic Doctrine, AFM 1-1. The AFIT School of Systems and Logistics has been given this task and will soon be contacting many of the MAJCOMs and senior logistics leaders, soliciting their views and comments. A revised Logistics Doctrine, AFM 400-2, is scheduled for publication in June 1980.

Doctrine, stripped away from the fancy language surrounding it is quite simple: it is what we believe and therefore what we should teach those who will follow us (25:69).

We observe an action and, over time, infer what we think is a general pattern for that action and many situations like it. From the concept, we establish procedures to guide others in “how to do it” or we build equipment to fulfill the objective. We observe those procedures or equipment in action, and infer again. Each time we redefine our concept closer and closer to the “truth”. Finally, when we believe that what we have done is truly what all should do in similar circumstances or that we have identified characteristics logistics should possess, we generalize our experiences or these characteristics into a set of rules we might call doctrine.

In general, there are four reasons for a written Air Force logistics doctrine: to serve as the underlying rationale for the logistics decision/planning process, to provide a structure for long range logistics planning, to encourage further thought on how we support and should support the combat strength of the Air Force, and to improve the training of our people.

Commanders and logisticians should use logistics doctrine, consciously or unconsciously, every time they make a decision. Resources, prudently applied to support the mission, should ensure the “most bang for the buck”. There should be an enduring set of rules we can use when considering how best to accomplish a mission.

Future systems should apply lessons we have already paid for through previous experiments, mistakes, and successes. Long range logistics planning will be most effective if guided by the tried and true rules we live by as well as by exciting new capabilities available from American technology.

This doctrine, even after coordination across the Air Force, cannot be the final word on logistics matters. Despite our best efforts, “enduring” principles do change as conditions change. A great deal of hard work will always be required to keep our doctrine, and hence our organizations, procedures, and techniques current and effective in light of the threat we face.

Finally, well-trained people are fundamental to mission accomplishment. Doctrine should give students the foundation for all they study thereafter: organization of logistics, mathematical models and management techniques used in logistics, and the procedures established to provide support to the combat forces. It should form the intellectual structure for thinking about logistics, why it is important, and how it relates to the rest of the Air Force.

THE PRINCIPLES

There is some useful logistics "doctrine" already available in standard rules of thumb, in the present logistics doctrine, and in some of the statements in Basic Doctrine. There is also much to learn from recent studies, from history, and from experienced Air Force logisticians. The following nine principles, proposed as the basis for revising current Air Force Logistics doctrine, are derived from all of the above sources.

Principle: OBJECTIVE

Support the mission

The first principle seems self-evident, but it is amazing how throughout history it has been ignored. For example, during World War II in the China-Burma-India theater the United States established under General Joseph W. Stilwell an early form of military assistance to Chiang Kai Shek's Chinese forces. The assistance originally was shipped to ports in Burma and trucked via the "Road to Mandalay" up into China, since the Chinese coast was largely occupied by the Japanese. After the Japanese overran Burma, the supplies were continued by flying them over the "hump" from India into China. The purpose of this logistics system was to tie down as many of the enemy as possible in China and thus ease the way back across the Pacific for U.S. forces. Unfortunately, Chiang Kai Shek decided to let the U.S. and British forces defeat the Japanese, and hoarded his supplies for an eventual showdown with Mao's Chinese Communists. Consequently, the Chinese under Chiang did not attack the Japanese, did not tie them down, and the logistics system established to do these things did not contribute to the U.S. objective (56:80, 156-158).

Supporting Statement: Mission requirements determine the level of logistics support required; however, if resources are limited, mission accomplishment will be constrained unless operations are phased to ensure continued logistics support.

This statement becomes clear if we look at the German disaster at Stalingrad in World War II. Immediately after the Soviets cut off the German Sixth Army at Stalingrad, Army Group South began plans for a relief attack. They envisioned simultaneous drives from inside and outside the pocket, a linkup, and a retreat away from Stalingrad to await more favorable conditions. However, Reichsmarshal Goring promised Hitler that his Luftwaffe could deliver the 500 tons of supplies Sixth Army required each day, and Hitler forbade the breakout attempt. Because of severe weather, unprecedented Soviet antiaircraft artillery concentration, and a worsening situation on the ground, the Luftwaffe was never able to deliver more than an average of 100 tons per day. Consequently, the condition of the troops in the pocket grew worse, and about two and a half months after being cut off, 91,000 survivors out of the 330,000 originally surrounded finally surrendered. Planning had not failed; the requirement was specified. The Germans were faced with inadequate logistics support and their operations were increasingly constrained as the "tyranny of logistics" took hold (51:83-87).

Supporting Statement: Logistics managers must participate in mission decisions to ensure the capability to support those decisions.

In Southeast Asia, decision makers decided that the United States would use B-52s to drop iron bombs on suspected Viet Cong base areas. The B-52s were duly deployed to the Western Pacific and began dropping the bombs. Unfortunately, no one had considered how these massive drops would be

supported. The existing inventories were soon almost gone; production lead times were so long that the U.S. was soon buying back bombs from the Federal Republic of Germany which we had recently sold to them at cutrate prices. If the logisticians had been in on the decision from the beginning, the B-52 deployment could at least have been phased in over time, and costly backtracking avoided (52:10).

Supporting Statement: Logistics tasks which directly support the mission should be controlled by the mission commander (e.g., those maintenance actions to turn around aircraft should be so controlled). Basic mission-essential functions must be organic to the Air Force.

When the Soviet Union was attacked by the Germans in June 1941, their front commanders were not in direct control of ammunition stockpiles in their own areas. Stalin had forbidden any provocation of Germany, which was translated by the politically loyal NKVD border guards as no forward deployment, little field work protection for the troops, and little or no ammunition distributed to front line units. Consequently, when the Luftwaffe struck, they were able to wipe out these stockpiles and materially aid the advancing ground troops. Had the stockpile been under the ground force commander's control, they could have issued the stocks to their units and still kept them well back from the border to avoid provocations (41:37; 42:10-11).

Principle: READINESS

Keep the equipment ready for war

This principle calls for logisticians to strip away the fog from all the things that could be supported with scarce resources and concentrate on the single overriding objective to keep our equipment ready to go to war as we have planned. The U.S. Air Force has so far been able to meet every demand placed on it. For example, in 1958 we dispatched a show of force in two directions sequentially, to Lebanon and to Taiwan. In 1962, we concentrated strong air forces in southern Florida. In 1965, we deployed to Vietnam, and in 1969 to South Korea. Our Israeli airlift in 1973 following the October War replaced vital equipment lost in that unexpected war of attrition. So far, the crises have been small enough, and our resources plentiful enough to meet all our operational and logistics requirements, and this is as it must be. We must always support the force needed within the times allowed to get it where it is needed.

Supporting Statement: Combat units should be self-sufficient; that is, manned and equipped to perform a defined mission on immediate notice for specific periods of time. Requirements for support should be defined, as clearly as possible, before initial wartime operations. Spares and equipment to sustain operations should be prepositioned at employment locations, identified for movement with the combat unit, or stored in a ready condition at a location under Air Force control for rapid movement into the operational area.

During the World War II Pacific campaigns, logistics snafus were quite common. Contents of boxes were not labeled properly, and as American forces island-hopped toward Japan, they left behind on island after island large quantities of unused, unidentified equipment and supplies. When the Korean War erupted in 1950, these supplies were still there, were broken open, identified, and rushed to Korea to save the Pusan perimeter. While not planned to be prepositioned, they were in fact and saved our foothold on the Korean Peninsula (5:14). If we can do this haphazardly, we should do better if we plan for it. The Harvest Eagle kits, centrally maintained at Warner Robins Air Logistics Center (ALC) are just this concept applied in a planned

manner. They are ready for deployment on very short notice to wherever needed. War Readiness Spares Kits (WRSK) are a stock of items needed by a specific unit to deploy with the unit and support it for a given period.

Supporting Statement: Logistics elements must be periodically exercised to ensure they can meet operational requirements.

Prior to World War II, the German Panzertruppen and the Luftwaffe were the only forces in the world practicing long distance offensive moves by armored forces and support and air base support. When war did come, Germany ran rings around her enemies for three full years (35:95; 43:118).

In the experience of several logistics officers at Air Command and Staff College, one or more exercises are required to learn new procedures: aircraft generation, mobility, dispersal plans, etc. The first time through, things will go wrong which cumulatively waste time and result in unsatisfactory performance. After practice, procedures "grease" themselves, times are met, and things go smoothly.

Supporting Statement: Logistics systems should be designed for wartime use, with peacetime procedures duplicating wartime procedures insofar as is possible. These systems should not require change during wartime. When operating mobile subsystems away from home station, logistics personnel should not have to learn or develop new procedures to do their jobs.

A horrible example where this was not applied was the French attempt to halt the German Meuse River crossing at Sedan in May 1940. The French artillery were suddenly faced with a panzer corps attempting to cross the river supported by massed Stuka dive bomber attacks. The French gunners held back their fire at the crossing Germans "in order to conserve ammunition and in the conventional belief that it might be four to six days before the (main) attack would come (35:131). The next day, all these French positions had been overrun, including their "conserved ammunition".

Supporting Statement: Critical systems, including communications and automatic data processing (ADP) equipment, must be protected from major disruption through equipment failure or enemy action. Logistics requires high-speed communications between field and depot and between depots under emergency conditions.

Operation Market-Garden (the Allied paratroop at Arnhem and other places during World War II) depended on good communications. However, because of a phenomenal mixup, the radios at Arnhem proved useless. When the Germans occupied the drop zones, the British were unable to communicate with follow-on supply airdrops; the result was most supplies fell into German hands. There was no backup system to the primary, and disaster ensued (12:146).

Supporting Statement: During operational readiness inspections and command post exercises, real world data should be used (when security permits) to reflect actual logistics capabilities and shortfalls.

In the experience of several logistics officers in the ACSC Class of 1979, it was the norm during exercises to "assume the equipment is available or ready". Consequently, the only thing learned during these exercises was how to fill out reports and use the message center. This situation was dangerously similar to German war-gaming of Operation Barbarossa, the invasion of the Soviet Union in 1941. The German planners used assumptions which did not conform to reality and the invasion fell short of the goal by several hundreds of miles (47:578-587).

Supporting Statement: Proposed plans should be evaluated for feasibility before they are adopted. We should highlight logistics capabilities and shortfalls

to aid the commander's decisions.

During the Normandy invasion in 1944, it was observed that

Six days after D-Day, the English ports were so badly scrambled that troops could not be sorted into the landing craft to which they were assigned. The situation became so disorganized that even available ships could not be loaded. Only extraordinary measures, such as indiscriminate shipment of troops without regard to craft-loading plans, plus an absence of enemy interference, allowed us to straighten out the chaos. (5:12)

Obviously, there was more emphasis on operational planning after the troops were ashore than in the logistics planning to get combat ready troops on shore beforehand.

Later, during the pursuit across northern France, gasoline supplies could not keep up with the rate of advance, and units came to a halt. This happened despite prodigious Allied efforts to keep supplies flowing by extensive use of one-way traffic (the Red Ball Express), air transporting critical items, and ruthlessly paring down vehicles eligible for gasoline (38:145).

Principle: SUSTAINABILITY

Support the mission until it is completed

In World War I, the 1914 German advance across Belgium and northern France was to sweep along the English Channel, then to the west of Paris, and finally singly envelop the French and British armies against the Swiss border. Unfortunately, in addition to communications, the Germans could not sustain the advance as directed and kept crowding further to the east. The primary cause of failure was the impossibility of pushing rail lines west and south fast enough to keep the troops supplied.

After the war, the Germans paid heed to this logistics shortcoming and built in their "blitzkrieg" army and Luftwaffe not only tremendous striking power, but the capability to support them in short, sharp campaigns within 600 miles or so of German's borders. The logistics system to support these forces continuously was crucial, and only failed after the design's capabilities were exceeded in the depths of Russia (43:177).

Supporting Statement: We must identify expanded operational force (surge) requirements and provide support when needed. We must have sufficient assets to support the initial surge and to sustain the force until industrial mobilization allows supplies to catch up with demand. To ensure continued support, we must prepare production facilities for rapid increases in output. This may require keeping some federal or private production lines minimally operating to accommodate quickly expanding requirements. We must plan purchases to ensure supplies and equipment are available when needed.

Probably the best example supporting this statement is seen in the Soviet Union's preparations prior to World War II. Diplomatic initiatives failed to stop Germany, so Russia signed a non-aggression pact with Germany to gain time to reconstruct her own forces after Stalin's disastrous purges of the Soviet high command. Soviet industry concentrated on a broad-based effort to improve its ability to produce war materiel. They ruthlessly cut back peripheral lines and concentrated on a very few proven models, such as the KV-1 heavy tank and the T-34 medium tank. Meanwhile, Germany continued to build the Panzer II, III, IV, the Sturmgeschütz III and IV, the Panzer 38(t), and a variety of assault, antitank, and self-propelled guns. Furthermore, the Luftwaffe, Army, and Kriegsmarine (Navy) each had their own dedicated factories, leading to further

inefficiencies. In Russia, war industries also specialized, but production responded relatively quickly to changes in land or air priorities. After Albert Speer became czar of German industrial production, similar rapid production increases resulted as he rationalized the hodge podge he inherited (63:210, 19:53; 48:101).

In the United States in 1975, the Texas delegation to the U.S. Congress tried to arrange for the F-111 to be produced until there was a definite decision on the B-1 bomber. This was to ensure that a warm production base continued until another was ready to take its place (39).

Supporting Statement: We must prioritize resource allocations during peacetime so that under emergency conditions, combat or contingency forces receive the highest support levels and nonessential peacetime functions are curtailed.

Rationing in the United Kingdom as World War II began provides a good example of what is meant here. Civilian uses of gasoline and sugar were sharply curtailed so that military vehicles and troops would have the energy they needed. By planning for such rationing during peacetime, it can be quickly implemented in wartime (33:83-84).

Another good example of this in the Air Force today is the Force Activity Designator (FAD) and the Urgency of Need Designator (UND). Together, these establish requisition priorities among missions in the Air Force, and thus serve as an in-being rationing system.

Supporting Statement: Long range logistics planning and programming must be accomplished in conjunction with operations planning to ensure the force is sustained.

There are many examples of this concept: building bases and the supporting infrastructure concurrently with producing new airplanes; arranging to produce avionics or support equipment concurrently; providing for shipping, berthing, and off-loading requirements for resupply in Vietnam (5:16). If this planning does not occur, the force will probably decline in strength and disaster may ensue. This is what happened to Rommel at el Alamein: inadequate long-range logistics planning (13:534; 36:109-111; 46:7, 11).

Supporting Statement: National policy requires reliance on the private sector of the economy for goods and services. However, there are specific instances where it is in the best interest of the government to have such goods and services provided from within the federal sector. Examples include military essential workloads, interservice depot maintenance capabilities, and control over basic management functions. In wartime, we should meet major increases in logistics requirements by mobilization as well as by contractual services.

Many services now thought to be purely military were once furnished by civilian contractors. When artillery first came into vogue during the French Charles VIII's invasion of Italy around 1500, the gunners were not military and did not furnish their own transportation, but hired it locally. Over time, these functions were incorporated into the military as being more efficient (57:32). Modern examples of this might include USAF Prime Beef teams for rapid facility or airbase construction, World War II U.S. Navy Seabees, or the German Organization Todt. In war, such activities should be under military control; in peacetime, the requirement is lesser and other considerations can apply (63:194; 24:51).

Principle: FLEXIBILITY

Support the force under all planned conditions

Before World War II, the Germans had several opportunities to practice certain phases of war before any other nation had comparable

experiences. In 1938 they occupied Austria, and in 1939 all of Czechoslovakia. These occupations enabled them to move large armored and air formations from their home bases several hundred miles across occupied territory. These exercises highlighted severe logistics deficiencies in repairing and refueling vehicles on the march or after landing. As a result of these experiences, Germany incorporated new mobile supply and repair teams into their fast columns. When war broke out against Poland, the organizations worked, the bugs were ironed out, and an even better organization supported the thrusts into French and the Low Countries in 1940. Unfortunately for Germany, the organization only worked for about 600 miles from the German borders, and failed in the tremendously long leap into the Soviet Union (43:177).

Today we are faced with progressive computerization of our support processes. The Penny Counter deployable computer is one attempt to meet the demands of the principle of flexibility.

Supporting Statement: Transportation and stockage policies should permit rapid redirection of resources. For example, prepackaging assets in a WRSK eases movement from one location to another.

Today C-130s, C-141s, and C-5s all have been configured to the 463L palletizing concept wherein loads are built to fit standard sizes. This permits easy on/offload of cargo, quick transfer to other means of transport (truck, rail, boat) and encourages standard labeling and other speed-up techniques (67).

Supporting Statement: Equipment supporting deployable units in combat operations should be air transportable, durable, reliable, easily maintained, and capable of quick assembly and use under operational conditions.

Khe Sahn, Dien Bien Phu, Stalingrad, the Demyansk pocket, and Bastogne all provide poignant reminders why airlift is so important in modern war. Circumstances like these happen even in wars of continuous fronts such as World War I and parts of World War II, and entire armies can be lost unless those surrounded can be relieved by a counterattack or resupplied until more favorable conditions obtain. To maximize air resupply, we must standardize our equipment and make it durable and reliable to overcome the strains of paratroop or of fast reloading. We must also make it easy to maintain because of primitive conditions likely in the employment area, and it must be quickly assembled because of combat conditions (44:305-306; 51:81, 83).

Supporting Statement: Organizations should deploy with only those assets needed to perform the mission. This reduces airlift requirements, freeing both airlift and equipment for other missions.

This concept can be most graphically illustrated by two short examples. During the Stalingrad airlift (November 1942-late January 1943), the Luftwaffe was committed by Reichsmarshal Goring to deliver needed supplies to the besieged Sixth Army. To meet the requirements of that army, a minimum of 700 tons had to be delivered each day, 500 if all the horses were slaughtered. The Luftwaffe could deliver but 300 tons on a good day and 100 tons on the average for the entire period. Consequently, the ground forces progressively weakened and finally surrendered when the Russians overran the last airfield in the pocket. During the airlift, 488 aircraft were lost. One can be sure that with 300,000 starving men in the pocket and air crews facing high losses only the most essential items were loaded and delivered in this airlift (51:83-87).

A more modern example is furnished by the U.S. Army requirement to reinforce NATO. According to a 1975 Air War College study by Lieutenant Colonel Alvin C. Ellis, U.S. Army, the Military Airlift Command

Air Force Journal of Logistics

using owned resources and the Civil Reserve Air Fleet (CRAF) could deliver approximately 100,000 short tons of unit equipment by M-Day plus 30. This is equivalent to delivering only two armored divisions, fully equipped, to Europe. In view of the Warsaw Pact threat, this is a very small reinforcement and emphasizes the validity of "take no more than you need" (15:29).

Supporting Statement: The logistics system, including procedures, communications, and automatic data processing, must support remote operations.

Oftentimes we must support forces deployed overseas, either as a show of force (for example, the 12 F-15s deployed to Saudi Arabia in January 1979), a detached force operating behind enemy lines (e.g., the Chindits or Merrill's Marauders in Burma in World War II), or because our troops have been cut off from our main force (such as at Bastogne in World War II or at Khe Sahn in Vietnam). While those forces are remote from normal support channels, we must maintain them in their mission. To do this today means that those forces must have access to the logistics system through high-speed, secure communications, various ADP subsystems, and by using the same procedures while deployed as one would use at home base. Thus, nothing more would have to be learned and practiced as far as system and procedures are concerned, although set-up and check out of the systems would be practiced. This can be done as micro computers become more durable and compact (8:144-118; 56-110; 7:130).

Supporting Statement: The capacity to move personnel, supplies, and equipment must be considered in any operational decision. As forces and equipment increase during wartime mobilization, transport capabilities must expand proportionately to ensure mission accomplishment.

In the opening days of World War I, the Germans leaped ahead of the other Great Powers because of their superior mobilization organization and procedures. The divisions, corps, and armies assembled on the German-Belgian-French border as provided in the tightly-controlled railway plan, and marched on the great turning movement into Belgium. Thereafter, things progressively began to slow down as the railroads could not be repaired fast enough to keep up with the record-setting pace of the German foot columns (40 km per day), the 6000 trucks mobilized could supply but a fraction of the needs, the horse-drawn wagons were shortly hauling more fodder for horses than ammunition and supplies, and the front line troops began to crack under the strain of exhaustion and too few supplies (35:31-32).

Today we face similar problems. If the Germans neglected supply past the railheads, the U.S. weak link today may be the sad state of our Military Sealift Command. Our Military Airlift Command can be likened to the German trucks: they can deliver, but not nearly enough to keep up with combat needs. Sealift is desperately needed to sustain the European force (15:25).

Principle: SYSTEM INTEGRITY

Logistics is a dynamic, interrelated, total system

We cannot treat logistics as distinct from military operations because they cannot be separated except to ease analysis. The idea of sending a squadron of airplanes somewhere with no support is ludicrous; logistics is completely intertwined with operations, and vice versa. Similarly, we cannot view logistics as separate pieces of transport, supply, or maintenance. One cannot function without the other, and all depend on the others to help get their own job done. Although we can break problems into smaller pieces to analyze them, and we do organize

for responsibility among our various squadrons, logistics support must be viewed from the standpoint of the wing commander: "My mission needs support—I don't care who supports what as long as it's supported."

Supporting Statement: Headquarters, United States Air Force Deputy Chief of Staff for Logistics and Engineering, the Air Force Logistics Command, the Air Force Systems Commands, the Air Training Command, the operating agencies and commands, the Defense Logistics Agency, the Military Airlift Command, the Military Traffic Management Command, the General Services Administration, the Department of Energy, and other Services and allied nations all contribute support to the Air Force mission. Transportation, logistics plans, supply, maintenance, distribution, acquisition logistics, logistics operations, disposal, and training logistics personnel are all functional components of an integrated, cohesive logistics system, separately defined for ease of understanding. Functional changes in one element of the system will often affect the entire system.

An example of a functional change in one part of the system affecting other parts also serves to illustrate why it is so important for logisticians to have a say in operational plans. In World War II, the Americans broke out from the Normandy bridgehead while the British and Canadians pinned down the German armor further east. Heading south then east, the Americans rapidly out flanked the Germans and caused them to retreat rapidly eastward, losing many troops and much equipment in the process. To keep up with the ever-lengthening supply line, the Americans made half the roads to the front one-way east and the other half one-way west back to the Normandy ports (the Red Ball Express). Trucks were loaded with ammunition, gasoline, and other supplies and sent in long lines to the spearheads to keep them moving.

The German retreat had broken their armies wide open, and disorganization and panic were setting in. The American commanders in contact with the enemy know this, and were anxious to press them with everything they had to complete the German defeat. When the long supply lines began to cramp their operations, some U.S. commanders seized the stocks of gasoline each truck carried to return to the Normandy ports. Combat operations were indeed enhanced for a short period, but the supply line eventually broke down as trucks dropped out, and all forward movement stopped for lack of gasoline.

Obviously, the operational commander was not restrained by a calculating logistician before he seized the gasoline, but logistics forcefully brought him to a stop eventually. Again, a change in one part of a logistics system (gasoline for the return trip) affected the entire system (stopped the supply line) (5:13; 7:118).

Supporting Statement: Inputs into logistics information systems must be accurate and timely to procure the right things, transport or store those things, and, to permit effective decisions. To satisfy these criteria, we must have trained personnel, adequate and reliable communications, and data handling systems.

It takes time to buy things, then transport them to where they are needed and issue them. Unless we quickly identify our needs and order them, no one can get what's needed to where it is to go in time. When the Japanese invaded the Philippines in 1941, General MacArthur would have given anything for a few hundred first-class fighter aircraft. They were not available, the Japanese secured air and sea supremacy, and the Americans surrendered within six months (5:11; 40:67).

On a smaller scale, if snowplows aren't repaired during the spring and summer, no amounts of money or manpower can get them ready when the

snow starts falling. We must identify and order the things we need, transport them to where they are needed, and do it ahead of the time the equipment is needed.

Supporting Statement: Information subsystems must be compatible and not require manual intermediate reformatting or other time-consuming activity. Extensive communications networks and computers have increased the interdependence of logistics processes and procedures, and conversely have increased our capabilities to respond to requirements. Changes in logistics requirements and procedures must allow for their impact on communications and ADP support; advances in these areas should be reviewed for their impact on logistics systems.

Time is money. Resources are always limited and will probably become more so. Anything we can do to make a task simpler must be done. Just as the Airborne Warning and Control System (AWACS) is a "force multiplier", so too can communications and computers multiply the efforts of a single, well-trained logistician. Micro computers can give very powerful tools to all who could use them.

Principle: VISIBILITY

Watch those things most critical to the mission

There are any number of things that a manager or commander could spend time doing. One approach following "Know your people" might have the commander trying to spend a minute with each person in the unit. If there are 3,000 people in the unit, it would take 50 hours just to do that, not counting access and waiting time. The point is that the manager *could* do a lot of things. What he *must* do is figure out what will cause mission failure and spend time making sure those things don't happen.

Supporting Statement: Assets which support or are critical to several systems must have Air Force-wide visibility with central control to ensure rapid redistribution to priority needs.

During the American Civil War, General Sherman marched from Atlanta to the sea, then turned north through the Carolinas to link up with General Grant near Richmond, Virginia. As he went through the Carolinas, he captured several warehouses full of uniforms, rifles, ammunition, food stocks, etc. gathered to support the vanishing "Home Guard". Meantime, up near Richmond, General Lee's Confederate Army was hungry, cold, and threadbare with no supplies in sight (61:687-690).

How often in warfare have adequate stocks been available one place and none whatsoever where the fighting was? Central control and visibility can also be a "force multiplier".

Supporting Statement: We should manage assets by weapon system to support the forces within mission priorities.

Weapon system identity for sub-assemblies and parts can be crucial. During World War II there were several models of German tanks on the Eastern Front. The Germans had a terrible time getting the right spare parts to the right unit: Panzer 38(t) parts would be delivered to Panzer III units, etc. Today our problems would seemingly be easier since we have fixed operating locations and fewer models in operation. But what happens if we equip with Harrier-type vertical or short takeoff and landing aircraft and single aircraft begin operating from dispersed locations? The lesson remains valid (29:43-44).

Supporting Statement: We must understand logistics systems from input through output; personnel should understand their place in an organization, how they receive inputs, and how and where we use their outputs.

In an organization the size of the Air Force, it is

easy to lose track of why we are doing something. A system can change so that reports formerly needed for a particular job are no longer required. But they keep coming because another procedure at the sending end calls for writing that report. If people do understand how and why, then they will catch waste such as this and eliminate it.

Principle: ECONOMY

Do the job the cheapest way possible

We must be efficient; money or resources saved in doing one task can be used to buy more of something else or to do other tasks that were going undone because resources weren't available to do them.

The United States has never fought a "cheap" war such as Britain or Germany were forced to do because of smaller industrial bases. We always have had enough to do whatever our leaders thought should be done. But each of our wars could have been fought more efficiently with consequent lesser burden on the taxpayer or greater capability elsewhere. Better labeling of our containers in World War II would have helped our overall supply system. Since labeling was so poor, stocks sat around invasion beaches near troops in need, while additional stocks were hurried forward from distant depots (5:14; 67).

Supporting Statement: We should design equipment to minimize the cost and effort required to acquire, operate, and maintain it during its life cycle. Increased costs of complex equipment should be offset by improved reliability and maintainability.

After World War II, the United States found we must maintain large, modern forces in peacetime. Our recent history shows that buying the cheapest piece of equipment is not necessarily cheapest in the long run. Often that cheap equipment costs a lot of money to maintain and operate over its life, where a bit more money spent in the beginning on more reliability or ease of maintenance could have saved money in operations (50:52; 11).

Supporting Statement: We must reduce the need for new support equipment and spares through parts commonality and standardization. To reduce new assets entering the Air Force inventory, new systems should use as much existing equipment and spares as is possible. When possible, we should use commercial products to avoid the additional costs of special military designs.

During World War II, the Soviets concentrated on one or two tank models early in the war, and upgraded them as time passed. The Germans, as we have seen previously, built too many models for too long. Scarce industrial capacity and resources were split among these many models, and each required its own logistics pipeline from factory to front line unit. The Western Allies, on the other hand, concentrated on the M-4 Sherman tank and out produced the Axis many times over (19:53; 31:40-43; 68-126).

Supporting Statement: Generally, we should concentrate assets near the point of intended use. However, the storage location can vary; high use, inexpensive items should be stocked near the point of use with more expensive items concentrated under central control at base, area, theater or Continental U.S. (CONUS) locations. Maintenance, storage, and transport requirements should be prioritized and capabilities used only for items which contribute to the mission.

This concept is similar to the basic doctrinal statement that air power should be concentrated under a single commander. We can buy few expensive items, and thus cannot always stock enough at each using location to ensure continuing

support. Thus, we either concentrate them at a few locations and speed them to where they are needed, or keep a few at each location and keep tabs on them so that when one place runs out, we can direct one in there from another place. Conversely, inexpensive items may be cheaper to store than to transport and thus should be concentrated in bulk at the using location.

One should note the close association of one principle to another, as shown in the above explanation. Concentration, monitoring expensive items, etc., are also descriptive of our "Visibility" principle discussed earlier, but clearly describe "Economy" as well.

Supporting Statement: We should do tasks which are not mission-related at a center, by contract, or by interservice support agreement. By consolidating inventories, equipment, and skills, we can reduce duplication and apply savings elsewhere.

We should group those direct mission-support tasks under the mission commander: aircraft generation, munitions loading, etc. The further we get from the primary mission, the more justification there is to centralize; the Accounting and Finance Center at Denver, Colorado is a good example of the latter. Depot maintenance requires heavy, expensive equipment and specialized skills not needed at each Air Force base. They too are centralized, but not to the degree of the paycheck function.

Money and resources often determine in part how we accomplish the mission. Centralization versus decentralization arguments usually follow the money/resources line, and centralization has been winning since World War II.

Supporting Statement: Logistics support must be available to the force within certain levels of risk and cost defined by those responsible for national defense. Resources will be applied against priority missions to ensure the least risk to accomplishing those missions. During peacetime, there may be insufficient resources to accomplish all tasks. During wartime, although more resources will be available, they will be concentrated on those essential tasks which contribute most to the mission.

As the very beginning of America's entry into World War II, it was decided that Germany would be defeated first and Japan later. The Pacific campaign would be given just enough to slow or stop the Japanese advance, and resources and troops would be concentrated against Germany. In short, the Pacific risk was deemed lower than Europe by those responsible for national defense. Germany was deemed to be the greater threat, resources were concentrated against that threat, and other missions were given a lower priority (16:28-29).

Supporting Statement: Development and acquisition costs of a system should be shared with other services or allies to reduce unit costs and make resources available for other purposes. In addition, sharing can decrease follow-on logistics support costs. This concept is well illustrated by U.S.-U.K. use of the M-4 Sherman tank in World War II, and the current NATO co-production effort with the F-16 aircraft.

Principle: AVAILABILITY

Get the right thing to the right place at the right time

This is an old saying in logistics, and it continues to be true. If any one of those "rights" fails, then logistics fails.

Field Marshal Rommel beat the British several times in 1941-1942, and always did it with inferior forces. After el Alamein in late 1942, Panzerarmee Africa was beaten. To avoid the Anglo-American forces coming down on his rear (Operation Torch—

the invasion of French North Africa), he hurried back to Tunisia. There he found new forces sent to Africa to maintain an Axis foothold on the continent. Rommel was extremely bitter about this. Had those forces been his six months earlier, he could conceivably have broken through the British at el Alamein, taken Alexandria and Cairo, and made the Mediterranean an Axis lake. The forces were in the right place, and were the right ones to do the job, but the timing was wrong (28:7; 36:135).

Supporting Statement: We must protect logistics resources from theft, deterioration, or enemy action. Stolen assets or those that rot or fade away are of no use and cannot support the mission. Yet insuring physical preservation from the elements and security from thieves is much easier than achieving protection from the enemy. All he must do is *destroy* our stocks. We can protect our assets through dispersion (stock items in several places rather than in one place), hardening (store them in a bunker), or by movement (run them around in trucks or issue them to the troops). For example, in the British retreat from Kabul, Afghanistan in the nineteenth century, General Elphinstone failed to protect the British garrison's stores, failed to retake them after the Afghans occupied the warehouse, and was forced into a disastrous retreat during which over 10,000 soldiers, women and children died. He failed to protect his supplies (12:74).

Supporting Statement: We should base resource allocation between commands and among units on their missions and established priorities between missions.

As mentioned above, defeat of Germany in World War II was to come before that of Japan, and resources were allocated accordingly. We now use the Force Activity Designator (FAD) and Urgency of Need Designator (UND) system to set priorities within the Air Force.

Supporting Statement: Logistics resources must meet operational tasking. When possible, operations should be phased to permit continued logistics support and sustained mission accomplishment.

Generally, operations planners build their plans with logistics planners, and thus a mission is planned that can be logistically supported. Sometimes, however, it is crucial to do something that cannot be supported with available resources. Under these circumstances, logistics must support the mission as far as it can be supported, using every skill and trick known to get the resources needed.

In the North African campaigns, Rommel attacked several times with inadequate logistics support. He counted on capturing enemy supplies, and did so time and again. Improvisation can work when all else fails (46:14; 55:363).

Operations should be phased, when possible, to meet logistics constraints. The seizure of Red Ball Express gasoline by the U.S. armored divisions in northern France is a horrible example of how not to phase operations to meet supplies.

Supporting Statement: To ensure mission accomplishment within available resources, logistics procedures must prevent stockage imbalances, over or under procurements, or other wasteful practices.

According to the *Air Force Times*, each year for the past several years, the U.S. Congress has cut money from the DOD budget to force efficiencies to make up the difference. The investigations of the House Appropriations Committee Surveys and Investigations team and those of the General Accounting Office show that the Congress has reason to believe efficiencies are possible. Consequently, we in military logistics have an obligation to seek out waste and inefficiency and expunge it ourselves, or we will have others do it for us (21:153).

When Logistics Doctrinal Principles Should be Considered

DOCTRINE: PRINCIPLES THAT APPLY	OBJECTIVE: SUPPORT THE MISSION.											
	READY				READINESS: KEEP THE FORCE READY.							
	SUSTAIN				SUSTAINABILITY: SUSTAIN MISSION UNTIL COMPLETE.							
	FLEXIBLE				FLEXIBILITY: SUPPORT THE FORCE UNDER ALL CONDITIONS.							
	SYSTEM INTEGRITY: LOGISTICS IS A DYNAMIC, INTERRELATED, TOTAL FORCE.											
	VISIBLE				VISIBLE				VISIBILITY: MONITOR TROUBLE POINTS CLOSELY.			
	ECONOMY: IF IT WILL DO THE JOB, DO IT THE CHEAPEST WAY POSSIBLE.											
							AVAILABILITY: GET THE RIGHT THING TO THE RIGHT PLACE AT THE RIGHT TIME.					
	SIMPLICITY: LOGISTICS SYSTEMS AND PROCEDURES SHOULD BE EASY TO UNDERSTAND AND TO OPERATE.											
	USE PHASES: FLY AND FIGHT											
PREDEPLOYMENT												
DEPLOYMENT												
LOGISTICS TASKS												
	EMPLOYMENT											

Figure 1.

Principle: SIMPLICITY

Logistics systems and procedures should be easy to understand and to operate

People using complex systems can get confused under stress. During the German invasion of Norway in 1940, some Norwegians were caught while trying to draw their weapons from central armories. The procedures for wartime issue were the same as they were for peacetime maneuvers, and the supply clerks weren't about to streamline them. These particular troops were rapidly overcome (45:12; 64:78).

Supporting Statement: Logistics management systems should highlight actual and potential problems. Areas that are not potential problems should not demand management attention.

Trend analysis, various simulations, and training exercises should point out areas where the unit needs more work to overcome deficiencies. Management should correct these deficiencies and watch other indicators to ensure nothing else fails while concentrating on the already-identified problems. This is sometimes called "management by exception".

Supporting Statement: New equipment and systems should use standardized parts, modules, and support equipment, and should be easily transported, sited, maintained, and recovered. This can reduce spare parts, support equipment, and maintenance requirements.

One reason the F-16 was chosen over its competitor was it used the engine built for the F-15. This is expected to ease maintenance, training, and equipment requirements and improve logistics effectiveness. Micro computers hold great promise to bring the Univac 1050-II-type supply support to remote units.

Supporting Statement: We should build logistics management systems incrementally with sufficient

time in the schedule for thorough training and understanding. Large systems should not be developed so the entire system must be implemented at one time. The overall system should be well-defined so that each added subsystem can be properly integrated to achieve the designed goal.

On the 1960s there was a master plan in the Air Force Logistics Command to build an Advanced Logistics System (ALS). Its purpose was to replace the equipment and procedures then used to perform wholesale logistics functions, and was to be all-encompassing compared to the old system. Unfortunately, the ALS did not work as planned, could not keep to schedule or cost, and was finally terminated by the Congress (62:1).

Supporting Statement: Air Force weapon systems should use advanced technology to ensure ours are equal or superior to those of potential enemies. By using modular construction and remove-and-replace maintenance concepts, we can simplify support procedures for these advanced systems, and reduce technical training requirements.

Many systems are so complex that we cannot afford to have the skills and equipment to repair them at base level. Consequently, we build these complex systems in boxes that can be removed and replaced by lesser skilled individuals. Then the boxes are sent to depot or to a contractor where the required skills and equipment are available.

Supporting Statement: System configuration stability ensures support for less cost.

Whenever a production item is changed, specifications change, technical data changes, training changes, and flightline maintenance changes. If we can stabilize design; then all other things will also stabilize and our job is easier. Since some change is necessary, we must make its implications clear to the decision maker, then do the job.

The purpose of this paper was to develop a "target" logistics doctrine for the Air Staff to dissect, change, add to, etc., to finally create a document that puts our basic beliefs out for all to see and use. The premise was that there were rules of thumb already in use, lessons derived from history, relevant experiences in members of the ACSC Class of '79, and other research that could all be reduced and codified into a relatively few principles or rules.

Some people may think there are too many examples from World War II or before, and that more recent examples would better serve the purposes. The author does not think so; World War II probably saw armies and air forces under more varied conditions than any other war in history, and if a particular instance served to illustrate the point, it was used. Recent history, while furnishing some excellent material, has not approached the breadth and depth of former operations and thus does not always serve our purpose.

Many of the principles seem contradictory and many of the supporting statements could fit under one principle as well as another. On the first point, the principles are contradictory; the art of logisticians is to balance these competing principles and still support the mission. On the second point, many supporting statements do support several principles and thus should be repeated to support the particular point being made.

THE APPLICATION

The final proof of any doctrine is in its application. Figure 1 shows how each logistics principle "fits" into various logistics tasks and with Air Force weapon system use phases. The intent here is to show where the principles should be considered by commanders, project managers, logisticians, and other decision makers. Perhaps the reader could expand the principles to areas not covered in this

rather primitive model, or even expand the model to cover such things as logistics characteristics (mobility, capital investment versus expendables, etc.). The point is that the principles should be considered in every major decision, and a logistics doctrine can lay them all out for everyone to see, discuss, and use them.

In sum, this article can serve as a target for discussion and change, and can get us on the path to an up-to-date logistics doctrine. As the philosopher Santayana said more than a hundred years ago, those who do not learn from history are doomed to repeat it. We've already paid for the lessons outlined in this paper; let's not pay the price again.

REFERENCES

- (1) Air Force Manual 1-1, *United States Air Force Basic Doctrine*. Washington: Department of the Air Force, 14 February 1979.
- (2) Air Force Manual 400-2, *Air Force Logistics Doctrine*. Washington: Department of the Air Force, 1 November 1968.
- (3) Aronowsky, A.J., et al. *A Study for the Development of an Air Force Logistics Doctrine*. Air Force Institute of Technology, School of Systems and Logistics, SLSR-46-67. Air University, Wright Patterson Air Force Base, OH, August, 1967.
- (4) Barker, A. J., *Yamashita*. New York: Ballantine Books, Inc., 1973.
- (5) Blank, Major General Jonas L. "The Impact of Logistics Upon Strategy". *Air University Review*, March-April 1973, appearing in *ACSC Readings and Seminars*, Vol. 7, Air Command and Staff College, Air University, Maxwell Air Force Base, AL, December 1978.
- (6) "Blitzkrieg", *History of the Second World War*, Part 1. New York: Marshall Cavendish USA Ltd, 1973.
- (7) Blumenson, Martin. *Eisenhower*. New York: Ballantine Books, Inc., 1972.
- (8) Calvert, Micheal. *Slim*. New York: Ballantine Books, Inc., 1973.
- (9) Chambers, Frank P. *This Age of Conflict*. New York: Harcourt, Brace & World, Inc., 1962.
- (10) "Conquest of Norway", *History of the Second World War*, Part 4. New York: Marshall Cavendish USA Ltd, 1973.
- (11) Department of Defense Directive 4100.35-G. *Integrated Logistics Support Planning Guide for DOD Systems and Equipment*. Washington: Department of Defense, October 15, 1968.
- (12) Dixon, Norman F. *On the Psychology of Military Incompetence*. New York: Basic Books, Inc., 1976.
- (13) "Duels with the Afrika Korps", *History of the Second World War*, Part 20. New York: Marshall Cavendish USA Ltd, 1973.
- (14) Eccles, Henry C. *Logistics in the National Defense*. Harrisburg, PA: The Stackpole Company, 1959.
- (15) Ellis, Lieutenant Colonel Alvin C., U.S. Army. *The Weak Link in Strategic Mobility*. Air War College Professional Study No. 5814, Air University, Maxwell Air Force Base, AL, April 1975, as appearing in *Air War College Associate Programs Vol. II, Chapter 2, Mobility Forces*, August 1975.
- (16) Fabyanic, Lieutenant Colonel Thomas A. USAF. *Strategic Air Attack in the United States Air Force: A Case Study*, appearing in *ACSC Readings and Seminars*, Vol. 11, Air University (ATC), Maxwell Air Force Base, AL, February 1979.
- (17) Farrar-Hockley, A. H. *Student*. New York: Ballantine Books, Inc., 1973.
- (18) Goldberg, Eric. "Descent on Crete". *Strategy & Tactics*, Nr. 66, January/February 1978.
- (19) Grove, Eric. *Russian Armor 1941-1943*. London: Almark Publishing Co., Ltd, 1976.
- (20) Hessel, Brad E. and Simonsen, Redmond A. "Cobra: Patton's 1944 Summer Offensive". *Strategy & Tactics*, Nr. 65, November/December 1977.
- (21) "Hill Panel Charges Supply 'Rip-off' ". *The Air Force Times*, August 14, 1978, appearing in *ACSC Readings and Seminars*, Vol. 7, Air University (ATC), Maxwell Air Force Base, AL, December 1978.
- (22) Holley, Major General Doctor I. E., Jr. *Doctrine: Theory and Process*. Lecture given at the Air Command and Staff College, Maxwell Air Force Base, AL, 31 January 1979 (with permission).
- (23) Horton, D. C. *New Georgia: Pattern for Victory*. New York: Ballantine Books, Inc., 1971.
- (24) "How Crete Was Lost", *History of the Second World War* Part 18. New York: Marshall Cavendish USA Ltd, 1973.
- (25) Hutchinson, Lieutenant Colonel D.L., USAF. "A New Look at an Old Problem". *Air University Review*, Vol. XXX, No. 2, January/February 1979.
- (26) Janowitz, Morris. *The Professional Soldier*. Glencoe: The Free Press, 1961.
- (27) *Joint Memorandum of Agreement on Basic Principles of Logistics*. Alexandria, VA: U.S. Army Materiel Command, Dec. 1967.
- (28) Jones, Vincent. *Operation Torch*. New York: Ballantine Books, Inc., 1972.
- (29) Jukes, Geoffrey. "The Panzer Problem". *The Tank Story*. New York: Marshall Cavendish USA Ltd, 1973.
- (30) Keegan, John. *Rundstedt*. New York: Ballantine Books, Inc., 1974.
- (31) Kershaw, Andrew, editor. *The Tank Story*. Bristol, U. K.: C. J. Mason & Sons Ltd, 1973.
- (32) Kosnett, Phil. "Highway to the Reich". *Strategy & Tactics*, Nr. 61, March/April 1977.
- (33) Lazarides, Margaret. "Time of Triviality". *History of the Second World War*, Part 3. New York: Marshall Cavendish USA Ltd, 1973.
- (34) Macksey, Major K. J., M. C., *Panzer Division: The Mailed Fist*. New York: Ballantine Books, Inc., 1968.
- (35) Macksey, Kenneth. *Guderian: Creator of the Blitzkrieg*. New York: Stein and Day 1976.
- (36) Macksey, Kenneth. *Kesselring: The Making of the Luftwaffe*. New York: David McKay Company, Inc., 1978.
- (37) Manvell, Roger. *Goring*. New York: Ballantine Books, Inc., 1968.
- (38) Mason, David. *Breakout: Drive to the Seine*. New York: Ballantine Books, Inc., 1968.
- (39) Mayer, Major Richard, USAF, Strategic Systems Liaison Officer, Secretary of the Air Force Directorate of Legislative Liaison, Pentagon, Washington, D.C. Personal interview on 22 February 1979.
- (40) Mayer, Sydney L. *MacArthur*. New York: Ballantine Books, Inc., 1971.
- (41) McCoy, Gene. "Operation Barbarossa". *Wargamer's Digest*, Vol. 5, No. 1, November 1977.
- (42) McCoy, Gene. "Wargamer's Digest Goes to the Eastern Front". *Wargamer's Digest*, Vol 4, No. 12, October, 1977.
- (43) Messenger, Charles. *The Blitzkrieg Story*. New York: Charles Scribner's Sons, 1976.
- (44) Mommyer, General William M., USAF. *Air Power in Three Wars*. Washington: Department of the Air Force, 1978.
- (45) *Narvik*. Normal, IL: Game Designer's Workshop, 1974.
- (46) Nofi, Albert A. "Panzerarmee Afrika". *Strategy & Tactics*, Nr. 40, September/October 1973.
- (47) "Operation Barbarossa", *History of the Second World War* Part 21. New York: Marshall Cavendish USA Ltd, 1973.
- (48) Orgill, Douglas. *German Armor*. New York: Ballantine Books, Inc., 1974.
- (49) Patrick, Stephen B. "War in the East", *Strategy & Tactics*, Nr. 41, November/December 1973.
- (50) Poe, General Bryce II, USAF. "Getting Weapons That Do the Job". Extracted from *Supplement to Air Force Policy Letter for Commanders*, June 1977. Appearing in *ACSC Readings and Seminars*, Vol. 7, Air University (ATC), Maxwell Air Force Base, AL, December 1978.
- (51) Price, Alfred. *Luftwaffe*. New York: Ballantine Books, Inc., 1969.
- (52) "Report Reveals Bomb Shortages", *Air Force Times*. Vol. 31, No. 14 E (Nov. 11, 1970), p. 10.
- (53) Rice, E. E. *The Foundation of Basic Logistics Principles and Quasi-laws*. Air War College Report No. 2874, Air University, Maxwell Air Force Base, AL, April 1965.
- (54) Rider, Graham W. "Logistics—The Bridge". *Air University Review*, Vol. XIX, No. 2, March-April 1968.
- (55) "Rommel: The Desert Fox", *History of the Second World War*, Part 13. New York: Marshall Cavendish USAF Ltd, 1973.
- (56) Rooney, D. D. *Stilwell*. New York: Ballantine Books, Inc., 1971.
- (57) Ropp, Theodore. *War in the Modern World*. New York: Collier Books, 1962.
- (58) "Russia Blunts the Blitzkrieg", *History of the Second World War*, Part 23, New York: Marshall Cavendish USA Ltd, 1973.
- (59) Sibley, Roger, and Fry, Micheal. *Rommel*. New York: Ballantine Books, Inc., 1974.
- (60) Schlitz, William P. "Military Airlift Command: The Prime Mover". *Air Force Magazine*, Vol. 62, Nr. 2 (February 1979).
- (61) Slocum, Major General Henry W., U.S. Volunteers. "Sherman's March from Savannah to Bentonville". *The Century Magazine*, appearing in *The Way to Appomattox*, Battles and Leaders of the Civil War. New York: Thomas Yoseloff, Inc., 1956.
- (62) *Special Hearing*. Department of Defense. Department of Defense Appropriations for Fiscal Year 1978. Tuesday, May 18, 1977. Washington: GPO, 1977.
- (63) Speer, Albert. *Inside the Third Reich*. New York: The Macmillan Company, 1970.
- (64) "The Germans Strike North", *History of the Second World War*, Part 3, New York: Marshall Cavendish USA Ltd, 1973.
- (65) *The United States Strategic Bombing Survey Summary Report*, from *Development of Air Power* U.S. Military Academy, West Point, NY as appearing in *ACSC Readings and Seminars*, Vol. 12, Air Command and Staff College, Air University (ATC), Maxwell Air Force Base, AL, January 1979.
- (66) Thompson, R. W. *Montgomery*. New York: Ballantine Books, Inc., 1974.
- (67) "Transportation", *Project Corona Harvest* Department of the Air Force, 1968.
- (68) Tremain, Rose. *Stalin*. New York: Ballantine Books, Inc., 1975.
- (69) *Webster's New World Dictionary*. New York: Ballantine Books, Inc., 1975.
- (70) Whiting, Charles. *Patton*. New York: Ballantine Books, Inc., 1970.

(This article was adapted from Air Command and Staff College research report 0810-79, by the author.)



CURRENT RESEARCH

AIR FORCE LOGISTICS COMMAND LOGISTICS RESEARCH PROGRAM FOR FY80

In Air Force Logistics Command, the Directorate of Management Sciences (XRS), Deputy Chief of Staff Plans and Programs, is responsible for developing, managing, and executing the command's logistics research program. Traditionally, logistics research is divided into two major areas: the engineering sciences and the management sciences. The principal focus of XRS is on the management sciences; AFLC requirements for research in the engineering sciences are developed at functional levels within the command and channeled to Air Force Systems Command laboratories by the Acquisition Logistics Division and the Productivity, Reliability, Availability, Maintainability Office, a joint-AFSC/AFLC organization.

The FY80 program has been structured around three major tasks. The first task is to improve the mathematical models used to forecast demands for logistics goods and services in both peace and war environments. Sub-tasks have been developed relating to demand modeling, war readiness material computation techniques, and demand/financial forecasting methods. The second task is to develop models and simulations in support of command initiatives in jet engine management. Sub-tasks involve examinations of modular engine maintenance policies and engine fleet forecasting models. The third task for FY80 is to provide consultative services to the AFLC staff in operations research, mathematics, and modeling and simulation. This customer service task is centered in eleven major areas involving on-going or proposed staff actions. A sub-task is to assess the potential for applying research done outside the command to contemporary or future AFLC initiatives.

The FY80 program consists of both organic and contract studies. Selected on-going and planned studies for FY80 in each area are addressed below. Additional organic and contract projects are under consideration at this time. Requirements for consultative services in areas other than those listed will be undertaken as AFLC staff needs dictate.

SELECTED STUDIES

TITLE: Preliminary Study of Failure Models

OBJECTIVE: The current model used for predicting the failures for aircraft investment items assumes failures are directly proportional to flying hours. A number of studies have suggested that as the average length of sortie increases, the failure rate decreases. In order to test this hypothesis, operational and maintenance data have been collected for the C-5 and C-141. The data has been segregated by tail number into periods at least six months with relatively short sortie

lengths and similar periods with relatively long sortie lengths. Failure models are fit to the short sortie length data and then used to predict the number of failures in the long sortie length periods. These predictions are compared to the actual number of failures to determine model accuracy.
LEAD ANALYST: Mr Henry Triwush and Maj Don Pederson (AUTOVON: 787-4239)

TITLE: FASTSITE

OBJECTIVE: The Force Allocation Simulation Technique for Spares Investments and TRC Estimates (FASTSITE) is a quick reaction "what if" simulation that

measures, by weapon system, the impact of changes in requirements factors on repair and procurement dollar requirements for replenishment spare investment items. Developed primarily to answer the kinds of questions that arise during the Program Objective Memorandum (POM) exercise, FASTSITE can also be used to facilitate the computation of the resources required to support a war.

LEAD ANALYST: Mr John Hill (AUTOVON: 787-4239)

TITLE: An Examination of Aircraft Availability

OBJECTIVE: The Logistics Management Institute (LMI) has developed an analytic model for the world-wide expected number of aircraft grounded due to parts shortages as a function of individual item stock levels. The model takes into account the indenture relationship between line replaceable units (LRU's) and shop replaceable units (SRU's), that is, backorders for SRU's are important only because they affect LRU backorders. AFLC is currently investigating applications of the LMI model. Use of the model will permit AFLC to support budget requests with aircraft availability figures resulting from that request. The model can also be used to determine the best mix of items to buy. Thus, if one aircraft has an unacceptably low availability rate, funds can be transferred to items on that aircraft from other aircraft programs.

LEAD ANALYST: Mr Armin Rubbert (AUTOVON: 787-4406)

TITLE: An Investigation of War Readiness Material (WRM) Requirements Techniques

OBJECTIVE: The current WRM algorithms attempt to minimize

the expected number of aircraft grounded at a base due to supply shortages. Another model has been proposed that attempts to minimize the probability of having more than a specified number of aircraft grounded at a base due to supply shortages. The second model has certain mathematical advantages (e.g., the objective function is separable and hence an optimal solution is possible; computer running time is shorter). The differences between the models will be investigated. For a fixed spending level, the day to day availability of aircraft is simulated as a function of the stock levels generated by each approach.

LEAD ANALYST: Capt Tim Bridges (AUTOVON: 787-4239)

TITLE: Engine Maintenance and Build Policy

OBJECTIVE: Formulate optimal policies for modular jet engine maintenance management. These policies prescribe when to replace life-limited parts so as to minimize long run logistics costs, and when to send whole engines instead of individual modules to the depot for repair. Develop simulation/mathematical models to evaluate alternative opportunistic maintenance policies and decision rules. The models are also used to calculate removal rates for input to engine requirements computations used in MOD METRIC and other marginal analysis models. (Recent work in this area is featured elsewhere in this issue of the AFJL.)

LEAD ANALYST: Mr. John Madden, Phil Persensky, and Ms Virginia Williamson (AUTOVON: 787-7408)

TITLE: Analysis and Engine Spares Requirements

Continued next page

OBJECTIVE: Evaluate engine and module spares for peacetime/wartime sufficiency for F100/F-15, F-16 and TF39/C-5A engines. Develop appropriate spares-flow and operations simulation models for use in making readiness assessments at base level and for assessing the validity and accuracy of worldwide engine and module spares requirements calculated by alternative methods. Assess short term impacts of proposed changes in maintenance and sparing policies on engine availability and readiness.

LEAD ANALYST: Mr Harold Hixson (AUTOVON: 787-6531)

TITLE: Other Logistics Systems
OBJECTIVE: Evaluate non-Air Force logistics systems in terms of classical logistics functions and unique policies and procedures.

LEAD ANALYSTS: Mr Don Casey and Mr Newton Foster (AUTOVON: 787-7408)

TITLE: Maintenance Direct Labor New Hire Effectiveness

OBJECTIVE: Formulate a quantitative estimate for the effectiveness of new direct labor hires at Air Logistics Centers. A programming assumption based on an earlier study states that new maintenance direct labor comes on board at

46% effectiveness and learns at an exponential rate. An update is necessary to determine the estimated effectiveness of new hires expected in a contingency build-up of depot maintenance.
LEAD ANALYST: Mr Herbert Walter (AUTOVON: 787-6531)

CONSULTATIVE SERVICE AREAS

Readiness Initiatives.
Marginal Analysis Model Enhancements (D028).
Variable Safety Level Model Enhancements.
Requirements Computation Services (D041).
Aircraft Battle Damage Repair.
Sortie Surge Exercises.
Long-Range Planning Initiatives.
Dynamic Resource Requirements Analysis.
Computer Graphics.
GPSS, FORTRAN, and SIMSCRIPT Modeling.
Engine Health Monitoring Systems.

SELECTED CONTRACT STUDIES

TITLE: Enhancement of Engine Pipeline System
OBJECTIVE: Adapt selected theoretical concepts to the development and validation of engine pipeline factors and standards. Develop

standardized definitions, measurement techniques, pipeline data reporting procedures and methods, and working manuals.
MONITOR: Mr John Madden (AUTOVON: 787-7408)

TITLE: Embedded Computer Systems.

OBJECTIVE: Develop a long-range plan and implementing procedure for the management and maintenance of embedded computers.
MONITOR: Mr Don Casey (AUTOVON: 787-7408)

TITLE: War Readiness Spares Kit Model and Solution

OBJECTIVE: Develop a mathematical model and associated computation technique for War Readiness Spares Kit Stocks.
MONITOR: Capt Tim Bridges (AUTOVON: 787-4406)

TITLE: Inventory Management Policy for Economic Order Quantity Items

OBJECTIVE: Compare the current methods for computing EOQ item demand with selected theoretical inventory management concepts. Establish the cost-benefit of any proposed enhancements to current techniques.
MONITOR: Mr Vic Presutti (AUTOVON: 787-4406)

TITLE: Logistics Management System Study

OBJECTIVE: Develop recommendations and alternatives for a logistics information and management system for the 1985-1995 time frame.

MONITOR: Mary Oaks (AUTOVON: 787-4406)

TITLE: Aircraft Hardness Study

OBJECTIVE: Develop an electromagnetic pulse hardness maintenance program for selected aircraft.

MONITOR: Mary Oaks (AUTOVON: 787-4406)

The AFLC FY80 Logistics Research Program is structured to meld study efforts with the command's planning process and readiness initiatives. The approach has been to balance work on contemporary and longer range study requirements. In every useful research program, there must be room to develop band-aids as well as grand designs. All logisticians, whether in line or staff functions, recognize two imperatives: today's force must be supported while we search for better ways to support the Air Force of tomorrow.

Detailed descriptions of selected studies will be presented in forthcoming issues of *Air Force Journal of Logistics*.

Information for Contributors

General. The *Air Force Journal of Logistics* is dedicated to the open examination of all aspects of issues, problems, and ideas of concern to the Air Force logistics community. Constructive criticism of logistics as it exists today is encouraged if it is issue oriented, rationally expressed and indicates the positive action necessary for future improvement. Contributions are welcome from any source inside and outside the Air Force.

Scope. The *AFJL* will consider for publication articles and research results that add to the understanding or improvement of any aspect of Air Force logistics from maintenance, supply, transportation, and logistics plans, to engineering and services, munitions, and contracting and acquisition; from base-level and operational units to depot-level and military and civilian industrial and production logistics; from logistics civilian, enlisted and officer personnel and manpower requirements to training and education; from internal organizational structure, policies and procedures to external relations with other services, government agencies, civilian industry and allies; from daily mission support challenges to the logistics aspects of national security objectives and Air Force strategy, doctrine and tactics.

Special Interest. Articles are especially invited that:

- ☐ give the results of the application of sound analytical and research techniques to existing Air Force logistics operations;
- ☐ offer possible alternatives to current operations based on a logical assessment of today's posture and tomorrow's requirements;
- ☐ demonstrate the interrelation of various parts of Air Force logistics systems internally and with non-USAF systems;
- ☐ consider basic Air Force logistics functions and issues from an unusual perspective;
- ☐ focus on logistics and Air Force mission accomplishment;
- ☐ or, provide insight into the reasons for and impact of recent or future changes in Air Force logistics.

Original Material and Revisions. Submitted articles are received with the understanding that:

1. They have not been published nor are being considered for publication elsewhere. Articles based on research planned for publication *only* as an in-house report or in symposium proceedings are acceptable.
2. Those articles with multiple authors have been approved by all. The *AFJL* will work with the lead author in preparing the manuscript for publication with the

understanding that any approved changes are acceptable to all.

3. To the greatest extent possible, necessary revisions in the manuscript will be coordinated with the author.

Length. In general, manuscripts should be between 2000-3500 words. Shorter and longer papers may be published on an exceptional basis. Formal research papers should briefly recognize the most significant research accomplished in the area of investigation and the relation of that research to the work addressed in the paper. A 50-75 word abstract should accompany each manuscript.

Format. Manuscripts should be typed with one inch margins, double-spaced on one side of standard size bond paper. References should be numbered and double-spaced on a separate page(s) at the end of the manuscript. The double number system for identifying references within the article should be used, i.e., (7:15), with the first number identifying the number of the source in the reference list and the second number indicating the specific page number in that source. When possible, potential textual footnote material should be incorporated in the main body of the article. Do not include a separate bibliography.

Figures and Tables. Supporting figures, if any, should be numbered consecutively and prepared on separate pages, one to a page. The text should clearly indicate where each figure is to appear. Tables should be numbered consecutively and be prepared within the appropriate text of the manuscript.

Awards. Published articles are eligible to compete for the Most Significant Article Award in each issue. The quarterly award winners will compete for the annual award from the *AFJL*. Selection is made by the members of the *AFJL*'s Editorial Advisory Board. Articles published by the Editorial staff, Contributing Editors, and Editorial Advisory Board are ineligible for the awards.

Reprints. Permission for schools and other publications to reprint material appearing in the *AFJL* will usually be granted, if requested.

Address. All correspondence and manuscripts should be sent to:

Air Force Journal of Logistics
AFLMC
Gunter AFS, Alabama 36114

Telephone: AUTOVON 921-4086/7

Commercial: (205) 279-4086

***"Is Logistics simply a science of detail? Or, on the contrary,
is it a general science, forming one of the most essential
parts of the art of war?"***

(Jomini, The Art of War, 1838)

AIR FORCE JOURNAL OF LOGISTICS
Air Force Logistics Management Center
Gunter AFS, Alabama 36114
