4-21-1976

Methods Of Cost Effective Utilization Of R & D Test Facilities

Joe E. Coulter

THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO 87106

Policy on Use of Theses and Dissertations

Unpublished theses and dissertations accepted for master's and doctor's degrees and deposited in the University of New Mexico Library are open to the public for inspection and reference work. *They are to be used only with due regard to the rights of the authors.* The work of other authors should always be given full credit. Avoid quoting in amounts, over and beyond scholarly needs, such as might impair or destroy the property rights and financial benefits of another author.

To afford reasonable safeguards to authors, and consistent with the above principles, anyone quoting from theses and dissertations must observe the following conditions:

1. Direct quotations during the first two years after completion may be made only with the written permission of the author.

2. After a lapse of two years, theses and dissertations may be quoted without specific prior permission in works of original scholarship provided appropriate credit is given in the case of each quotation.

3. Quotations that are complete units in themselves (e.g., complete chapters or sections) in whatever form they may be reproduced and quotations of whatever length presented as primary material for their own sake (as in anthologies or books of readings) ALWAYS require consent of the authors.

4. The quoting author is responsible for determining "fair use" of material he uses.

This thesis/dissertation by Joe E. Coulter has been used by the following persons whose signatures attest their acceptance of the above conditions. (A library which borrows this thesis/dissertation for use by its patrons is expected to secure the signature of each user.)

NAME AND ADDRESS	DATE

10/73—1M
L-133

This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of The University of New Mexico in partial fulfillment of the requirements for the degree of

MASTER OF ARTS IN PUBLIC ADMINISTRATION

Methods of Cost Effective Utilization of R&D Test Facilities

Title

Joe E. Coulter

Candidate

Division of Public Administration

Department

Dean

April 21, 1976

Date

Committee

Chairman

METHODS OF COST EFFECTIVE UTILIZATION OF R&D TEST FACILITIES

BY
JOE E. COULTER
B.S., Arlington State College, 1962

THESIS

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Arts in Public Administration

in the Graduate School of
The University of New Mexico
Albuquerque, New Mexico

May, 1976

ACKNOWLEDGEMENTS

I am indebted to the United States Air Force for the opportunity to participate in the University of New Mexico Fellowship Program in Public Science Policy and Administration.

I extend special appreciation to Dr. Albert H. Rosenthal, Director of The Program for Advanced Study in Public Science Policy and Administration, Dr. Leonard Stitelman and Mr. V. V. Berniklau for their expert advice, counsel and encouragement in writing this manuscript.

Assistance and suggestions were provided by so many people at the Central Inertial Guidance Test Facility, and indeed throughout the guidance industry, that individual recognition is impractical. However, Dr. Martin J. Jaenke, Mr. P. V. Zagone, Mr. R. P. Jones and Mr. Gerald Ray Mozer were especially helpful.

And perhaps most important is the gratitude I owe my wife, Johnnie, for taking over so completely on the home front in managing all those things that go hand-in-hand with "kids in school," "faulty hot water heaters," "feeding out and getting the steer butchered" and the like, during my academic year of freedom away from my family.

METHODS OF COST EFFECTIVE UTILIZATION
OF R&D TEST FACILITIES

BY
Joe E. Coulter

ABSTRACT OF THESIS

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Arts in Public Administration
in the Graduate School of
The University of New Mexico
Albuquerque, New Mexico
May, 1976

ABSTRACT

The Department of Defense budget request for fiscal year 1976 included $9.61 billion for research development, test and evaluation required in the acquisition of new improved highly complex weapon systems. Defining the multiple and varied development test needs and matching those needs to existing test capabilities, and/or designing and developing required new test capabilities to meet these advancing requirements continue to be an extremely difficult and expensive task. This thesis postulates that more effective communication between responsible weapons developers and government test agencies can lead to a significant reduction in the overall weapon systems development cost. Furthermore, the thesis proposes that a marketing concept which emphasizes customer needs can be employed by test agencies to effect an information exchange system that enhances communication with the weapon developers.

Chapter I discusses some problems common to all government research and development test centers, formulates a hypothesis from those problems and describes the methodology used in the research study. Chapter II describes a typical research and development test center, The Central Inertial Guidance Test Facility. Chapter III defines the modern

marketing concept and discusses the application of that concept to government test agencies. Chapter IV documents the need for development testing early in the weapon systems acquisition cycle and suggests new management concepts that can lead to significant cost savings. Chapter V, summary in nature, develops a cost of marketing in the private sector for comparison with the cost of implementing the marketing function in government test agencies. These costs are compared with the potential benefits that can result from marketing, and the findings are applied to the hypothesis.

The results of this study show the cost of marketing to be less than one percent of the operating budget for the Air Force test agencies investigated. Thus the cost of marketing in government test agencies is insignificant when compared to the potential savings that can result from less duplication, more productive utilization of test resources and more effective developmental testing early in the development cycle.

If a research and development test center seriously implements a marketing program as defined by Dr. Philip Kotler's Marketing for Nonprofit Organizations and established based on the concepts advocated by C. West Churchman's Systems Approach, more effective communication between the test center and its publics is sure to follow. More

effective communication between test centers and weapon systems development offices can lead to earlier and better planning for both parties. Better planning can result in the avoidance of a large measure of costly duplication, in reduced workload instability at test centers, and in effective development testing for significantly more cases than is presently occurring. This ultimately can foster a lower cost for weapon systems development.

CONTENTS

CONTENTS

CHAPTER I

PROBLEM SCOPE AND APPROACH

Today with pressure of priorities and concern with inflation, National Defense budget requests for new weapon systems development are being closely scrutinized and for the most part not fully funded. Thus the nation has entered an era in National Defense for which a dollar's worth of output from a dollar's worth of input becomes a necessity. Consequently, the topic of this research is concerned with an investigation of the applicability of modern marketing[1] to Research and Development (R&D) test centers on the premise that better utility of these facilities could lead to reduced weapon system procurement cost.

Purpose of Study

The Department of Defense (DOD) budget request for fiscal year 1976 included $9.61 billion for research development, test and evaluation.[2] These funds, justified by the 1976 strategic program, are intended to enable DOD to:

> Continue engineering development of the B-1 strategic bomber and begin full scale production in 1977 if performance goals in relation to costs are achieved;

> Proceed with the Trident submarine system to be deployed in 1979 and design a lower cost alternative to the Trident;
>
> Develop options for future deployment of improved intercontinental ballistic missiles that could be launched from fixed silos or mobile launchers;
>
> Continue development of ballistic missile warhead accuracy improvements and long range cruise missiles;
>
> Maintain technology for ballistic missile defense systems and improve the capability for surveillance and early warning of nuclear attack;
>
> Improve the command, control and communication of the strategic forces.[3]

Each of the areas listed above will require substantial development test activity. The magnitude of the problem of defining these multiple and varied development test needs, and of matching those needs to existing test capabilities is, to say the least, immense. An ample amount of the high cost incurred in the weapon systems procurement process could be avoided if more effective communication could be implemented in matching needs with capabilities.

The purpose of this research then is to determine if R&D test centers by implementing modern marketing techniques that emphasize "clients-for-service instead of customers-for-profit"[4] can reduce overall weapon systems procurement cost. That is, can a relationship be established between the test agencies and their customers, the weapons developers, that encourages effective communication.

Problem Analysis

Much work has been done within the DOD to develop effective management principles, and managers, for insuring that the nation's defense objectives are met. These objectives dictate ". . .steady and unfailing advances in technology to overcome obvious, near-term deficiencies and to support developments to meet the foreseeable needs of the future."[5] Defense needs are never static; they are dynamic to say the least, changing not only as technology changes, but also as a result of world events and our own internal policy changes. As a result of these continual changes, weapons development managers must be ever persistent and alert in their efforts to remain objective. They must be particularly careful in their selection of basic avenues and approaches in the Research and Development (R&D) sector for it is the development test phase that is perhaps the most critical step in procuring weapon systems that meet their stated objectives. Thus information exchanges between test agencies and users becomes all important if rational decisions are to be made.

There are approximately 150 laboratories and test centers within the DOD in addition to about 350 nonprofit scientific advisory organizations, 300 university research centers, around 1400 industrial enterprises, and a large number of private foundations and scientific committees

which compete for substantial portions of the DOD R&D budget. The DOD inhouse installations usually account for about twenty-five percent of all R&D expenditures and in a large number of situations they are very competitive among themselves.[6] It is not unusual for test centers within the same branch of service and even within the same command to compete vigorously for major roles in the development of new weapon systems. Consequently, duplication of test facilities and capabilities has occurred. This is not meant to imply that all duplication is bad. There are cases where duplication is absolutely mandatory. Many R&D organizations have small and scattered units which support overall agency missions in varied manners. There are also numerous units that perform some R&D function as an incident to their primary responsibilities.[7]

With this vast segment of R&D units it becomes almost imperative to establish some reasonable and effective means for allocating scarce R&D funds. These resources must be distributed so that test requirements can be adequately achieved while at the same time wasteful and unnecessary duplication is avoided. Private industry and, indeed, some government agencies have used marketing principles and techniques in successfully confronting problems of this nature.[8]

Workload instability can pose a very serious problem among R&D test centers. Salaries of highly technical

people create sizeable test center expense outlays, especially when the people are not being fully used; and possibly more important, highly motivated and talented people are hard to retain when the workload is low and they do not have challenging assignments. Thus maintaining a satisfactory level of test expertise in order to meet development test needs in a timely manner becomes very difficult.[9] This same type of problem appears to be somewhat alleviated in the private sector by effective marketing.

A third major problem that plagues weapon system developers and test agencies alike is the difficulty of obtaining timely and sufficient test results for meeting development test objectives. Failures in this area have generally led to very expensive operational testing that in reality turned out to be unplanned developmental testing. In many instances these problems could probably have been eliminated or significantly curtailed had there been effective communication between the test conductor and the test customer.

The fourth, and possibly the most significant area of concern, and the most expensive, occurs when development testing either fails to meet its test objectives or test results are not adequately communicated to the weapon system procurement manager. Problems resulting from these sources do not appear to be uncommon. Southeast Asia gives some credulity to the existence of problems of this type.

Also related to inadequate testing is the fact that numerous weapon systems have ended up in government inventories that were never subjected to rigorous preproduction engineering development tests. Instead they were in many cases subjected to quasi-operational testing with limited instrumentation in order to meet higher headquarters directed time constraints.[10] This has resulted in the production of weapon systems that do not always meet specified goals. Problems of this type have forced maintenance and logistic commands into the role of corrective engineering development testing in order to modify the production run on stockpiled weapons. This is certainly a most expensive way to achieve an operational weapon system.

Some weapon systems fail to receive proper development testing simply due to a lack of effective communication between the testing agencies and the potential test customers. One cause for this is the high turnover rate of staff personnel in the weapons development offices due to the nature of military assignments--job rotation every three or four years. Thus it is not unusual for the weapons developers to lack an adequate knowledge of government inhouse test capabilities. In cases such as these, as often as not weapon systems of this category go through the same expensive growing pains of being placed in production, recognized not to meet desired goals when subjected to combat conditions or real

world operational test, and then modified as a result of after-the-fact testing.

Theoretical Framework of Study

This research paper addresses Dr. Philip Kotler's theory of marketing as applied to nonprofit organizations as the theoretical framework for this study.[11] Kotler's theory is investigated for its utility as an information exchange mechanism for overcoming inadequate or ineffective communication between test agencies and weapons developers. Kotler's work is supplemented by J. Howard Westing's and Gerald Albaum's Modern Marketing Thought.[12] Their concept of marketing asserts foremost the recognition and satisfaction of customer needs. This enhances the idea of information exchange between the marketer and the customer. As such the concepts promoted by Westing and Albaum are particularly suited to marketing by public agencies. The communication in question specifically concerns the test and evaluation of weapon systems, subsystems, and/or components.

As defined by United States Air Force Regulations, there are two basic types of tests and evaluations--Development Test and Evaluation (DT and E) and Operational Test and Evaluation (OT and E). DT and E is conducted by the command responsible for the acquisition of the system and focuses on its technological and engineering aspects.

> Development Test and Evaluation is conducted to refine engineering design, measure progress and verify accomplishment of the development objectives. The analysis of resulting data is used to verify the performance characteristics, determine compliance with specifications, and secure the initial portion of operational suitability, and logistics supportability data for a system. Development Test and Evaluation functions will normally utilize models, prototypes, or preproduction systems/equipment test articles and will be designed to determine the extent to which the technical and operational requirements, as stated in the requirements documentation, have been met. Test data will be used to consider practical trade-offs between system capability, operational suitability, requirements, cost (including cost of ownership) and schedules.[13]

Operational Test and Evaluation is the responsibility of the command which will use the system in the field. OT and E focuses on the development of optimum tactics, techniques, and procedures for operational use.

This study is generally limited to those aspects of R&D testing found in a single area of expertise associated with weapon system development prior to the production decision. It is primarily concerned with the development test and evaluation of the guidance and navigation subsystems of aircraft and missile systems.

With the advent of the space age, guidance and navigation subsystem costs have on the average represented about forty percent of the total cost of missiles and space rockets.[14] Thus it is felt that even though the scope is constrained to one area of expertise, it is an area which

is truly representative and can be used as a predictor for total or integrated weapon systems development testing.

Detailed Statement of Problem

The basic problem to be addressed by this research has been formulated as follows: Can marketing by government test facilities decrease weapon systems development costs?

This problem statement was derived from the following incomplete list of significant and most pertinent questions which are presently of major importance to R&D test centers and their respective commands.

- Can marketing eliminate the duplication in R&D test centers? Or at least prevent further unnecessary duplication from occurring?
- Can marketing stabilize the workload of R&D test centers? That is, can marketing insure that available resources are used productively?
- Can marketing increase effective output while reducing resource expenditures? That is, can marketing help to insure timely and sufficient results for meeting development test objectives so as to preclude the very expensive operational testing from turning out to be unplanned development testing?
- And finally, can marketing by R&D test centers alleviate the very real problem associated with inadequate testing which has led in a significant number of cases to

procured weapon systems that failed the real test when subjected to live combat use?

Each of the problems stated lead to unwarranted costs in the process of weapon systems acquisition.

Hypothesis

The major hypothesis stated as follows was derived from the preceding problem descriptions:

> Marketing as a method of information exchange by test agencies can decrease weapon systems development costs.

The major hypothesis can be logically divided into the following minor hypotheses:

> Marketing can reduce further unnecessary duplication in government owned and operated test facilities.
>
> Marketing can help insure that R&D test resources are used productively.
>
> Marketing can help to insure timely and sufficient results for meeting development test objectives.
>
> Marketing can help to insure adequate engineering development testing prior to final production buy decisions.

Methodology

This research was accomplished using a literature search, personal interviews and a detailed review of a single test agency's test and evaluation project records.

The literature search and personal interviews were conducted in order to:

- Determine the formal organizational structure and mission of an R&D test center within the Air Force System's Command.
- Determine the marketing cost investment versus the potential return for private agencies that conduct test and evaluation programs as part of their weapons development contract.
- Determine how nonprofit organizations apply modern marketing principles to achieve their goals, and at what cost.
- Supplement findings resulting from the detailed test agency review and the personal interviews.

Personal interviews with managers of guidance and navigation system test specialists, and the specialists themselves, were conducted in conjunction with a review of representative test programs accomplished at a major guidance and navigation system/component test lab. The interviews and project review were directed towards:

- Determining the cost incurred for nonproductive use of people and facilities during periods of slack workload.
- Determining the cost incurred as a result of facilities duplication in specific easy-to-define and recognizable areas.
- Determining the cost incurred as a result of repeat testing for specific easy recognizable examples.
- Determining the cost of representative examples of "fixing" ineffective weapon systems that were brought into the inventory prematurely.[15]

These costs were then compared to the costs required to implement a complete marketing function tailored to the mission of the test agency under review.

This comparison yields adequate results as to the cost effectiveness of employing modern marketing techniques to R&D test centers within DOD.

Due to the sensitivity associated with the true cost of weapon systems development testing and to the time limitations for the conduct of this study, only one R&D test center was thoroughly investigated as pertains to the specific problems posed previously. A literature survey was accomplished, however, to support the results obtained from the test center review.

Authority to pursue this type of investigation within an Air Force test agency, the Central Inertial Guidance Test Facility at Holloman Air Force Base, was granted, subject only to appropriate security and Air Force policy restrictions.

Report Structure

Chapter II provides a detailed description of the DOD R&D test center selected for review of its project test records. The Central Inertial Guidance Test Facility (CIGTF) is a typical DOD R&D test center, similar in structure and organization to many other DOD "inhouse" laboratories.

Chapter III, titled "Marketing," defines the marketing function and relates it to nonprofit government agencies such as the CIGTF and other test centers within DOD.

Chapter IV, "Weapon Systems Developmental Test Cost," reports the results of the indepth investigation of the CIGTF's project records and the literature survey pertaining to the cost associated with duplication of facilities or capabilities, workload instability, and ineffective or inadequate testing. Cost benefit examples resulting from effective development testing are also presented. The chapter documents the need for more effective development testing and suggests that new management concepts such as Kotler's modern marketing theory should be implemented.

Chapter V, "Analysis and Conclusions," is summary in nature. The cost of marketing in the private sector at the CIGTF and for one other R&D test center is presented. This data is compared to the potential benefits to be derived from the marketing function. This result then is applied to the hypothesis and presented.

END NOTES

[1]Kotler's definition of marketing as used here is "The effective management by an organization of its exchange relations with its various markets and publics." Philip Kotler, Marketing for Nonprofit Organizations (Englewood Cliffs, New Jersey: Prentice-Hall, 1975), p. x.

[2]The Budget of the United States Government Fiscal Year 1976 (Washington, D.C.: U.S. Government Printing Office, 1975), p. 71.

[3]Ibid., pp. 73-74.

[4]Kotler, Marketing for Nonprofit Organizations, pp. 16-34.

[5]Ralph Sanders, ed., Defense Research and Development (Washington, D.C.: Industrial College of the Armed Forces, 1967), p. 5.

[6]Sanders, p. 19.

[7]Clarence H. Danhof, Government Contracting and Technology Change (Washington, D.C.: The Brookings Institute, 1968), p. 400.

[8]Kotler, pp. 281-430.

[9]Danhof, pp. 101-104.

[10]Sanders, p. 5.

[11]Kotler, p. 5.

[12]Gerald Albaum and J. Howard Westing, eds., Modern Marketing Thought, 3d edition (New York: Macmillan Publishing Co., Inc., 1975), pp. vii-viii.

[13]U.S. Air Force Regulation 80-14, Test and Evaluation, 12 May 1972.

[14]Robert C. Seamans, Jr., Secretary of the Air Force, "Air Force Policies in the Field of Guidance Testing," Keynote address at the Fifth Biennial Inertial Guidance Test Symposium, Holloman Air Force Base, New Mexico, 14 October 1970.

[15]The term "fixing" as used here means to identify and correct the problem or problems causing weapon systems that are already in the production phase to be ineffective.

CHAPTER II

AN AIR FORCE R&D TEST FACILITY

Introduction

As background information, this section of the paper defines the role of testing in weapon system development, provides the rationale for selecting the Central Inertial Guidance Test Facility (CIGTF) for a detailed project review and describes the CIGTF role in testing.

Role of Testing in Weapon System Development

Test and evaluation plays an important role throughout the development process. It involves looking at every part of a weapon system, all the way from the smallest component to an entire aircraft or missile. Test and evaluation does not stop at the production phase point but continues after the weapon system has been provided to the ultimate user. The use of test and evaluation is a major management tool in weapon system development. It provides a means of measuring the attainment of technical and performance goals and brings to light areas needing further improvement. Done properly, testing shows the manager where a greater or lesser concentration of resources is needed on his program.

Each military department has established its own specialized facilities to provide the needed test and evaluation capability. The major facilities in the Air Force include Air Force Eastern Test Range (AFETR), Arnold Engineering Development Center (AEDC), Air Force Special Weapons Center (AFSWC) (presently undergoing disestablishment), Air Force Flight Test Center (AFFTC), Space and Missile Test Center (SAMTEC), Armament Development and Test Center (ADTC), and the Tactical Fighter Weapon Center. These facilities perform the bulk of all Air Force testing, but a significant amount is also done by Army and Navy test centers.

The Central Inertial Guidance Test Facility is a part of the Air Force Special Weapons Center. However, as a result of the AFSWC closure, the CIGTF will become part of the Armament Development and Test Center (ADTC) and is presently undergoing that transition. This paper addresses the CIGTF as if it were still a part of the AFSWC structure. For the purposes of this study, a change in the headquarters command location and name has no bearing on the study results.

Reason for Selecting CIGTF

The CIGTF accomplishes test and evaluation functions which are concerned with what are normally the most expensive parts of weapon systems. Guidance and navigation systems

usually account for thirty to forty percent of total weapon system acquisition costs.[1] Thus the investigation of guidance and navigation subsystem test and evaluation programs should provide representative information that is applicable in a very broad sense to completely integrated weapon system test and evaluation, while allowing the scope of the investigation to be narrowed such that it becomes practical with respect to the time and resources available.

Other reasons which were influential in the selection of the CIGTF as the prime test center to be investigated evolved from the personal experience gained by the author during more than ten years of employment within the CIGTF as a test engineer associated with the rocket sled evaluation of guidance systems and components.

CIGTF Role in Testing

CIGTF was established to provide an Air Force capability to test and evaluate the products of the inertial navigation and guidance industry.[2] Goals of the CIGTF are:

- Unbiased evaluation of components and systems, to provide data from which the customer can select the optimum equipment for a given mission application.
- Development of a single centralized test facility, to avoid the prohibitive costs of duplicated facilities.

- Standardization of tests, to provide common yardsticks for comparative evaluations.
- Competence in both personnel and equipment, to insure meaningful evaluations.[3]

The CIGTF was originally established to provide test support for the development of early ballistic missile systems. It has since expanded its capability to cover the full spectrum of evaluation of navigation and guidance equipment. The development of advanced precision test facilities and the acquisition of a hard core of experienced personnel have produced an unequaled facility for the evaluation of missile, spacecraft, and aircraft systems and components. Consequently, there has been an increased emphasis on CIGTF's role as the national focal point for navigation system test and evaluation. Test programs are conducted for the three military services, National Aeronautics and Space Administration, Federal Aviation Administration, and private industry and foreign governments through government sponsorship.[4]

CIGTF Organizational Structure

The CIGTF is officially designated as the Guidance Test Division. It forms a major part of the 6585 Test Group. The primary components of the 6585 Test Group in addition to the CIGTF include the high speed test track, radar target scatter facility, and their necessary support

activities. The Test Group reports to the Air Force Special Weapons Center at Kirtland Air Force Base, New Mexico which in turn reports to the Air Force Systems Command at Andrews Air Force Base, Washington, D.C.

AFSWC Organization and Mission

The overall AFSWC mission as stated by AFSC Regulation 23-11 is:

> AFSWC is the lead test center for special weapons and support equipment testing, airborne missile test, nuclear testing air support, aerospace navigation and guidance system test, high-speed track test, radar target scatter test, and terminal guidance subsystem testing; operates the Central Inertial Guidance Test Facility, AFSC High-Speed Test Track, and Radar Target Scatter Site; supports the test and evaluation of selected aircraft reconnaissance systems and missile re-entry vehicles; provides target drone support for testing of selected weapon systems; provides DOD directed representation and support to White Sands Missile Range (WSMR); and provides the management for T&E Systems Development/ Acquisition as directed.[5]

AFSWC is directly responsible to Headquarters AFSC for mission accomplishment. Specifically, AFSWC:

a. Performs aircraft compatibility testing of advanced weapons and associated ground equipment, including laboratory testing and flight testing.

b. Performs development engineering and testing of parachutes and other retardation devices for special weapons development programs.

c. Performs test and evaluation of selected air-launched missiles.

d. Performs or supports test and evaluation of United States and foreign aircraft weapon systems and subsystems, missile weapon systems and subsystems, reconnaissance subsystems and countermeasures (aircraft defense).

e. Performs operations in support of AEC/DOD test programs.

f. Provides Air Force support to the National Nuclear Test Readiness Program by developing operational concepts and plans for air operations, maintaining and operating or arranging for primary air drop and diagnostic test aircraft, arranging for additional Air Force resources as required from other Air Force organizations, and providing the staff nucleus for Joint Task Group 8.4 for all nuclear test operations and training exercises.

g. Accomplishes tests and evaluations on United States and foreign systems, subsystems, and support equipment for nuclear safety and reliability.

h. Performs test and evaluation of aircraft navigation systems, including developmental testing and systems integration, and is the DDR&E-designated DOD focal point for aircraft inertial navigation test and evaluation.

i. Operates the High-Speed Test Track which conducts testing under controlled and instrumented dynamic simulations of flight conditions, and performs launches into a flight trajectory from track-borne test vehicles. The former includes acceleration, vibration, rain and dust particle environments, and impact and blast effects. The latter includes testing of recovery systems and launch of flight vehicles.

j. Under Mil Std 846B, tests Air Force ejection seat escape systems and escape capsule systems.

k. Operates the Rader Target Scatter Site to conduct electromagnetic and electro-optical signature measurements and determine radiation patterns of United States and foreign ground and aerospace equipment.

l. Performs and supports test and evaluation of missile guidance systems and terminal guidance subsystems used for weapons as well as mid-course guidance subsystems when used in conjunction with terminal guidance.

m. Operates and maintains aircraft and target drones and provides test instrumentation in support of assigned tasks.[6]

Of the specific missions for which AFSWC is responsible, almost all except for some of the support functions and for items e., f., and g. are accomplished through the 6585 Test Group at Holloman with the CIGTF being responsible for all work relating to guidance and navigation.

CIGTF Organization and Mission

The Guidance Test Division (formal Air Force name for CIGTF) is organized internally into three major branches and two staff support offices: The Operational Test Branch, the Laboratory Test Branch, the Analysis Branch, the Operations Office and the Administration Office. The branches as well as the staff offices report directly to the Guidance Division Chief. The "AFSWC Organization and Functions Chart Book" gives the following as the official Air Force Mission Statement for the Guidance Division:

> Guidance Test Division--Operates the Central Inertial Guidance Test Facility (CIGTF) with responsibility for test, evaluation and analysis of components and systems applicable to missile guidance and aircraft navigation; develops new facilities, equipment and techniques to maintain capabilities compatible with technology. Provides environmental test support to other organizations and agencies.[7]

The same document breaks the generalized mission statement for the division into the following for individual branches and offices:

Administrative Office--Provides administrative supervision and support of Division requirements for publications, reproduction, documentation, communications, manpower and personnel actions, military and civilian training and administrative orders.

Operations Office--Provides staff management of guidance test programs, support requirements and resources.

Analysis Branch--Develops and applies advanced mathematical techniques and data reduction methods for the quantitative evaluation and analysis of all guidance and navigation tests. Operates, maintains and evaluates the data processing equipment required to accomplish data reduction and analysis for the Division. Navigation Analysis Section. Conducts quantitative performance evaluations of systems which are designed primarily for navigation; including inertial navigation systems and components, navigation aids and attitude reference systems tested in the laboratory and aboard operational aircraft. Guidance Analysis Section. Conducts quantitative performance evaluations of systems which are designed primarily for guidance; including inertial guidance systems and components, terminal guidance systems and components, and weapon delivery systems tested in the laboratory, on the high speed test track, and in operational aircraft. Data Processing Section. Operates and maintains the data processing equipment required by the Navigation Analysis and Guidance Analysis Sections. Develops new data processing techniques and acquires new data processing hardware to accomplish the missions of the division.

Laboratory Test Branch--Conducts laboratory tests and evaluates missile and space navigation and guidance components and systems. Develops tests and test equipment for laboratory tests. Components Test Section. Conducts tests and laboratory evaluations of inertial quality accelerometers and gyroscopes. Environmental Test Section. Conducts and evaluates laboratory environmental tests on space and missile guidance systems and components, aeromedical specimens, and atmospheric instrumentation packages. Instrumentation Section. Responsible for Data Acquisition System (DAS) build-up, repair, and maintenance of hardware and software for laboratory projects. Operates model shop and fabricates parts and components in support of equipment requirements. Terminal Guidance Test Section. Conducts tests and laboratory evaluations of terminal guidance, celestially-aided and inertial guidance systems and subsystems.

Operational Test Branch--Conducts sled and aircraft tests to evaluate terminal guidance, inertial guidance and navigation components and systems. Instrumentation and Support Section. Designs, fabricates, operates and maintains instrumentation, signal conditioning and ground support equipment and evaluates telemetry records. Sled Test Section. Conducts sled tests to evaluate terminal guidance, inertial guidance and navigation components and systems. Aircraft Test Section. Conducts aircraft testing to evaluate terminal guidance, inertial guidance and navigation systems.[8]

Each of the sections whose mission statements were given within their respective branches are unofficially organized into units and they in turn are sometimes further organized by project.

Types of Testing

Being the focal point for independent Air Force testing and validation of guidance systems, testing accomplished at the CIGTF ranges from research and development test of components through verification testing of complete guidance and navigation systems. The test facilities include complete static and dynamic laboratory capabilities along with two very important operational type test capabilities--high speed rocket sled testing and captive aircraft flight testing.

Laboratory

CIGTF's Laboratory Test Branch is comprised of what is probably the most sophisticated set of test equipment gathered in one location for the test and evaluation of

precision guidance components. An extensive gyro test laboratory is available for performing standard-torque-to-balance tests on gyros to solve for the CIGTF standard nine-term gyro error model coefficients. Accelerometer tests are accomplished by rotating the accelerometer in the 1-g field in twenty discrete steps. An optical polygon is used for setting the position of the accelerometer precisely with respect to the earth's gravity vector. The output response of the accelerometer to these acceleration inputs is used to fit error model coefficients to the output data. The response of the accelerometer to higher accelerations and those coefficients which are due to non-linear effects are determined by centrifuge test. A 100 inch radius arm precision centrifuge is used to determine the operational characteristics of accelerometers under accelerations up to 25g's. Characteristics of the accelerometer under cross-axis accelerations are investigated using the centrifuge and/or vibration equipment in the Environmental Laboratory.

A major facility in the CIGTF laboratory is a large precision 260 inch radius arm centrifuge with a counter-rotating platform. This centrifuge was designed for testing to acceleration levels of 100g's with a counter-rotating mode. Phase-locked servo loops are used to control the acceleration levels to five parts per million, and the

orientation of the counter-rotating platform to a few (±30) arc seconds accuracy. This important test tool provides a unique capability for obtaining performance data of inertial systems under high acceleration levels.[9]

Other unique laboratory test facilities include a comprehensive test facility for testing infrared heat seeking missiles with missile guidance hardware in the loop. This simulation facility is interfaced with a hybrid computer which is programmed to provide the missile dynamic transfer functions between the seeker and a three-axis gimballed test table. Range is simulated by varying target size and intensity. A zoom optical target simulator is also used for testing of electro-optical terminal guidance systems. This simulation facility provides a capability of doing "hardware in the loop" simulation of television type guidance systems where range, the X and Y coordinates, and roll can be controlled.

An Environmental Test Laboratory is used for conducting precision angular and linear vibration tests on guidance hardware. In addition, an extensive capability exists for performing altitude and temperature tests. The environmental laboratory is also used in the conduct of experimental and development testing in fields other than guidance and navigation. In fact, the CIGTF's Environmental Test Laboratory was instrumental in some of the very early work

conceived with space travel. This laboratory conducted tests for NASA and the Air Force Biomedical Research Facility that verified the feasibility and later showed the practicability of manned space flight.[10]

The Environmental Laboratory provides major related support to guidance sled testing, aircraft testing, and rocket sled testing of other than guidance or navigation systems as well as support to varied organizations and fields where environmental factors such as pressure, temperature and vibration are significant.

The Laboratory Test Branch also provides as a major and unique guidance/navigation test capability a celestial-inertial laboratory complex. This facility represents the technological state-of-the-art for precision guidance component test and evaluation in a precisely controlled test environment. The development of this facility was conceived and grew as a result of the extreme accuracy requirements levied for orbital space applications and third generation missile systems. It is now being recognized by guidance experts[11] as the only facility of its kind capable of assessing static one-g component parameters to the levels necessary for meeting improved accuracy requirements as denoted by the 1976 DOD budget request justification for R&D funds. As indicated by the budget document, a lion's share of the DOD R&D budget request of $9.61 billion was justified

against developing options for future deployment of improved intercontinental ballistic missiles with mobile launches, and continued development of ballistic missile warhead accuracy improvements.[12] These two requirements are based to a great extent on guidance accuracy improvement.

Rocket Sled Testing

One of the major test capabilities available at the CIGTF is sled testing of missile guidance systems and subsystems. This is a unique test capability which offers engineering development and statistical evaluation with dynamic acceleration inputs which simulate the missile environment. These tests fill the gap between laboratory testing and free flight missile tests which have limited instrumentation.

Rocket sled testing of guidance systems and components, of course, centers around the Holloman high speed test track. It was originally built 3,550 feet long in 1948 for launching of the SNARK missile, and extended in 1950, 1956 and 1959 to a total length of 35,000 feet. The test track was first used for inertial guidance systems testing in 1956. The latest extension, which is in progress at this writing, will bring the track to a total length of 50,788 feet (ten miles). Over eight hundred sled runs have been accomplished in support of guidance sled testing. The test track also provides a very useful tool for testing a large variety of missile and

weapon systems for other than guidance and navigation systems. For example, it is used for seat ejection tests to ascertain that the pilot capsule will properly eject from an aircraft under emergency conditions, and that the recovery chute will properly open.

Accelerations in excess of 300 g's and velocities in excess of 8000 feet per second have been obtained on the test track in support of nonguidance projects. Accelerations of 140 g's and velocities in excess of 3,500 feet per second can be achieved for precision guidance tests. Both a qualitative and quantitative evaluation of inertial guidance and terminal guidance systems is performed. A key item which makes the test track so useful for a quantitative evaluation of an inertial guidance system is a photoelectric, knife-edge instrumentation system with precise measurement of sled position and time for comparison with the test specimen. The test track space time reference system represents the most accurate operational type reference system in the free world with respect to determining sled position as a function of time.

The test track provides a means of testing guidance hardware in a near operational environment. Inertial guidance systems are finding application in all aerospace vehicles. The environments in which these systems must operate range from a high acceleration and vibration of missiles in space boosters to the long flight time and relatively low acceleration

of conventional aircraft. To adequately evaluate these systems requires that the test environment simulate the operational environment as closely as possible. The instruments that must be used are generally non-linear and the effects on system performance due to these non-linearities becomes most apparent in the dynamic mission environment.[13] Thus the test track used in conjunction with the ultra-accurate reference system represents a unique test tool for cost effective evaluations of guidance systems and components.

Continuing developments in test equipment, instrumentation, test vehicles, facilities, data reduction and analysis methods applicable to rocket sled testing of guidance systems have resulted in the present status of the CIGTF as one of the finest development test facilities in the world.[14]

Aircraft Testing

Captive testing of guidance and navigation systems provides the third major type of test accomplished by the CIGTF. The role played by the Aircraft Test Section took on national prominence when in 1965 the CIGTF was recognized as the national focal point for all aircraft navigation verification testing within DOD.[15] This position was further strengthened in April 1967 by a Director Defense Research and Evaluation (DDR&E) memo addressed to the

Assistant Secretaries of the Army, Navy, and Air Force for R&D. This memo said in part:

> This Office considers that CIGTF test and evaluation of an aircraft inertial navigator's specified performance should be completed prior to the selection of that navigator for a specific aircraft avionics system engineering development, operational system development, or modification program. Otherwise, the Department of Defense and development contractors would continue to face possible development problems, poor reliability and performance, program delays, etc.[16]

Based in part on the direction from DDR&E, the CIGTF developed a set of standardized aircraft navigation system verification tests. These standardized flight tests result in the verification of the performance of systems before they are considered for selection for specific avionics applications. The test results enable the potential customer (Army, Navy, or Air Force) to select the best available equipment for either future weapon system development or modification of existing systems.

A verification test program minimizes the risks of using newly developed inertial navigation systems. Evaluation of such systems at the CIGTF permits an assessment of performance and operational suitability. The resulting test reports are made available to the appropriate DOD agencies by direct and Defense Documentation Center distribution, thus providing a "shopping list" for the offices responsible for navigation avionics programs. Within the Air Force, the Aircraft Navigation System Verification

Program provides for evaluation of systems other than those already selected for a specific aircraft application.

The CIGTF with the support of other AFSWC agencies and several test ranges provides the capability for complete test and performance evaluation of inertial navigation systems. This permits unbiased performance evaluation under conditions closely simulating an operational environment at a cost less than contractor testing.

The CIGTF manages the overall program during these tests. In addition to identifying resource requirements and preparing test plans and program documentation, the CIGTF performs laboratory and flight tests, completely analyzes the test data, and prepares engineering and analysis reports.

The U.S. Army's White Sands Missile Range (WSMR) provides flight test instrumentation facilities. In addition to performing precision radar and optical tracking, WSMR reduces tracking data and acts as lead range in tests using the tracking facilities of USAEPG, Fort Huachuca, Arizona; AFWTR, Vandenberg, AFG, California; and AFFTC, Edwards AFB, California.

Flight test programs are divided into two categories: development programs and verification programs. Developmental tests of early prototype equipment provide information for design improvement and performance evaluation. Verification tests are performed on systems which are well along in

the development cycle and which have normally undergone some previous dynamic testing.

The types of system navigation mechanizations which are tested include pure (unaided) inertial, doppler heading reference, conventional doppler-inertial, Kalman doppler-inertial, loran-inertial, doppler-inertial-loran, and stellar-inertial-doppler. Systems may employ different alignment schemes including ground, air, and transfer of alignment.[17]

The types of testbed aircraft currently in use for verification flight tests are C-130 and C-141 transports, and the RF-4C fighter. A limited amount of ground testing is done for every verification program, and van testing is used when required.

The CIGTF is continually expanding its capability to evaluate a broad range of the advanced, complex systems expected in the future. Planning spans the spectrum from acquiring higher performance testbeds to developing new test methods and analysis techniques.[18]

In addition to the inertial navigation test capability, a large amount of terminal guidance seeker development work has been accomplished using captive flight test techniques. The captive flight test provides an ideal environment for determining range lock on and tracking capabilities for air-to-ground and air-to-air type missile systems. Developmental testing accomplished by CIGTF was instrumental in

the successful development of terminal guidance systems.[19] Terminal guidance testing as a result moved up to a par with the DOD directed navigation system verification testing.

Resources

The CIGTF, as indicated by the preceding section, represents perhaps the most complete test facility available in the free world for accomplishing R&D testing of guidance and navigation systems and their components. The CIGTF achieved this capability as a result of very strong leadership and because of a relatively small number of highly motivated scientific and engineering personnel. The expenditures described below in terms of manpower and tax dollars appear to have been wise investments when consideration is given to what those expenditures have achieved with respect to the national defense.[20]

Manpower

Test programs undertaken by the CIGTF are conducted in what has been termed an "inhouse blue suit operation."[21] The total manpower allocation is comprised of approximately 270 people. The military civilian (federal civil service) mix is about 50/50. The vast majority of these 270 people, around 235, have highly specialized technical backgrounds with approximately 113 holding either scientific or

engineering degrees. The remaining 142 technical people are for the most part electronic technicians with instrumentation specialties, and who have on the average one or two years of college. Of the degreed people, there are about 46 who have masters' degrees and 8 who hold Ph.Ds.[22] It has been said that CIGTF is comprised of a small group of highly elite specialists. This of course has been mandatory in achieving the goals set forth when CIGTF was founded, and it has provided the attendant benefits that go with highly trained and capable people. However, there are attendant disadvantages that also go along in keeping highly skilled people motivated and retained.

Funding

The CIGTF presently operates under what is termed test and evaluation funding.[23] Simply stated this means that all direct costs incurred during a test program must be reimbursed by the test customer or sponsor. There is one major exception and some minor exceptions to this oversimplification. For instance, military pay for programs conducted for the Air Force is not reimbursable. However, military pay for the same services performed for non-government agencies must be reimbursed.[24]

The CIGTF budget for fiscal year 1976 has allocated approximately $6.0 million for operating expenses which includes civilian and military pay, supplies, travel, and

contract maintenance. Investment monies for equipment and instrumentation update amounted to approximately $0.5 million.[25]

Reimbursements from test customers are expected to run upwards of $2.0 million, leaving $4.0 million to be funded by headquarters systems command.

Value of Capital Assets

The CIGTF instrumentation equipment and prime facility is valued in excess of $20 million. This excludes the aircraft testbeds and the support facilities owned and operated by other agencies, but used for guidance testing such as the high speed test track, White Sands Missile Range, and computational facilities. Replacement costs of the CIGTF at today's dollar value has been estimated at approximately $30 million.[26] Thus the CIGTF represents a substantial investment that must continue to develop advanced test techniques in order to remain abreast of technology changes if the facility is to continue to serve its stated purpose.

Some Problems

The CIGTF has a noteworthy history of effectiveness. Numerous outstanding achievements have been made which significantly contributed to the successful achievement demonstrated by the intercontinental ballistic missile, limited tactical warfare weapons, the precise ability to navigate aircraft without external aids, manned-space

travel and deep space exploration.[27] However, problems are now being surfaced which may seriously impede the ability of the CIGTF to continue in the success mode that has been so characteristic of its history.

To maintain the effectiveness of the organization under the industrial funding concept defined by Air Force Systems Command REgulation 172-8, it is necessary to apply more ingenious management methods. An important aspect of this is the marketing approach. Chapter III critically reviews what presently is being done in this respect and to what extent it can be improved.

END NOTES

[1]"SLCMs Keeping the Options," Government Executive, May 1975, p. 16; Robert C. Seamans, Jr., Secretary of the Air Force, "Air Force Policies in the Field of Guidance Testing," Keynote address at the Fifth Biennial Inertial Guidance Test Symposium, Holloman Air Force Base, New Mexico, 14 October 1970.

[2]David Bushnell, Guidance System Testing at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1960, p. 1.

[3]Central Inertial Guidance Test Facility, "Test Planning Information and Procedures for Testing Aircraft Navigation Systems," ADTC-TR-75-70, October 1975, p. ii.

[4]Ibid.

[5]U.S. Air Force Systems Command Regulation 23-11, Organization and Mission of Air Force Special Weapons Center, 29 December 1972.

[6]Ibid.

[7]U.S. Air Force Systems Command, "Organization and Functions Chart Book," Kirtland Air Force Base, New Mexico, March 1972.

[8]Ibid.

[9]G. R. Mozer, Testing Philosophy and Methods of Guidance and Control Systems and Subsystems (Nevilly Sur Seine, France: Advisory Group for Aerospace Research and Development, 1972).

[10]George Meter, The Holloman Story (Albuquerque, New Mexico: University of New Mexico Press, 1967), pp. 52-59.

[11]Interview with Martin J. Jaenke, CIGTF Technical Director (retired) Holloman Air Force Base, New Mexico, 10 July 1975.

[12]The Budget of the United States Government Fiscal Year 1976 (Washington, D.C.: U.S. Government Printing Office, 1975), p. 71.

[13]Mozer, p. 5.

[14]Ibid., p. 31.

[15]Director of Defense Research and Engineering, "Test and Evaluation of Aircraft Inertial Navigators," memo to Assistant Secretaries of the Air Force, Army and Navy for R&D, 6 July 1965.

[16]Ibid., April 1967.

[17]Central Inertial Guidance Test Facility, "Aircraft Testing of Inertial Navigation Systems." Test Planning Information, MDC-TR-70-9, June 1970.

[18]Ibid.

[19]Interview with P. V. Zagone, Chief Operational Test Branch of CIGTF, Holloman Air Force Base, New Mexico, 29 November 1975.

[20]Ralph Sanders, ed., Defense Research and Development (Washington, D.C.: Industrial College of the Armed Forces, 1968), p. 30.

[21]Interview with R. P. Jones, Section Chief of CIGTF, Holloman Air Force Base, New Mexico, July 1975.

[22]Interview with Fred P. Ray, Chief of Administrative Resources of the CIGTF, Holloman Air Force Base, New Mexico, 1 December 1975.

[23]U.S. Air Force Systems Command Regulation 172-8, Test and Evaluation Support, 18 April, 1974.

[24]Ibid.

[25]Ray.

[26]Ibid.

[27]Meter.

CHAPTER III

MARKETING

". . .A man's judgment is no better than his information."[1] As pointed out in Chapter I and also mentioned in Chapter II of this paper, effective communication between R&D test centers and weapons development managers is potentially capable of alleviating some of the major problems facing the test centers which in turn can act to reduce overall weapons development cost.

The purpose of this chapter is to describe the modern marketing concept and its relationship as it would specifically apply to government owned and operated test centers.

Definition of Marketing

Dr. Philip Kotler, the Harold T. Martin Professor of Marketing at Northwestern University, has just recently had a new book published which describes the marketing function and its utility in the public sector. In his book Dr. Kotler very broadly defines marketing as ". . .the effective management by an organization of its exchange relations with its various markets and publics." He points out that in order to apply this concept of marketing to the nonprofit sector, the idea of profit maximization must be ". . .translated into benefit cost maximization."[2]

The central concept of modern marketing is this idea of value exchanges. It requires at least two parties, each of whom has something of value or benefit to the other which motivates the exchange. In order that the exchange be fruitful to both parties normally requires, or is at least much enhanced, if one, or preferably both of the parties are good at understanding, planning and managing such exchanges. Understanding, planning and managing imply that: the needs of the other party have been defined; a valued offering to meet those needs developed; a method of effective communication has been established between the parties; and that a tool has been established to present the offer in a good place and, most important, in a meaningful time frame. All of this restated leads to Kotler's more detailed definition of marketing:

> Marketing is the analysis, planning, implementation, and control of carefully formulated programs designed to bring about voluntary exchanges of values with target markets for the purpose of achieving organizational objectives. It relies heavily on designing the organization's offering in terms of the target markets needs and desires, and on using effective pricing, communication, and distribution to inform, motivate, and service the markets.[3]

According to Kotler, every organization must operate in an environment of publics. He defines a public as a "...distinct group of people and/or organizations that have an actual or a potential interest and/or impact on an organization."[4] According to this definition, the publics of a

typical R&D test center, such as the CIGTF, would include such other organizations as: the potential test customers, namely the weapons development groups within DOD; supporting test facilities such as the White Sands Missile Range and the high speed test track; supply, procurement, and administrative support groups; guidance and navigation system/component manufacturers; other test labs concerned with guidance and navigation, both public and private; Air Force Headquarters, Test Group Commanders Offices, and others in the CIGTF chain of command and budget review cycle; military and civilian personnel offices; and the CIGTF personnel themselves.

Even though this is an incomplete list of the organizations that have some impact on the CIGTF, it is sufficient to show that there are input publics, internal publics, agent publics, and consuming publics. A complete modern marketing concept includes the recognition and necessary interplay with all of an organization's publics.

At this point the question might arise as to how a public differs from a market. Kotler defines a market as a "....distinct group of people and/or organizations that have resources which they want to exchange, or might conceivably exchange, for distinct benefits."[5] According to this definition then some of CIGTF's publics could also be markets. For example, the test customers are both publics and markets as are the supporting test agencies, and for that matter, all of the previously defined publics can be markets. It

depends on whether or not the CIGTF is taking a marketing viewpoint toward that public.

The modern marketing concept stresses the need not to sell, but to determine and be responsive to the requirements of the organization's various publics. This concept of marketing is agreed to throughout the business world. John Adams states in Modern Marketing Thought that:

> If in fact the primary or overriding purpose of business is to make a profit, then the free enterprise system should and will be self-destructive. The idea that profit per se is good no longer stands examination. Profit is good if the process of making a profit results in satisfying the needs of the customer more effectively and more efficiently than a non-profit system. But profit without this result is a waste which the public as a consumer and a voter will not continue to sanction.[6]

Paul E. Green and Yoram Wind, writing very recently in the Harvard Business Review, promote the concept of recognizing and meeting customer needs over the older sales oriented marketing concepts.[7] The April 14, 1975 issue of Business Week contains an article called "When the Growth Slows" which has inputs from a number of leading businessmen, a noted sociologist, a market researcher and Dr. Philip Kotler, marketing professor. This article also points out that the old marketing concepts are no longer applicable to today's markets. The article as a whole also supports the theme that the marketing approach to be successful in today's environment must be oriented towards the needs of the customer.[8]

Even though the concept of modern marketing--making the customer's needs a first priority--has been espoused

by almost everyone in business for the last ten years or so, some authorities point out that it has not yet been implemented on a broad scale. Mark Hanan, writing in the 1974 November/December issue of the Harvard Business Review stated that:

> Throughout the 1960's, market orientation was such a dominant business concept that it is surprising to find, a decade later, that few companies have found a way to organize themselves so that their customers' needs consistently come first.[9]

This statement by Mr. Hanan is in keeping with Peter F. Drucker's assessment of how well the modern marketing concept has in reality been implemented. His statement, in discussing the phenominal growth of Sears, illustrates this point quite well: "Sears today may be the first truly marketing-focused manufacturing business in the U.S. practicing what most manufacturing businesses so far only preach, that is, the total marketing approach."[10]

Drucker feels that the recent wave of consumerism propagated by the Ralph Nader inspired consumer protective societies "...is the shame of marketing." He believes that "marketing and the marketing approach is still rhetoric rather than reality in far too many businesses." He poses two most important questions that must be addressed if the new marketing approach is to be successfully implemented. These two questions are of utmost importance to an R & D test center such as the CIGTF. Drucker asks, "What is value to a customer? Which customer wants are not satisfied?"[12]

One further clarification of the marketing function has to do with purpose. Any business or organization must have a purpose, and that purpose must lie outside of the business or organization.[13] This, of course, is especially true of R&D test centers.

To summarize, the marketing function, as applied to an R&D test center in this paper, can be described as being "user-oriented and not seller oriented."[14] It does, in fact, adhere to Dr. Kotler's very broad, but bounded definition that marketing encompasses all forms and types of organization. His definition has at its base the idea that modern marketing ". . .is the process of making selling unnecessary," and that ". . .the notion of marketing being simply the stimulation of demand or a response to demand. . ." must be abandoned, and furthermore, that "marketing has got to evolve toward demand management or the management of growth."[15] In other words, Kotler, along with the other sources cited, stresses that marketing should serve a need rather than selling a product. It must be with these concepts and limitations kept foremost in view that any form of marketing can be successfully applied to an R&D test center or any other nonprofit organization. In all cases, care must be taken to insure that the marketing function objectives remain user-oriented and not self-oriented so that the marketing function will not be used in an unethical manner.

Marketing in Nonprofit Organizations

Administrators in nonprofit organizations are increasingly becoming aware of the potential relevance of marketing discipline to solve their problems. Yet managers of such agencies as R&D test centers, universities, hospitals, and churches, to name just a few, approach marketing with a great deal of skepticism because it has the image of being exclusively a tool for use in commercial businesses and one identified with selling and promoting. This, of course, tends to make administrators feel uncomfortable. After all, "Producing and selling a breakfast cereal is one thing and running a hospital or a university is another. The administrator of a not-for-profit organization understandably says 'show me.'"[16] Kotler's reply, and it is certainly most valid, is: "The issue is not one of whether or not nonprofit {public sector} organizations should get involved in marketing, but rather how thoughtful they should be at it."[17]

Dr. Kotler advances the hypothesis that the conceptual system known as marketing will come more vividly into practice in all four classes of organizations, business concerns, service organizations, mutual benefit associations, and commonwealth organizations. Marketing is already entrenched in business concerns; is moving rapidly into service organizations and mutual benefit associations, and ". . .finally marketing will ultimately move into the thinking of commonwealth

organizations {including DOD} who will increasingly recognize the quality of treatment they accord to their captive publics will affect the amount of public criticism and the size of their budget."[18]

Government agencies are the hardest to convince of the potential benefits to be derived from marketing of which improved service at reduced cost in conjunction with providing accountability may be paramount according to the hypothesis presented by Kotler.[19]

Many public administrators still view the concept of marketing in the very limited sense of profit motivated salesmanship. But, certainly there are numerous public administrators who apply marketing principles as defined by Kotler in a most professional and highly effective manner. However, few examples, if any, exist whereby a government agency or nonprofit organization openly acknowledges that it uses or is formally structured towards the use of a complete set of marketing techniques. It can be argued that groups such as the Public Information Service or those similar to the Military Information Offices have as their mission marketing oriented functions. However, these offices are concerned, primarily, with favorable image projection. They definitely are not concerned with, nor are they sufficiently staffed to assess the wants and desires of their customers (the public) which is perhaps the essence of marketing in the most general sense.

The very critical features which act to impede the formal recognition of the outstanding utility of marketing that has been proven not only in the private sector but by specific occurrences (rather than general) in the public sector are given as follows: For instance, the election of a president, health warnings on cigarettes, and successful school bond issues could represent examples where ethical marketing techniques have been implemented; however, they could also represent examples from which high pressure salesmanship and/or other unethical promotion schemes were implemented. This resulting dichotomy of "did you get there by ethical or unethical means" is faced by all responsible administrators--one that they do not welcome with open arms. Therefore, it may be that managers and administrators who go ahead and use ethical marketing techniques simply disguise the approach as best they can to alleviate or reduce adverse criticism which results because too many people still view marketing as getting someone to buy something they either did not want or did not need.

Whatever the reason for the lack of frankness in the use of this technique, one only has to look around to see that every organization, whether it be nonprofit or profit, does indeed carry on marketing activities.

Administrators cannot ignore the ethical questions raised by marketing. They must be sensitive to the criticism that marketing wastes money, that it is intrusive, and

that it is manipulative. Furthermore, the good administrator must avoid any marketing practice that cannot be ethically defended. Although this is like saying that a man with power and responsibility should not use them for unethical or illegal reasons, great care must be taken in order to gain public acceptance of the modern marketing concept.

One can safely bet that marketing has been, and will continue to be, applied in a questionable manner in some situations from now on just as power has been, and will be misused on occasion. However, these tools of necessity can no better be denied than the use of electricity can be denied simply because it can cause death by improper application.

Kotler describes a nonresponsive, non-marketing oriented bureaucracy in the classical sense:

> Organizations come into being to accomplish some purpose. The founders are clear-minded about the organization's mission and they often pursue it with single minded dedication. The new hospital is organized to serve the sick; the public school to provide education and job skills to the young; the new church to minister to the spiritual needs of the community. The original founders are spirited, dedicated, and customer-oriented.
>
> The organization that meets the needs of its customers grows and prospers. As it grows, it becomes more complex and multipurpose. It takes on additional responsibilities to its customers, employees, agents, suppliers, and other publics. The organization has to serve well. . .the various internal and external groups that derive their income or symbolic status from the organization. . . .

> Management members grow increasingly self-serving; that is, their purpose becomes to maintain the organization and their jobs at any cost. Spontaneous job relations are replaced by careful job descriptions and hierarchial chains of command. Relations with outside groups are routinized by rule-bound behavior. The organization develops an officialdom that shows an impersonal face to the world. The officials exhibit care and caution instead of daring and innovativeness. They feel safest in maintaining traditional policies, procedures, and products.[20]

This description of a bureaucracy certainly agrees with the generally accepted description. This is what some experts in the field believe happens in time to all bureaucratic organizations. Kotler believes that this state of affairs comes about because "The world and the markets are continually changing while the organization stands still. New needs emerge, new interest groups appear, new stages are reached in the economy, law, technology, and culture."[21] This, then, results in the organization finally becoming maladapted to its environment. If this is truly the case, then it stands to reason that a formalized marketing activity, properly implemented, could prohibit, or at least impede, the process.

For example, one can postulate that, given the proper marketing role, the National Aeronautics and Space Administration (NASA) could have perceived the energy needs of the nation and redirected that vast amount of talented resources towards that end. As it stands now, a new group is being formed to approach the problem through no other than the

most expert marketers in the world, "big oil," while NASA appears headed down the bureaucratic path described by Kotler.

In summary, good marketing most definitely is needed in nonprofit organizations. However, the cost of implementing a marketing approach must be compared to the benefits to be derived for each specific organization.

The next section of this chapter addresses the cost requirement as a part of the discussion on the application of a marketing system to a typical R&D test center.

Application of Marketing to an R&D Test Center

"Although marketing logic has a unity that transcends particular organizations and products. . ."[22] it cannot be applied across the board to all types of organizations in the same manner. There is a creative challenge to selecting those concepts and tools that are particularly appropriate for each type of organization. Different organizations have different objectives, goals, publics, marketing problems and in general different outlooks. Thus, the system that would work best for hospitals, universities, R&D test centers, museums, etc. will vary. Therefore, this section of the paper addresses the requirements for establishing a marketing system within a typical R&D test center, namely the CIGTF. Some of the advantages of such a system, and some disadvantages, are discussed and, where practical, similarities with other types of organizations are noted.

Requirements

In order to establish a meaningful marketing plan, the objectives of the plan must be clearly developed. Once the objectives are set, the organizational structure, facility and personnel requirements can be assessed. Completing this will then allow the estimation of the cost involved to implement the plan.

Objectives

The marketing plan objectives must coincide with the goals as set forth by the CIGTF mission. These goals, as previously stated and given below, form the basis for establishing the marketing functions:

- Unbiased evaluation of components and systems to provide data from which the customer can select the optimum equipment for a given mission application.
- Development of a single centralized test facility, to avoid the prohibitive costs of duplicated facilities.
- Standardization of tests, to provide common yardsticks for comparative evaluations.
- Competence in both personnel and equipment, to insure meaningful evaluations.[23]

Analysis of each of the goals or objectives stated above leads directly to the conclusion that the CIGTF marketing plan must foremost assess the needs of the CIGTF publics.

For only after this step has been accomplished can planning take place which is oriented towards meeting those needs. The objectives of the marketing plan must not be in conflict with the reason for CIGTF's existence.

The CIGTF, and most R&D test centers, are actively involved in a number of functions that can act as a base for implementing a modern marketing plan. For instance, the Air Force Systems Command (AFSC) requires a yearly revision of what is called the 5-10 Year Plan. As a planning basis they make available an extensive listing (classified) of weapon systems and subsystems and components which will be developed during the coming ten-year period. This list reflects explicit test requirements--when, where, and by whom. In this manner, basic information on "customer needs" is provided, which is then used to establish estimates of required test resources such as laboratory hours, aircraft flights, sled runs, manpower, and equipment requirements. The estimates, practically speaking, are based on <u>past</u> experiences and are reflected back into AFSC's 5-10 Year Plan.[24]

This, of course, does not solve all the problems, one of which is to match the actual budget with what the 5-10 Year Plan says. Furthermore, customer needs are often constructed which are not reflected in the development list.

Another important aspect of the marketing approach presently employed by CIGTF is the close contact with the customer before, during, and after a test program. This sequence normally starts with the CIGTF briefing their various publics, such as DOD weapons developers to familiarize them with their capabilities, plans, and problems. These discussions and meetings provide an opportunity to assess customer needs in detail once a program has been sold, and to establish a base of firm credibility for future test programs.[25]

In addition to the very necessary functions in any successful marketing approach discussed above, CIGTF also addresses its very important public--the guidance and scientific communities. The CIGTF hosts a biennial guidance test symposium and participates actively in the Advisory Group for Aerospace Research and Development (AGARD) lecture series and other professional scientific symposiums when funding is available.

There are other numerous activities and functions that CIGTF involves itself in which are related to the marketing function Among these are: The publication of Test Planning Information Guides, participation in weapon systems source selection boards, and budget preparation and defense.[26]

All of the activity mentioned here can be described as the basic ingredients necessary for a good and meaningful marketing approach. However, these entities alone do not effect a sound marketing "plan."

Even with the marketing activity described above, which is certainly helpful and denotes a large step in the right direction, the closest thing most R&D test centers have, including CIGTF, as a marketing "plan," is the budget submission. These budgets are often based in part on constructed needs, as well as customer needs, which has led to the development of some test capabilities that are definitely applicable to the needs of weapons developers, but not used. Reasons given are: alleged lack of time, due to scheduled completion or operational flights, money, external competition from the manufacturer and the weapons development technical advisors, and from other test labs that do not have the same capability but try to get a piece of the test pie. History bears this out as shown in the next chapter.

This is just one example of the need to improve communication with potential test customers. Improve, meaning that test customer budgets would reflect usage of specific test facilities, particularly if development funds were internally alloted to achieve necessary facility improvement or capabilities updating the long range requirements of the test

customer. This hopefully would lead to the channeling of scarce resources in one direction to achieve the maximum good rather than dispersing scarce funds to a number of competing test labs or contracted advisors who may want foremost a lion's share of the test funding.

The Air Force officially recognizes CIGTF as being the focal point for guidance test and evaluation; however, except for the DDR & E directive that all aircraft navigation systems would be evaluated at CIGTF prior to DOD procurement, there has not appeared to be any influencing force towards the actual implementation of this concept.[27] Thus, here again persuasive communication must be initiated between CIGTF and those sets of publics which can provide this influence.

Persuasive communication requires as a minimum three distinct entities: something worthy of communication to begin with, someone capable of presenting the message in a persuasive manner, and organizational structure that does not impede the message transmission. Chapter II had as an underlying intent the verification that CIGTF does indeed have a message worthy of communication; furthermore, there are engineers and scientists working at CIGTF who are potentially capable of presenting the CIGTF message in a persuasive manner. The existing organizational structure could be used to enhance the transmission without the necessity

of a structure change. What then is needed to effect a sound marketing plan? Very simply, for the CIGTF it appears to be mainly a question of emphasis.

In the past the marketing function at CIGTF, if it can properly be called that, has been attempted by a few key individuals who necessarily played the role in a secondary fashion. That is, their first order of priority has been to the ongoing test missions with emphasis often switching to the "sales" approach when slackened workloads dictated. Consequently, there has not been a uniformly directed policy plan for this very important aspect of management. CIGTF has, as appears to be the case with most nonprofit organizations, left this function as a side-line to be handled by the agency director and upper level management. According to Kotler, "most nonprofit organizations operate without any marketing personnel as such. . . ."[28]

Thus, CIGTF's marketing might be described as piece-meal but moving rapidly in the right direction.

According to Peter F. Drucker, "Marketing is so basic that it cannot be considered as a separate function (i.e., a separate skill or work) within the business, on a par with others such as manufacturing or personnel. Marketing requires separate work, and a distinct group of activities."[29]

Harry Hansen, writing in Modern Marketing Thought described marketing as the discovery and definition of

consumer needs, (in the case of CIGTF, test consumer needs) the translation of these needs into a product or service specifications, and the delivery of these products and services to the customer.[30] That precisely is the generalized objective of the proposed marketing plan for CIGTF. It must allow for a continual anticipation, exploration and probing in contrast to reaction or resisting or withdrawing.[31]

Much seriousness must be alloted to the marketing plan. Fred R. Brown writing for the Industrial College of the Armed Forces comes to this same conclusion when he states that:

> Great care must be taken to assure that each subsystem or element in the overall comprehensive planning system is designed to accomplish its particular true purpose and serve functional as well as managerial needs.[32]

If great care is not taken, management may very well become a process of reacting only to immediate and urgent problems and in effect degenerate into a "fire fighting operation."[33] Some CIGTF managers may feel that this is already the case for their specific positions.

Good marketing certainly will not eliminate <u>all</u> "fire fighting operations for management; it can reduce by a significant amount the water that has to be applied for control. However, it must be strongly emphasized that DOD R&D test centers do not operate in a free market. They are a link in the chain of events of a fairly rigidly planned scenario. This limits the marketing freedom considerably. What R & D

test centers must and can do is "play ball" with the "system" and do everything plausible to make it a success.[34]

The 5-10 Year Plan, despite its shortcomings, is a promising tool to help accomplish effective marketing. First it tells what the higher level public (i.e. command) has in mind, what to do, when, and by whom. If, after a critical review of the plan, disagreement with it exists, then it must be taken up formally with the respective agencies as early as possible. Time becomes a critical factor. The main objective in this respect is the avoidance of duplication.

The 5-10 Year Plan depicts potential customers for the test agencies. Thus, the test agencies could form their own ideas of the efforts required and then contact the potential user and present to them the suggested effort and get their reaction and hopefully reach a consensus and agreement on funding. This then is a potential tool also for avoiding or reducing workload fluctuations within the test agencies. Furthermore, a realistic picture of resource requirements for the future can be developed.

The two steps described above, with proper direction could enhance: the determination and response to actual customer needs by test agencies; the planning necessary to reduce workload fluctuation by test agencies; and by getting test agencies involved in policy planning early enough to avoid duplication of efforts and facilities.

Fortunately, the tools, mechanics and organizational structure to do all this are in existence and at least in partial use at the CIGTF. What remains to be done is to make this use more systematic and efficient.

Organizational Structure

The CIGTF is presently organized such that the marketing structure could be imposed with little or no organizational change. However, it will take a major re-emphasis and possible reorientation of all CIGTF personnel.

The Operations Office, staff function to the director, has as its major responsibility administrative control of all CIGTF test programs. This office is responsible for setting policy, both internal and external, with respect to test programs conducted by the CIGTF. The officers and engineers in this office provide financial management and in a very few cases technical direction to the programs assigned to them. They are supposed to serve as the CIGTF input/output link. As such, they are primarily situated to handle the marketing function. They have in fact been assigned that role by past CIGTF commanders. But the assignment without a clearly stated marketing objective has done much less than the other undirected efforts which have been vigorously pursued by a few key individuals.

The Operations Office engineers and officers are titled test directors which in most cases is a misnomer. Test

coordinator is a little more valid, and for most purposes the title financial manager might be more appropriate.

The organization structure as it now exists should employ total responsibility for the CIGTF marketing function within the Operations Office. However, as a minimum, the branch chiefs and section chiefs throughout CIGTF should have their job responsibilities redefined to encompass the marketing aspects of their individual areas. This then would allow experienced line managers to support the test directors when necessary.

The test director should be given uniform direction with respect to CIGTF marketing plans which could be developed by a committee formed by the CIGTF commander, the Technical Director, and Chief of Operations, the Chief of Administrative Resources and the branch chiefs. There would be some advantage in developing a single marketing position to perform at the branch level (possibly the Technical Director) for formulating and implementing plans developed by the marketing committee. The chief marketer would be responsible for the implementation of the marketing plan as developed by the committee. He would in effect provide liaison between the planners and doers. Thus, he must necessarily receive upper management support, and he must be recognized both technically and administratively.

Facilities

As was the case with the organizational structure there would be no changes in facility requirements to support a marketing function at the CIGTF. Existing office space could house the marketer; or better yet revise old job descriptions to convey the new concepts, and new office space would not be required. All normal base support in terms of visual aids, publication, professional eloquence courses, etc. are available for this purpose already.

Personnel

In terms of establishing the marketing function, a sufficient number of slots already exists. However, the most pressing problem of implementing a CIGTF marketing concept will be one of personnel. As stated by Dr. Kotler:

> The modern marketing man has to be multilingual, for he obtains his material from many disciplines. He must be able to converse with economists about marginal analysis, elasticity, and diminishing returns; with psychologists about projective techniques, latent needs, and nonrational behavior; with sociologists about acculturation, social norms, and subcultures; and with statisticians about standard error, least squares, and correlation.[35]

Even though Doctor Kotler probably overstated the capabilities required of a marketing man, his point is clear. Handling the marketing function for a highly technical scientific R&D test center does require some special qualities--namely in-depth knowledge of the test center capabilities and a very broad general knowledge of the science and

technology important to the test customer. However, the most expert marketing man cannot accomplish satisfactory results alone. Marketing must be implemented and stressed throughout the organization. The CIGTF test directors in a marketing sense should be like the ball carriers in a football game. They cannot go far without support from up front--the line organizations.

A marketing function for CIGTF first of all should demand marketers that are technically knowledgeable and display a communicative ability with respect to the test capabilities of the CIGTF. Expertise associated with the test capabilities most probably can only be obtained through experience. Thus, a program of selective reassignment of experienced personnel as test directors should be considered. Communicative ability, at least for professional engineers and scientists with the required technological expertise, can probably be derived from inherent characteristics. However, short term (two to four week) training courses exist to enhance one's ability to effectively communicate.

It must be recognized that the marketing aspects of a test director's job will encroach on a substantial amount of the time available for their total job. Thus, the possibility of switching some of the test director's responsibilities in terms of test management to the conducting branches exists. This switch of responsibility might very well raise the morale of the line personnel involved yielding improved

test results and greater efficiency while freeing the test director in order that he may accomplish the marketing aspects of his job.

According to Boyd and Massey as stated in their book Marketing Management:

> Control is critically dependent on detailed relevant communication from the market. In other words, it is inextricably linked with marketing information systems.
>
> Constant monitoring of the market place with respect to the program being made or not being made in attaining the subobjectives takes up a large part of a marketing manager's time.
>
> Formal feedback is but one part of the control system; it does not indicate the thoughts or attitudes of company personnel. Personal contact is the only effective way for the marketing manager to find out how members of his and other departments think and feel about a situation. Certainly control is most effective when it anticipates how individuals will react to a given situation. Once this is known, management can adapt its decision with some accuracy to capitalize on the anticipated reactions.[36]

This presentation by Boyd and Massey states precisely the need for test directors to become involved in the work of marketing.

Cost

To implement the marketing plan as generally presented above will require an insignificant amount of dollar resources. Instead, it will require a strong emphasis by CIGTF management.

Personnel costs should not materially increase since no new slots were recommended. The same applies to facility costs. No new facilities were proposed.

Training and travel appear to be the two, relatively speaking, most costly items. Eight to ten man months of formal marketing training could be accomplished for approximately $25,000. This would be a one time cost with annual update training running only about $5000 per year.

Travel for the most part could be bootlegged under project funding. However, a substantial increase over the present TDY budget should be expected. On the average the marketing functions should require in the neighborhood of $8000 to $10,000 yearly.

Thus, the estimated first-year cost would run about $38,000 with succeeding year costs running about $16,000 per year. After three years these costs could be substantially reduced going down possibly to $2000 or $3000 per year.

Advantages

As pointed out by Armen A. Alchian writing for the Industrial College of the Armed Forces, "There has long existed in the military an unfortunate confounding of research and development decisions with the procurement or production decision."[37] "This has come about partly due to the lagging effect that R&D choices have on defense costs."[38] As reported by Sanders, "Defense officials have a deep interest in assuming that exploratory development money is being spent wisely." Sanders also states that:

> Defense R & D managers apparently are showing increased confidence in the value of exploratory

> development. OSD (Office of Secretary of Defense) has also recognized that this R & D phase will prove most effective if much of the decision making authority remains at the working level. Thus, OSD permits level-of-effort funding, and supervisor activities in a general way. For their part the services specialize mostly in those disciplines and investigations that offer the greatest promise to accomplish their mission.[39]

In this ultra important area one of the minor hypotheses of this thesis is that effective communication may help to reduce unwarranted costs by enabling money to be spent wisely.

A marketing orientation emphasized within the existing CIGTF structure has the advantage of minimum cost for implementation. It also provides a method for minimum change to personnel; thus its acceptability to CIGTF's internal public, its employees, will be enhanced.

As cited by Fred R. Brown:

> Rapid change not only increases the cost and risk of innovation but, at the same time, requires innovation if an organization is to compete and survive. An environment of violent technological flux is created with rapid obsolescence and high uncertainty.[40]

This statement applies not only to new products in an industrial sense to which it was referred, but it applies equally well to the capabilities in use by R&D test centers throughout DOD. A marketing orientation will stress the need for a system of plans as a basis for decision making. This should result in obtaining knowledge of future requirements so development of test capabilities does not linger behind and be lost due to ineffective timing. Thus, one

great advantage of the marketing orientation is that it will provide a basis for the CIGTF oriented development plan rather than allowing a set of individual plans, for which resources are not available anyway, among the various test sections.

John E. Smallwood of product life cycles said that ". . .products are born, mature and die."[41] This is not unlike test capability development to meet changing needs in an ever increasing era of changing technology. But as new needs arise, old needs disappear. And as R. S. Alexander said, "Just as barnacles on the hold of a ship retard the vessel's movement, so do a number of worn-out items in a company's product mix affect the company's progress."[42] Burial of unneeded facilities in R&D test centers is difficult for a number of reasons--mainly the people responsible who feel their jobs may be at stake. However, with a new marketing orientation, old processes should give way to new, since the internal environment plays a critical role in new test capability development as in the development of most new products. William H. Reynolds has said: "In fact, innovation itself, the actual creation or invention of a new product, ordinarily takes place entirely inside the firm. It is only rarely that successful products are innovated by customers and adapted by firms. More commonly, the firm innovates and the customer adapts."[43]

Disadvantages

The only major drawback for establishing a marketing orientation is only a potential problem. That is, care must be taken not to misuse the marketing tool. As Kotler says:

> Although the need for government agencies to communicate with their publics is well-accepted, there is always a danger that this communication could become excessive and indeed manipulative . . . The Selling of the Pentagon indicated how easy it is for a government agency to use public funds to build up its influence in ways not clearly required to serve the public better.[44]

These types of problems existed long before the term marketing orientation came into use, and will undoubtedly remain for a long time to come. It is not unlike telling people with power not to abuse it. Some will.

Summary

As stated before, "Defense officials have a deep interest in assuring that exploratory development money is being spent wisely."[45] So do the directors and managers of R&D test centers such as the CIGTF. The trend towards customer oriented marketing plans as indicated by the literature offers great potential for insuring that scarce resources are indeed spent wisely. This new marketing approach directed at recognizing and then satisfying customer needs is being applied to all types of organizations throughout the country. Government, quite naturally when one considers the past concept of marketing as pressure selling, is the last type of organization to look seriously at this approach.

It is true for R&D test centers as it is true for other types of business; the decision maker and the marketer must work closely together if they are to obtain the "best" data for the problem at hand. Thus, the marketer must know quite a bit about the problem setting, including who the real decision maker is, the environmental constraints under which he operates, his goals, and what alternative courses of action he is considering. Only then can the marketing approach be effectively implemented.

The cost estimated for developing a marketing function within the CIGTF will be minimal due to the easy adaptability of the existing organizational structure. The major requirement for successful implementation is that very strong emphasis by upper management must be openly demonstrated.

Dr. Kotler in arguing for a marketing orientation for government organizations closed with the following which summarizes the underlying intend of this chapter:

> . . . Marketing orientation would potentially lead to improved service, improved efficiency, improved legislative support, and improved public accountability. Obviously, this must be compared to the costs of implementing this orientation, and quite clearly marketing will be perceived hostilely as an alien thought process in many institutional contexts. But this is one of the pleasurable challenges of the discipline at this stage. The question of the seventies may well be: can marketing market itself to nonbusiness organizations?[46]

END NOTES

[1]John W. Crawford, Advertising: Communications for Management (Boston, Mass.: Allyn and Bacon, Inc., 1960), p. 112.

[2]Philip Kotler, Marketing for Nonprofit Organizations (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1975) p. x.

[3]Ibid., p. 5.

[4]Ibid., p. 17.

[5]Ibid., p. 22.

[6]John R. Adams Jr., "Put Profit In Its Place," Modern Marketing Thought, 3d ed., edited by J. H. Howard Westing and Gerald Albaum (New York: Macmillan Publishing Co., Inc., 1975), p. 4.

[7]Paul E. Green and Yoram Wind, "New Way to Measure Consumers' Judgments," Harvard Business Review, 53 (July/August 1975): 107-9.

[8]"When the Growth Slows," Business Week, 14 April 1975, p. 45-47.

[9]Mark Hanan, "Reorganizing Your Company Around Its Markets," Harvard Business Review, 52 (November/December 1974): p. 110.

[10]Peter F. Drucker, Management (New York: Harper and Row, 1974), p. 55.

[11]Ibid., p. 64.

[12]Ibid. p. 91.

[13]Ibid., p. 61.

[14]Kotler, Marketing for Nonprofit Organizations, p. 7.

[15]Philip Kotler, "A Marketing Man Takes Marketers to Task," Business Week, 28 July 1975, p. 42.

[16]Kotler, Marketing for Nonprofit Organizations, p. x.

[17]Ibid., p. 9.

[18]Philip Kotler, "Defining the Limits of Marketing," Modern Marketing Thought, 3d ed., edited by J. Howard Westing and Gerald Albaum (New York: Macmillan Publishing Co., Inc., 1975), p. 518.

[19]Ibid., pp. 521-2.

[20]Kotler, Marketing for Nonprofit Organizations, p. 38.

[21]Ibid., p. 39.

[22]Ibid., p. 281.

[23]Central Inertial Guidance Test Facility, "Test Planning Information and Procedures for Testing Aircraft Navigation Systems," ADTC-TR-75-70, October 1974, p. ii.

[24]Interview with Martin J. Jaenke, CIGTF Technical Director (retired) Holloman Air Force Base, New Mexico, 6 January, 1976.

[25]Ibid.

[26]Ibid.

[27]Director of Defense Research and Engineering, "Test and Evaluation of Aircraft Inertial Navigators," memo to Assistant Secretaries of the Air Force, Army and Navy for R&D, 6 July 1965.

[28]Kotler, Marketing for Nonprofit Organizations, p. 229.

[29]Drucker, p. 63.

[30]Harry L. Hanson, "A General Marketing Strategy," Modern Marketing Thought, 3d ed., edited by J. Howard Westing and Gerald Albaum (New York: Macmillan Publishing Co., Inc., 1975), p. 205.

[31]Ibid., p. 205-8.

[32]Fred R. Brown, Management: Concepts and Practice, (Washington, D.C.: Industrial College of the Armed Forces, 1967), p. 102.

[33]Hanson, p. 205.

[34]Jaenke.

[35]Philip Kotler, "The Use of Mathematical Models in Marketing," Modern Marketing Thought, 3d ed., edited by J. Howard Westing and Gerald Albaum (New York: Macmillan Publishing Co., Inc., 1975), p. 448.

[36]Harper W. Boyd, Jr., and William F. Massey, Marketing Management, (New York: Harcourt Brace Jovanovich, Inc., 1972), p. 48.

[37]Armen A. Alchian, A Commentary on Defense Management, (Washington, D.C.: Industrial College of the Armed Forces, 1967), p. 71.

[38]Ibid., p. 129.

[39]Ralph Sanders, ed., Defense Research and Development, (Washington, D.C.: Industrial College of the Armed Forces, 1968), p. 103.

[40]Brown, p. 81.

[41]John E. Smallwood, "The Product Life Cycle: A Key to Strategic Planning," Modern Marketing Thought, 3d ed., edited by J. Howard Westing and Gerald Albaum (New York: Macmillan Publishing Co., Inc., 1975), p. 228.

[42]R. S. Alexander, "The Death and Burial of Sick Products," Modern Marketing Thought, 3d ed., edited by J. Howard Westing and Gerald Albaum (New York: Macmillan Publishing Co., Inc., 1975), p. 235.

[43]William H. Reynolds, Products and Markets, (New York: Appleton-Century-Crofts, 1969), pp. 1-2.

[44]Philip Kotler, Marketing for Nonprofit Organizations, p. 342.

[45]Sanders, p. 99.

[46]Philip Kotler, "Defining the Limits of Marketing," Modern Marketing Thought, 3d ed., edited by J. Howard Westing and Gerald Albaum (New York: Macmillan Publishing Co., Inc., 1975), p. 521.

CHAPTER IV

WEAPON SYSTEMS DEVELOPMENTAL TEST COST

Introduction

This chapter presents the results obtained from a detailed review of selected project test records of the Central Inertial Guidance Test Facility (CIGTF). The record reviews were complemented by a literature search and numerous interviews with CIGTF engineers, analysts and test managers in a serious attempt to determine the cost associated with facility/capability duplication, workload instability, and inadequate development testing as well as the savings accrued from effective developmental testing.

Projects Reviewed

The projects selected for the detailed review had to meet at least one of the following criteria: be a current program; be a recently completed program with at least two of the three prime participators, test director, test engineer or test analyst, available for interview; or be a program for which the author had acted as the test engineer or the test engineer's supervisor. In addition to satisfying this criteria, the projects selected had to also provide a reasonable cross-section of all of the types of testing

involved, and the approximate times of the testing. In addition to the project listed, numerous other test programs were discussed with CIGTF management during the interview session that were not investigated in depth due to the inaccessibility of the project records. Where pertinent, the results obtained from the interviews with respect to those programs are included.

Project names were replaced with an alphabetical code in order not to jeopardize unnecessarily the project funding sensitivity of specific programs.

Basis for Cost Determination

In order to develop a measure of cost associated with the duplication of facilities/capabilities, workload instability and development test benefits required first that a measure of the actual cost of developmental test programs be made. This in itself proved very challenging. For the test programs conducted prior to 1974, the best measure of program cost obtainable was from initial estimates used to document and fund the test programs. These estimates included all direct costs such as manpower, supplies, travel and equipment costs unique to the particular program.[1] The estimates prior to 1974 did not include the indirect costs associated with overhead, building and equipment maintenance, etc.[2] The cost of test programs conducted after 1974 are traceable through the Job Order Control

TABLE 1

CIGTF PROJECTS SELECTED
FOR DETAILED REVIEW

Project	Type of Test			Approximate Time
	Lab	Aircraft	Sled	
A	X		X	1973-1974
B	X	X	X	1973-1974
C	X	X	X	1973-1975
D	X			1975
E		X		1974-1975
F		X		1976-
G	X			1975
H		X		1975-1976
I			X	1972-1975
J	X	X	X	1976-
K		X	X	1971-1972
L			X	1972-1973
M			X	1969
N			X	1969-1970

Source: Data compiled by author from project records at CIGTF January 6-12, 1976.

Accounting System (JOCAS).[3] This system documents direct costs associated with these programs and calculates an indirect charge based on the total Air Force Special Weapons Center operating cost.

Even after 1974 the true developmental test costs are difficult to assess for two reasons. The record of direct charges maintained by JOCAS according to CIGTF test directors appear valid. However, each of the test directors interviewed, the Chief of Administrative Resources, and CIGTF's JOCAS Manager, were all in agreement that the indirect charges calculated by JOCAS could be subject to question.[4] The indirect charges for the programs investigated varied from one-half to four times that of the direct charges. There was no obvious pattern established that might lead to the reason for the large variation in the indirect charges. This problem was not pursued since for the purposes of this paper it was easier and more pertinent to develop worst case cost figures.

The developmental test costs that are external to the test organization, but necessarily borne by the weapon system developers in outside support of the actual testing, was the most difficult cost to assess. For instance, costs accrued for contractor services in direct support of actual testing paid directly by the weapon systems developers could be ascertained only through records maintained by the weapons systems developers. These records more often than

not were not sufficiently detailed to break out the relevant costs. Consequently, this external cost had to be reconstructed for some of the test programs by a ratio derived from test programs where the true external support cost was available.

The question of the validity of the indirect charges indicated by JOCAS and the lack of an indirect charge available for test programs prior to 1974 was addressed on a worst case basis. For those programs where the indirect cost was not readily available, an average ratio of three to one for the indirect to direct costs was used.

There is subjective weighting associated with the cost ascribed for developmental testing. In each case where the actual costs could not be ascertained, the weighting was such to increase rather than decrease the somewhat subjective estimates of the cost. This was done to insure that the cost data could be properly applied to the hypothesis.

Project Costs

Table 2 summarizes the costs developed for the test programs under investigation. The direct and indirect costs are those costs borne by the test agency. The external costs are those relevant test costs borne by the weapons system developers but not incurred by or through the test agencies. Except where denoted, the costs were obtained from the actual

project records. The estimated and calculated numbers were developed by the author according to the ground rules set out in the previous section. The external costs associated with Project A include some contractor services that supported the test customer in other areas such as logistics and maintenance as well as the test agency. Consequently, the external cost figure given is somewhat higher than what would have been attributed to the actual testing. It is left as the total since it would have been required of either of the users anyway and could not be adequately separated. This same logic in developing the total cost was used throughout. That is to say, if the true costs were not readily determinable, a worst case (higher) figure was applied.

Duplication of Facilities/Capabilities

General

Duplication has long been an area of concern within the Department of Defense, especially the Air Force. In fact, it was in addressing this concern that gave birth to the establishment of the Central Inertial Guidance Test Facility at Holloman Air Force Base. The Scientific Advisory Board recommended in 1958 that the Air Force establish a test facility with the express purpose of "concentrating the valuable resources of expert manpower and specialized equipment in one facility and of avoiding duplication of effort

TABLE 2

SUMMARY OF PROJECT COSTS

Project Name	Direct Costs	Indirect Costs	External Costs	Total
A	$3500K	$7000K*	$400K*	$4600K
B	532K	1460K	250K*	2240K
C	(Data Not Broken Out)			390K
D	36K	156K	30K	222K
E	1124K	1256K	2700K	5080K
F	210K*	(Not Yet Estimated)		
G	15K	66K	--	81K
H	106K	154K		
I	52K	96K	10K	158K
J	1120K*	(Not Yet Estimated)		
K	200K	600K	600K	1400K
L	130K	390K*	40K	560K
M	140K	420K*	80K	640K
N	77K	231K*	60K	368K

Source: Data compiled by author from project records of CIGTF January 6-12, 1976.

*Estimated

within the Air Force."[5] This move was clearly motivated by economic considerations. Holloman Air Force Base was selected because the high speed precision test track already located at Holloman promised to be a useful tool for testing of ballistic missile guidance systems--which indeed it did.

Dr. Seamans, a member of the Scientific Advisory Board that recommended establishment of CIGTF, noted that the concept of centralization with respect to guidance testing had paid off:

> Originally established as a central test facility for the Air Force, it has provided extensive support not only to the other military services but also to NASA, industry and some foreign countries. It is a good example of pooling capabilities and expertise to avoid duplication. In the future this could pay even greater dividends as testing increases its importance in the sequence of our R&D activities.[6]

Findings of Blue Ribbon Panel on Duplication

In contrast to what on the surface may appear to be insignificant duplication in the field of guidance and navigation system development testing the Blue Ribbon Defense Panel pointed out some very major areas of duplication that apply Defense Department-wide in their report to the President and Secretary of Defense in July 1970. The panel reported that:

> The evolution of defense organization since 1947 has not substantially reduced the inherent difficulties arising from the fact that the division of roles and missions among the Military Departments is still based fundamentally on distinctions between

> land, sea and air forces which have become increasingly less relevant. This results in continued adversary relations between the Military Services, which although usually confined to the internal paperwork that constitutes the Department's decision-making process, severely inhibit the achievement of economy and effectiveness required for adequate defense within available resources. The continuing interservice competition seriously degrades the decision-making process through obfuscation of issues and alternatives, and leads to attempts to circumvent decisions, repeated efforts to reopen issues that have already been decided, and slow, unenthusiastic implementation of policies to which a Service objects.
>
> The results of such parochialism are, for example, reflected in: the development of the AX aircraft by the Air Force and the Cheyenne aircraft by the Army for the close air support role; the lack of enthusiasm for airlift expenditures by the Air Force and the Fast Deployment Logistics program by the Navy, both intended to support the Army;. . .and the continued failure to resolve the issue of the best balance between land and carrier-based tactical air.[7]

This attitude, so well depicted by the Panel, may also have led to the birth and growth of the large number of laboratories within the Department of Defense. There were 78 laboratories and 48 test and evaluation centers that, as of 1970, according to the Panel were not organized in any systematic fashion. Instead, they were fragmented along technology lines with limited scope and responsibility. The Army had 55 labs, the Navy 45, and the Air Force 25.[8] There was and still is, possibly by necessity, a large amount of overlap in the missions of some of the labs and test centers. For instance, both the Army and Navy have guidance test facilities that display capabilities similar to the Air Force's CIGTF except for that portion concerned with precision rocket

sled testing. And even here the Navy has demonstrated a limited capability.[9]

Other Findings on Duplication

The Blue Ribbon Panel's report emphasized the need for better test and evaluation management and cited the need for a major Department of Defense-wide study of the Test and Evaluation Facility Base. This study was completed in August of 1971 and, as a result of its findings, the Test and Evaluation Facility Base was established, consisting of 26 activities with a combined annual budget of well over one billion dollars.[10]

This study indicated that while each of the major test and evaluation support facilities is unique, some overlapping capability does exist for certain routine jobs. According to the study, direct competition exists only for a small portion of test and evaluation work. There is competition, however, for test support work assignments in some limited circumstances extending even beyond the Defense Department. Competition exists not only for jobs within existing capability where overlap is minimized, but also for major new programs requiring more sophisticated instruments that provide justification for extending or upgrading capability.[11]

The following comments extracted from the April 1974 issue of the Defense Management Journal from an article on

funding policy for test and evaluation activities indicates competition between these agencies for work which in itself leads to the high probability of some facilities duplication:

> Healthy competition can be beneficial but the lack of uniformity in funding practices distorts cost comparisons between projects, causes inflexibility in the choice of support facilities for specific tests, tends to inhibit joint military service and interservice use of support activities and can result in mismanagement of work.[12]

> The managers of support activities generally prefer institutional funding, but not all of them. Those who have learned to operate successfully under a user funding system usually prefer that system. But they do not like unfair competition and resent losing work to organizations that do not charge users.[13]

The tone expressed by these two statements becomes crystal clear when consideration is given to the fact that most R&D test activities are charged with maintaining a state-of-the-art test capability. Thus when guidance technology expands, or is extended from wire guided missiles to radio guided, to inertial guided, to terminal guided, to maneuverable re-entry guidance, and to whatever comes next, the competition for advanced development funds to develop the instrumentation necessary to meet the new weapon testing requirements becomes very great. In fact, survival of test agencies could and does in some cases depend on their ability to adequately support these test missions of the future. Thus the competition is strong to play a role in future test activities and quite naturally leads to some duplication of efforts. This is not to say that all duplication in R&D

testing is bad and should be prohibited. The competition, for instance, displayed by the private sector offers numerous benefits that can be likened to test and evaluation in the public sector. What is most important, however, is the astute need to understand and provide direction and control to the competition in the public sector.

Up to now duplication has been discussed which is hard to attribute a cost factor to. However, the point is that evidence does exist which indicates that some duplication does unnecessarily prevail and probably always will. Perhaps with a recognized marketing approach of assessing customer needs rather than competitively attempting to sell test capabilities, this type of duplication could be reduced significantly. After all weapons developers would like to achieve as much as they can for their dollar.

The next section attempts to attach a dollar figure to specific areas of unnecessary duplication that were uncovered in the CIGTF Project Review.

Specific Incidences of Duplication as Observed from CIGTF Project Review

The development test cost relating to a duplication of facilities was not found to be as critical a problem as the literature through 1973 suggested. However, specific cases were discovered within the projects reviewed that do show unnecessary duplication and a cost associated for these specific cases was determined.

A thorough study of duplication was not conducted since the intent was only to show that duplication does exist.

As pointed out by the Blue Ribbon Panel, three times the level of expenditure associated with major systems is required in the development of minor systems.[14] Thus the duplication indicated by the following is indeed significant when consideration is given for this type of activity as it might exist department-wide.

Project A--Vibration Test

Project A, a major lab and sled test program conducted at CIGTF was canceled in late 1974. A substantial portion of the testing was moved to another Air Force Base under a different command where a complete vibration test facility was established to replace the testing previously accomplished at CIGTF. The fact that the CIGTF had the necessary facility, unique test equipment and technical expertise to do the planned testing seemed to have no bearing on the decision. The new facility has not yet produced other than to show its feasibility while CIGTF underwent a reduction in force as a result of the program cancellation.

The added cost of developing the vibration test facility to do the job that could have easily been accomplished at CIGTF was in excess of $300,000.

Project D--Accelerometer Centrifuge Test

Project D conducted by the CIGTF encountered an interesting case of testing a prototype accelerometer on facilities belonging to a private contractor rather than using the more precise equipment owned and operated by the CIGTF. This obviously occurred as a result of ineffective communication between the test agency and the test customer. This occurrence was estimated to have cost the weapons developer approximately $30,000 more than would have been required had CIGTF conducted the test in accordance with the CIGTF test director's recommendation.[15]

Other Less Clear Cases

The two examples given here, Project A and D, show clear duplication that was unnecessary. There were other projects reviewed that indicated in a somewhat cloudy manner that similar situations had also occurred but on a much more expensive level. However, these were highly controversial issues with possibly biased positions being held by those interviewed. One of the questionable areas was concerned with what appeared to be the development of a second aircraft test group for the test and evaluation of guidance systems.[16] A second questionable area recently encountered was the direction to CIGTF to phase out its Terminal Guidance Laboratory effort and ship the sophisticated equipment that had been developed at CIGTF and in use at CIGTF to their

mother organization at the Armament Development Test Center at Eglin Air Force Base, Florida. It remains open to serious question as to whether or not this equipment would have been of much more value in supporting the rocket sled test and captive aircraft test missions of the CIGTF than it will be at Eglin.[17]

Workload Instability

Workload stability for research and development test centers has always been of great importance to test center managers. The cost, associated with unproductive resources, concerns itself with much more than just the manpower payroll. Indeed, the lack of challenging work for competent engineers and scientists as required in the research and development test area can lead rapidly to the demise of adequate test capabilities. Dr. J. S. Foster, Director of Defense Research and Engineering, observed that:

> Our most important asset in the labs is PEOPLE--dedicated professionals whose careers are committed to the development of systems and weapons of the operational forces. The people uniquely provide continuity and integration in what would otherwise be a highly fragmented pattern of discontinuous and heterogeneous contributions to the desired end.[18]

Workload stability under institutionally funded test centers could be and was in many cases successfully accomplished by innovative management. The CIGTF, for instance, has historically applied about twenty percent of its available resources to insuring the maintenance of a state-of-the-art

test facility for guidance and navigation system/component testing. These resources were expended for the most part during periods of low workload and did on occasion exceed fifty percent of the work force for various sections. Policy of this nature called for workload stabilization, good planning, and close attention to future requirements. As such, the development of test techniques and instrumentation systems for test items of the future provided challenging and meaningful work to the scientific and technical personnel making up the CIGTF. This same approach to providing workload stability was successfully pursued by a number of the smaller R&D test centers prior to the unified Test and Evaluation Funding Policy implementation.

Funding Policy Background

The Test and Evaluation Facility Base Study did not investigate funding policy of the twenty-six centers established as the facility base. However, the study group did find that variations in funding practices had contributed to the selection of test facilities that were clearly not the best choice for some specific test applications.[19] This finding led to an indepth study of the twenty-six activities by a Funding Policy Group that was completed in April 1972. The study group recommended that indirect costs be funded institutionally and direct costs except for military labor be funded by the agency regulating the test, the user, on a

uniform basis at all twenty-six activities.[20] In January 1973, Deputy Secretary of Defense Packard directed implementation of this funding policy to become effective at nineteen (later changed to eighteen) of the twenty-six activities on July 1, 1974.[21]

Managers at most of the larger test facilities which were under full institutional funding prior to the Secretary's funding directive felt that they could not operate effectively under a system of complete user funding. They contended:

> . . .{that} their costs do not vary with workload; that user funding discourages testing; that reliance on customer funds could compromise independence; that user funding creates administrative difficulties; that they cannot predict their workload very well; that last minute cancellations and delays which characterize the test and evaluation business could cause severe financial problems; and that user funding would cause erratic budget fluctuations not conducive to maintenance of an adequate test and evaluation base.[22]

In summary, the larger test centers that were operating under the institutional funding concept were reluctant to support the full user funding concept and were uneasy about depending on users to finance their operating expenses.

As history shows, these concerns for full user funding were valid. The Arnold Engineering Development Center (AEDC) switched from full institutional funding in 1970 to an almost full user funding posture in 1971 and was almost forced to close their doors due to significant decrease, down to

fifteen percent, of their anticipated workload. This resulted partly from the economic decline in the aerospace industry as a whole and partly from the inability of potential (expected) customers to pay the new higher price for testing.[23]

A study conducted in early 1975 showed a significant drop in utilization rates of a large number of the test centers that had come under the new funding policy. The utilization rates dropped to about sixty-five percent for some of the larger test activities under a funding scheme that was established at approximately seventy-five percent institutional and twenty-five percent user.[24]

In contrast to the opponents of full user funding, a few of the test activity managers, those accustomed to and successfully operating under a complete user funding policy, preferred that system. They maintained:

> . . .that user funding encourages cost consciousness; greatly improves communications between support activities and their customers; supports the program management concepts now practiced by DOD; highlights overcapacity; and asks the right questions of the right people at the right time.[25]

These managers also suggested that high priority projects tended to unnecessarily monopolize test facilities that were institutionally funded. In short, managers of full user funded activities that had been successfully used prior to Secretary Packard's funding directive felt that partial

institutional funding was ". . . a major step backward in the evolution of financial management systems."[26]

The view of most program managers, users, supports that voiced by the proponents of user funding. They contend that:

> . . .without testing funds, they have responsibility without matching authority; that they are and should remain primarily responsible for the quality of their product; that they should be able to balance resources between testing and other aspects of their programs; that they get better reaction to requirements if they have the funds; and that institutionally funded activities tend to be overly independent and insensitive to time schedules.[27]

However, program managers for the most part do not relish increases in their budgets, even when the increase is in reality nothing more than a cost transfer for services previously provided without reimbursement.[28]

Program Terminations and Slippages

Under the new funding policy, test centers are finding it difficult to effectively cope with project cancellations. This results primarily due to the fact that some budget expenses are fixed costs. Thus, some test program costs are incurred whether any project work is completed or not. Civilian pay is one example of a major cost for which test center managers have little control flexibility. Bound by Civil Service regulations, they are not free, nor would it be desirable, to hire and fire personnel as the workload at the center fluctuates. Thus, while small changes in

workload can be handled, the test center manager is still faced with an essentially fixed size payroll every two weeks. The same may also be true for other elements of expense such as contractor services or equipment maintenance contracts.[29]

Thus the cancellation of a program results in the loss of anticipated reimbursible income for which the test center must recoup from some other source or face cutbacks in other areas.

A problem closely related to program cancellation is that of program slippage, particularly slippage to the following fiscal year. Testing is a very dynamic business, not only in actually running the tests, but also in scheduling. Since testing is usually conducted at the end of some developmental or production activity at the contractor's plant, it is extremely sensitive to slippages early in the program. Historically, tight development and production schedules at the contractor's facility have led to the late arrival of the system at the test facility.

These delays can occur for a multitude of reasons other than contractor slippages. For example, there may be hardware problems in the test build-up, or poor test results may necessitate further testing. These slips may affect not only the immediate project, but any other programs that were planning to use the same test apparatus or engineering personnel.[30]

Examples of this variability are shown by three projects which were examined during project review. One project was on its current schedule, but comparison with its original schedule was impossible since its scope of work had increased by almost a factor of two. A second project arrived at the test facility seven months late due to contractor technical problems which delayed construction of a subassembly. The testing itself was running approximately three months behind schedule due to hardware problems and uncertain test results. The third program examined had still not arrived at the test center as of January 1976. It was originally scheduled to begin testing in December of 1974 and had gone through a series of slips. Hardware complications and changes in technical direction and scope were pointed to as reasons for the delays.[31]

It is not the purpose here to justify the slippages or even give a detailed explanation as to why they occur. Rather, what must be emphasized is that slippages are an important fact of life at any test facility and their effects must be recognized.

Under the old institutional funding arrangements, slippages (even those across fiscal years) were bothersome, but were not important from a financial standpoint. The test center received just as much money for working on in-house projects as they did for working on a customer's

project. If some slack time developed, the test engineer could use it to work on some in-house effort or help out on one of the other on-going projects. Likewise, the user was not put in any financial "pinch." The customer (user) only reimbursed the test center for items such as supplies and test equipment which could be purchased ahead of time and stored until needed.[32]

However, this has all changed under direct cost funding, and slippages, particularly slippages across a fiscal year, can hurt both the test center and the user. The test center must earn the reimbursible portion of the budget, but this can only be done by performing work on the project. If the project arrival has been slipped, or if the work has been halted due to poor test results, civilian personnel and other direct fixed costs of the "slipped" project still have to be paid. Instead of being earned and thus paid through the reimbursible portion of the budget authority, these costs must now be paid from some other source such as overhead--where the money supply is limited.

The need of the test center to recoup its fixed costs can also put the user in a financial dilemma. Should the test center be unable to find new and previously unfunded programs to utilize the resources left idle by a slipped program, the user faces two alternatives. First, if the user has another test project within the same program

element at the same facility, he may transfer the funds from the original project to this new effort. If the user is not this fortunate, his command may choose to redistribute his T&E support funds to previously unfunded test efforts at the test facility so the center can earn the required reimbursible to stay in business. Should both of these alternatives be unfeasible, the test activity has the option to assess termination costs against the user. These termination costs can be assessed up to the full amount of the previously budgeted expenditures at the test center.[33]

The user can also be in financial difficulty if his program slips to the point where the testing cannot be finished by the end of the fiscal year. If there is money left in the user's T&E fund, then it is subject to reprogramming action at the close of the fiscal year. Short extensions to finish the testing can be obtained, but not easily.

Either way, the user may end up in the same position--without his money and without his tests. This leaves the user in a very undesirable situation. First, he still has a legitimate need for testing in the program that was slipped, but his test funds have been "reprogrammed away."[34] Second, even if the user's budgeted T&E support funds were taken away early in the fiscal year, it would quite probably be too late for him to include funds for this required test

in the following year's budget. Instead, the user must assume the difficult role of rejustifying the needed money from fall-out of other programs.

This problem must be observed from both the standpoint of the test center and the user, keeping in mind that funding practices of either users or range operators must not impair legitimate and valid testing.[35]

Uncertainty in Test Requirements

The new funding policy has a direct impact on test center planning. It has caused much more than changes in the mere structure or form of the budgeting process; it has changed by demanding a great deal more attention to the planning process. Test centers are having to move from a functional type of planning which concentrates on cost classifications such as civilian pay and contractor services to job order planning where it is necessary to look at the costs of individual tasks.

Along with this change in the type of planning comes a change in the relative importance of project costs. No one will say that it was never important for a test center commander to plan accurately and remain within his budget under the old institutional funding. It was indeed very important. But the requirements of direct cost funding now make it critically important that test centers accurately forecast and remain within the many "budgets" (cost

estimates) of the various projects accepted from customers/ users.

Also changed is the source of funding for the test center. This is likely to influence the attitude of user and test activity alike. The test center is now dependent on the user for at least a portion of his budget and is thus more likely to pay even closer attention to the user's needs. The user in turn is paying for the tests and having to defend budget requests before his command, DOD and Congress. Thus he is more likely to pay close attention to the type of support requested and the efficiency with which the work is carried out. Both of these self-interests should dictate closer coordination between user and test center as to test requirements and resources. This improved coordination is necessary because both must now plan and budget together for testing which will not even start for another two years.[36]

The cost estimating approach used at the CIGTF is essentially sound. However, there are several general problems and specific procedures which can lead to highly inaccurate estimates.

A recent study found that the long lead time required for the new budgeting procedures of direct cost funding has begun to affect the quality of the test requests submitted to the test agencies. In many cases, the weapons developers were unable to sufficiently define testing requirements two

years in advance. Some test requests were received with only a two-line statement of work. In the best of circumstances this results in long delays while the test center contacts the user and determines what he really wants. In the worst case, the user does not know what the test requirements will be, but has submitted some vaguely worded statements so that he can include some type of cost estimate in the budget.

The test center is caught in a bind because it must submit a cost estimate for even the most poorly worded test request. The centers do not have the option of "not bidding" on poorly defined efforts. In some instances the user is truly unable to determine his long lead time requirements in sufficient detail. In other cases he is simply unwilling to expend the effort needed to write a good test request. In either situation, the cost estimate degenerates to a mere guess.[37] Thus cost overruns and underruns have been experienced.[38]

The magnitude of changes in test requirements is dependent on the clientele using the facility. At the CIGTF, over 75 percent of the proposed FY75 reimbursable budget was for projects in the exploratory and advanced development program elements. This type of program was investigated by Captain Walter Peterson, Jr. to determine the pattern of change in test requirements that could be expected.

Captain Peterson found that:

> Records of past test program changes were not readily available at the test center. The financial impact of changing requirements had not been as important under institutional funding, therefore there had been no compelling reason to keep a separate record of these changes. In the search for information, it was pointed out by test center personnel that the test center is often the last to hear of proposed changes and that better information might be available from the users.
>
> The users did indeed have more detailed information. A total of 56 FY75 projects in the exploratory and advanced development program elements were investigated. These projects related to a single user and were scheduled in the original direct cost funding exercise of June 1973. As of May 1974, 35 of these programs had been deleted either because of program cancellation or slippage into a different fiscal year. Offsetting this decrease were fifteen new projects requiring testing during FY75. Of the remaining 21 original programs, six had changed in scope by an average of 41%. Thus, only 27% of the projects identified in June of 1973 remain unchanged just one year later.39

Changes of this magnitude reflect the unknowns present in applying newly developed technology and the quick reaction required to support the various weapons developers and operational commands. The changes also reflect the fact that future test efforts are highly dependent on the results of current testing. These tests may show the project's approach infeasible, and the project will be abandoned in favor of another that promises to be more successful.

The need for last minute changes in these advanced technology programs is recognized by the fact that their technical review lags the budgeting cycle by a full year. For example, the FY76 Air Force programs which were budgeted

in October 1973 were not reviewed by DDR&E, Strategic Air Command, Air Staff and Air Force Systems Command until October of 1974. This type delay does allow advantage to be taken of the latest technology and operational requirements.

Changes in the exploratory and advanced development programs highlight the dynamic nature of testing. However, changes are by no means limited to programs in these categories. Determining what testing needs to be done and then forecasting where and when is difficult on any program. Planning over a two-year lead time leaves the manager at the mercy of unanticipated equipment difficulties or preliminary test results showing needed additional development.

Even when the program gets to the test center, the situation is fluid. One person at Air Force Systems Command cited studies that show tests will change as much as forty percent over their lifetime, and a branch chief at the CIGTF said that any estimate within twenty to forty percent was a good one.[40]

The reason behind testing is to find the unexpected. The performance of the system needs to be determined and any problems located and explained. For that reason testing cannot be planned as a known entity. Testing is dynamic and therefore needs flexibility in the level of testing and where the tests are conducted.

Cost

One result associated with the uncertainty of being able to adequately define test requirements as far as two years in the future for "fixing" budgets is workload instability. The cost that could be attributed to workload instability depends on numerous circumstances. However, when highly trained and paid scientific personnel are idle, the cost of that idleness could mean much more in terms of lost capability than it does in terms of lost payroll. But in order to develop a worst case for purposes of the hypothesis (lowest reasonable cost), only lost salary will be considered.

The results obtained by Carter and Cavender in their "ASC Funding Structure Study" indicated that utilization rates had dropped to near sixty-five percent on the average for the eight facilities reviewed. These facilities, of course, employed different numbers of personnel ranging from fifty-five at the smallest to well over one thousand for the largest.[41] Since this drop in utilization could have been a result of the first year budget estimates, a very conservative approach to developing a cost figure was taken. It is based on an approximate ten percent reduction in the utilization rate that occurred at CIGTF during calendar year 1974 as a result of program terminations and cancellations. CIGTF employs about 135 civilians with an average salary

of $12,000 per annum. Thus ten percent of the 135 civilians times $12,000 equates to a dollar loss of $162,000 die to workload instability. This type of cost calculated for the test centers whose utilization dropped by as much as thirty-five percent could be tremendous.

Lack of Effective Developmental Testing

> In recent years, paper studies and analyses have often been substituted for essential hardware development and testing. As a result, uncertainties which could be eliminated or reduced are carried over into engineering development or operational systems development, where unresolved technical problems are significantly more expensive and troublesome to remedy. In addition, new technology which would improve weapons capabilities is often lost in the process.
>
> Increased emphasis on and funding of advanced development to yield various forms of prototype equipment, which can be tested prior to commitment in a weapon system, is essential.[42]

These two paragraphs quoted from the Blue Ribbon Panel's Report to the President and the Secretary of Defense in 1970 brought to light the true inadequacy of development testing associated with weapons procurement. From this starting point, numerous policies with respect to weapons procurement were initiated. Most noted among them were the fly-before-you-buy concept. Deputy Secretary of Defense David Packard described this concept as:

> . . .fly-before-you-buy means having an acceptable level of confidence that we know what we are doing before we move ahead. It means development problems are in hand before we do engineering. It means engineering is ready before we go into production. It means we have confidence in the need for the capability before we enter into any of these phases.

> It means the management plan is sound and the costs are described and controlled. Within these meanings, we must have the objective of fly-before-you-buy on all of our programs.[43]

This fly-before-you-buy idea was not expected to be an instant cure-all for inadequate testing, but since the start of its implementation in 1971, much improvement has been made. However, a review of current literature and the project record review at the CIGTF reveals far too many cases where the development test phase is being drastically shortchanged in spite of the advice and direction which has continually come from top level managers, scientific advisory boards, and scientists within and outside the Department of Defense since the Blue Ribbon Panel Report.

Development Testing Stressed

Typical of that continuing emphasis are such comments as those made by Secretary of Defense, Melvin R. Laird, in reporting to the Congress;

> . . .faulty initial decisions based upon unrealistic requirements, improper contracting and inadequate testing have gotten the Department of Defense "locked-in" with contractors and inadequate weapon systems designs.[44]

The Defense Science Board in its Report of Task Force on Reducing Costs of Defense Systems Acquisition in March 1973 stated as one of its ten recommendations that ". . . greater emphasis be placed on the test and evaluation of prototypes, and less on paper specifications."[45]

David Packard, after his tenure as Deputy Secretary of Defense after returning to his post as Chairman of the Board for Hewlett-Packard, stressed that prototyping could provide considerable improvement in R&D management and bring weapons cost down. Writing in the Defense Management Journal, Mr. Packard stated:

> There are some practices in this business {weapons acquisition} which are real waste rather than conspicuous waste. There has been real waste of both time and money in almost every program in which production was started before development and testing was complete. That includes almost every program.
>
> Engineering changes that are made on the production line are costly and wasteful. They generate waste, real waste, right down through the subcontract structure.
>
> Hundreds of millions of dollars have been wasted buying spare parts before the final design is settled and before the real requirements for spares have been confirmed. A recent report by the General Accounting Office (GAO) found over a hundred million dollars wasted on spares on one program alone. I happen to know the GAO was right in making this conclusion.
>
> Prototypes-hardware models and adequate testing before production can be a major step forward to correct some of the disastrous failings characteristic of the total defense system approach and the total package procurement.[46]

Mr. Packard's article strongly points out the need for adequate development testing before making procurement commitments. He speaks of his first-hand knowledge of the fact that hundreds of millions of dollars have also been spent unnecessarily because weapons development managers felt they could not

afford to waste the time required for development testing and as a result ended up incurring more costly delays.[47]

Mr. Packard's grasp of ineffective weapons development testing appears monumental. He forcefully stated that reliability, a quality lacking in recent major programs, cannot be achieved by formula or analysis. He said the only way to achieve reliability is to "Build it, test it, and fix the things that go wrong. Repeat the process until the desired reliability is achieved."[48] With respect to fixed schedules, Mr. Packard had the following remarks:

> A few months ago at a meeting of military project managers, someone objected to extensive testing because it would delay the program. He complained that testing showed up things that needed to be fixed and it took time to fix them, and this would delay the initial operating capability. Unless we get rid of that kind of thinking, there will be no hope.
>
> Prototyping must be backed with testing, and schedules must not be fixed until we have a hardware model that meets the requirement of the job and which has demonstrated reliability.[49]

This same emphasis on development testing was also strongly voiced by Dr. John S. Foster, Jr. when he was Director of Defense Research and Engineering. Dr. Foster made such statements as follows: "Performance is enhanced only if the system performs longer and cheaper and better in service tests, not in the brochure . . . {do not} give up something familiar and proven for something that looks ten times better on paper."[50]

Barry J. Shillito, Assistant Secretary of Defense, strongly encouraged subsystem development independently of system acquisition. Writing about testing, Assistant Secretary Shillito said:

> Within the last year (1972) we formalized our testing procedures to give greater emphasis to hardware tests and test results, particularly independent operational testing of weapons systems. But a "go/no go" evaluation of a weapon system is not enough. Each subsystem must be thoroughly tested early in its development cycle before it is interfaced with other subsystems to comprise a complete defense system.
>
> . . .it is worth the time to test early rather than spending more time and much more money to change a design and rebuild a system which turns out to be deficient after delivery. On most weapons, the cost of changes goes up exponentially as they move from the design phase to production.[51]

This very strong emphasis on the necessity for development testing is still being promoted even as recently as January 1976. Mr. O. C. Boileau, President of the Boeing Aerospace Company, wrote:

> The old expression "haste makes waste" was never more true than in the front end of an R&D program. The usual reaction of a program manager who knows that money is time and people is to squeeze them both, ultimately making the mistake of assuming too much. He assumes that a technique that worked on one project will work on another, perhaps taking a component or subsystem from a sister project without bothering to test it. And when he goes into production, the question he glossed over during R&D comes back to haunt him.

Ineffective Testing Cited by the Literature

Even with the very great emphasis on development testing as pointed out in the preceding section, there are numerous

instances where this concept has not been employed; and it can be questioned with respect to quite a large number of the weapon systems components that are in the conceptual design review phase now.

Dr. Foster writing in the Defense Management Journal described two cases of ineffective development testing concerning aircraft avionics subsystems. The first was uncovered when a special study of five airborne radar systems with specified mean time between failures (MTBF) ranging from seventy-five to two hundred and fifty hours actually exhibited MBTF's of five to ten hours. The second case concerned the aircraft navigation systems. For one group of navigator sets, the annual operating and maintenance costs were about half the purchase price. For a new version of the system requiring much more stringent accuracy, the annual operating and maintenance costs exceeded the purchase price. Dr. Foster said that this exemplifies the "paper approach" to improvement and certainly leads to waste.[53]

Mr. O. C. Boileau, President of the Boeing Aerospace Company, provides just one case as an example where development testing is cost effective:

> If we at Boeing had made one small test--a $10,000 test--on a sample foil for our jet foil boat program, we would have conclusively found that our first design was inadequate from a cost standpoint. Instead, we sent on to manufacturing a detailed design which caused no end of cost and schedule grief.[54]

Mr. Boileau then proceeds to say that, "People are going to have to be convinced of the inherent wisdom in spending money upstream to save more money downstream."[55]

Aviation Week and Space Technology reported in its November 17, 1975 issue that the A-10 close support aircraft, predicted to have a ten percent improvement in performance over the prototypes had instead a performance decrease of twenty to thirty percent.[56] The reasons as yet have gone undetermined.

The Navy's Condor missile reliability was questioned by the unit responsible for conducting the operations evaluation testing of the prototype. Fierce infighting between Pentagon officials favoring Condor and the Defense Systems Acquisition and Review Council who questioned the Condor finally resulted in a compromise whereby continued testing would be accomplished while entering missile production at a slow rate, five missiles per month instead of twenty per month. Thus the Navy's Commander, Operational Test and Evaluation Force Report on Condor's questioned reliability was written off by high Pentagon officials as being less than objective in its "zeal to be honest."[57]

The Government Accounting Office (GAO) found that nineteen Condor firings were conducted using pilot production missiles which resulted in twelve successes, five failures and two "no tests." They reported that the Test

and Evaluation Force expressed serious concern over the operational effectiveness of the missile because of:

> Condor acquisition of targets is degraded significantly in haze or in presence of low scattered clouds.
>
> Penetration aids such as jamming, anti-radiation missiles, or decoys are required to assist Condor to reach a defended target.[58]

Consequently, GAO recommended more testing before production.

The cost of the Condor missile under large production quantities (855) will exceed $305,000 per copy. The cost of the extra reliability testing was estimated at $800,000 when first suggested by the Navy Test Team. Those estimated costs as of November 1975 had risen to $1,700,000.[59] This example suggests that appropriate development testing was not accomplished at the subsystem level, thus resulting in the extremely high cost of system level operational type testing to solve the problem.

There are many other examples of ineffective development testing of weapon systems and their components showing up in the pertinent trade magazines. The few cases cited here are intended only to show that development test needs are not being satisfactorily met; and that it is indeed expensive when test needs are not met.

After-the-Fact-Development Testing

Of the fourteen projects reviewed at CIGTF, projects C, I, and K were required in order to help solve design

problems in systems that had already been stockpiled for operational use. In each case, the tests were successful in determining the design flaw. The cost of after-the-fact testing for these three projects added up to approximately $2,000,000. However, this was insignificant compared to the cost of modifying and retrofitting the stockpiled weapons system which was over one hundred times as much. Had these subsystems undergone the same type of testing prior to the production decision, not only would the exorbitant cost of modification have been avoided, but chances are that the earlier testing would also have resulted in performance improvement rather than just a fix.

The weapon systems tested under projects C and K were discovered defective after deployment in Southeast Asia. Thus there may have been additional major costs, possibly even life itself, as a result of ineffective performance in combat situations. The weapon system tested under project I had not been deployed. Its failure to operate properly was observed during a combined operational test flight/training program.

In addition to these three cases, test programs are now being considered for at least two major weapon system's guidance units that are suspected to have performance problems. These guidance subsystems were not evaluated at CIGTF (focal point for guidance test) prior to production buys.

Cost Savings of Effective Developmental Testing

This section is concerned with a much more pleasant topic--examples of weapon systems and subsystems development testing that paid high dividends. It provides some proof that testing early in the development cycle when started at the lowest possible subsystem level is cost effective and undoubtedly a major reason behind the very strong emphasis to employ the concept of fly-before-you-buy.

A Few Cases Cited by the Literature

Robert C. Seamans Jr., while serving as Secretary of the Air Force, made the following comments about some of the cost benefits that had been derived from rocket sled tests of the Guidance system for the minuteman Intercontinental Ballistic Missile:

> ". . .those very effective tests led to a reduction in the number of missile test flights and brought about significant savings in the overall program costs. Subsequently. . .the Titan I guidance package and many other systems with potential application for ballistic missiles were tested, including Atlas, Skybolt and Dynasoar. Also, being aware of this capability, NASA submitted a number of their guidance systems for testing--including Saturn, Centaur and LEM backup system.[60]

The cost for a complete rocket sled test evaluation of a missile guidance set (approximately twenty sled runs) of Minuteman complexity can cost from $500,000 up to approximately $1,000,000 if accomplished predominantly inhouse by the Air Force. The conduct of just one Minuteman Missile

flight costs about $10 million.[61] Thus any time an operational missile test flight fails and that failure could have been observed via the cheaper test, a tremendous amount of resources has been unnecessarily wasted. Conversely, if the failure mechanism can be observed from the less expensive testing, and corrected, then the resources required to conduct those additional operational flight tests to identify and solve that particular problem will have been saved.

Each of the rocket sled test programs cited by Dr. Seamans, except for the Lunar Excursion Module (LEM) tests, uncovered major problems that would have led to unsuccessful missile test flights had they not been observed and corrected.[62] The LEM sled tests verified the functional integrity of this Apollo backup guidance system that brought Apollo 13 safely home.

A significant case of cost savings reported by the Defense Science Board concerned aircraft tests of subsystems of the Airborne Warning and Communication System (AWACS). They reported that over $100 million and a twenty-five percent increase in performance resulted from the fly-before-you-buy competitive test accomplished by the Air Force.[63]

A Few Cases Observed from the CIGTF Review

Of the fourteen projects reviewed at the CIGTF, twelve had achieved their stated objectives and testing had not

yet begun on two of the projects. Project E, an Aircraft Navigation System test costing a little over $5 million produced a significant and unexpected cost benefit. An unexpected problem was identified which saved more than $50 million in lifetime maintenance and repair costs in addition to providing improved accuracy. Project A was a test program established to determine if fleet degradation occurred due to aging in one of the operational missile systems. Data was obtained to meet this objective; but more important, the test series identified two significant component errors and a missing error term in the system error model that had never been observed even though numerous operational flight tests had been conducted. The cost benefit derived from the potential for improved accuracy is difficult to determine, but could be most significant if it means missing or hitting a target.

Similar results could be quoted for each of the systems reviewed that were far enough into their test cycle; in addition to the projects investigated, numerous other cases were pointed out by the CIGTF engineers, analysts and managers where real money had been saved as a result of CIGTF test activities.[64]

Cost Benefit

As might well be expected, the cost of effective development testing is practically insignificant compared to the return.

The savings produced by Project E alone, $50 million, was about three times the cost of conducting all fourteen of the test programs investigated and the savings accrued from the other projects are not even considered.

When the millions of dollars savings suggested by the examples reported by Dr. Seamans and the Defense Science Board are considered, development testing not only looks cost effective--it looks mandatory, especially with limited budget situations.

END NOTES

[1]U.S. Air Force Systems Command Regulation 172-8, Budget--Test and Evaluation Support, 18 April 1974.

[2]Ibid.

[3]Ibid.

[4]Multiple Interviews with: CIGTF Test Directors, Capt. Larry F. Sandlin, Capt. Frank A. Conner, Capt. Richard E. Rumph, and Capt. Terry Hodges: Mr. Fred P. Ray, Chief of Administrative Resources; SMSgt. Emory Magda, JOCAS Manager, conducted at Holloman Air Force Base, New Mexico between 6 and 12 January 1976.

[5]Robert C. Seamans, Jr., Secretary of the Air Force, "Air Force Policies in the Field of Guidance Testing," Keynote Address at the Fifth Biennial Inertial Guidance Test Symposium, Holloman Air Force Base, New Mexico, 14 October 1970.

[6]Ibid.

[7]The Blue Ribbon Defense Panel, Report to the President and Secretary of Defense on the Department of Defense, 1 July 1970, p. 21.

[8]Ibid., pp. 86-87.

[9]Interview with Dr. Larry Mixon, Chief, Improved Capabilities and Development Office, Test Track Division, Holloman Air Force Base, New Mexico, 12 January 1976.

[10]John W. Cooley and James W. Saylor, "New Funding Policy Established for Test and Evaluation Activities," Defense Management Journal 10, No. 2 (April 1974) 15-19.

[11]Ibid., p. 17.

[12]Ibid., p. 17.

[13]Ibid.

[14]The Blue Ribbon Defense Panel, p. 76.

[15]Interview with Richard E. Rumph, Captain USAF, CIGTF Test Director, at Holloman Air Force Base, New Mexico, 6 January 1976.

[16]Interview with Peter V. Zagone, Chief Operational Test Branch at Holloman Air Force Base, New Mexico, 6 January 1976.

[17]Interview with G. R. Mozer, Chief Laboratory Test Branch at Holloman Air Force Base, New Mexico, 9 January 1976.

[18]John S. Foster, Jr., DDR&E. Address at the Thirteenth Annual Air Force Science and Engineering Symposium, Arnold Engineering Development Center, Tennessee, 27 September 1966.

[19]Cooley and Saylor, p. 16.

[20]Ibid.

[21]Ibid.

[22]Ibid., p. 17.

[23]Reuben M. Carter and Pauline P. Cavender, Special Report ASC Funding Structure Study, U.S. Army Missile Command, Redstone Arsenal, Alabama, 25 March 1975, p. 8.

[24]Ibid.

[25]Cooley and Saylor, p. 17.

[26]Ibid.

[27]Ibid., p. 17-18.

[28]Ibid., p. 18.

[29]Walter Peterson, Jr., "The Impact of Direct Cost Funding on Test Center Management," (Master's Thesis, U.S. Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, 1974), p. 17.

[30]Ibid., p. 19.

[31]Data obtained from the project record review conducted at the Central Inertial Guidance Test Facility, Holloman Air Force Base, New Mexico between 6 and 15 January 1976.

[32]Peterson, p. 20.

[33]Ibid., p. 21.

[34]Ibid.

[35]Ibid., p. 22.

[36]Ibid., p. 30.

[37]Ibid., p. 34.

[38]Data obtained from Project Records Review.

[39]Peterson, p. 44.

[40]Ibid., p. 46.

[41]Carter and Cavender, pp. 8-25.

[42]The Blue Ribbon Defense Panel, p. 69.

[43]David Packard, "Toward Better Management of--The Development and Acquisition of New Weapons Systems," Defense Management Journal 7, No. 2 (Fall 1971): 6.

[44]Melvin R. Laird, Final Report to the Congress of Secretary of Defense January 1969--January 1973, 8 January 1973, p. 47.

[45]Defense Science Board, Report of Task Force on Reducing Costs of Defense Systems Acquisition, 15 March 1973, p. xvii.

[46]David Packard, "Improving R&D Management Through Prototyping," Defense Management Journal 8, No. 2 (July 1972): 4.

[47]Ibid., p. 5.

[48]Ibid., p. 6.

[49]Ibid.

[50]John S. Foster, Jr., "Defense Systems Acquisition--As Seen by the Director Defense Research and Engineering," Defense Management Journal 7, No. 2 (Fall 1971): 10, 11.

[51]Barry J. Shilliot, "Defense Logistics: Challenge of the 1970's," Defense Management Journal 9, No. 1 (January 1973): 3.4.

[52]O. C. Boileau, "I Dreamed We Went Nowhere in Our Solid Gold Airplane," Defense Management Journal 12, No. 1 (January 1976): 7.

[53]Foster, p. 10.

[54]Boileau, p. 7.

[55]Ibid., p. 8.

[56]"Industry Overview," Aviation Week and Space Technology, 17 November 1975, p. 11.

[57]Clarence A. Robinson, Jr., "Civil Role in Weapon Efforts Scrutinized," Aviation Week and Space Technology, 17 November 1975, pp. 18-19.

[58]Ibid.

[59]Ibid.

[60]Seamans.

[61]James R. Schlesinger, Annual Defense Department Report FY1976 and FY197T, 5 February 1975, p. II-25.

[62]CIGTF, "Problem Areas and Design Deficiencies Identified and Major Test Accomplishments by Sled Test Programs," Holloman Air Force Base, New Mexico, August 1975.

[63]Defense Science Board, p. 4.

[64]CIGTF.

CHAPTER V

ANALYSIS AND CONCLUSIONS

This, the last chapter of the thesis, is summary in nature. It addresses the cost of marketing in the private sector for weapons development contractors concerned with guidance and navigation subsystems and provides a measure of the significance allocated to the marketing function by these contractors. Next, the cost of marketing in an R&D test center is developed and compared to the potential benefits available through the modern marketing concept. These results are then applied to the hypothesis.

Cost of Marketing in the Private Sector

As indicated in Chapter III, the marketing function varies from organization to organization for the private and public sectors alike, depending on the goals or objectives of each specific organization. Consequently, the cost for this function can also vary.

In order to minimize this cost variability only those companies concerned with guidance and navigation systems defense contracts were queried in developing the cost of marketing in the private sector. Representatives of six large companies and three small companies (less than 500

employees) were contacted and asked how much their companies spent in bidding on specific contracts. In each case answers were made available on condition that the respective companies would not be disclosed. Four of the large companies were asked about the same contract that was awarded for $300,000. The winning company estimated that they had spent $21,000 in their successful marketing effort. The other three companies estimated that they had spent $18,000, $23,000, and $30,000 respectively in their unsuccessful bids. The other two large companies were both successful in their bids on different contracts. The first spent approximately $2,000,000 in landing a $100 million contract. The second estimated that his company had used a little over $50,000 in their succesful bid for a $630,000 contract.

The three small contractors were bidding on the same study contract which contained a prohibitive hardware clause excluding the successful company from bidding on any hardware requirements that might result from the study effort. The study contract was awarded for $97,000. The company winning the contract estimated that they spent $2,500 on their proposed effort. The two losing companies claimed that they had spent approximately $1,200 and $700 respectively for their proposal efforts.

As can be seen from a review of these numbers, the marketing cost for these nine companies with respect to specific applications ranged from expenditures as high as ten percent of the anticipated return to less than one percent of the anticipated return. Of the nine cases, two were less than two percent, five were six percent or greater, and two were between two and three percent.

Each of the nine company representatives interviewed, when asked generally what their companies allocated for the marketing function as a whole, responded with five to 25 percent of the anticipated return. They were all quick to point out also that expenditures could go higher or lower depending on a large number of parameters.

Marketing costs for private industry are not unlike those, generally speaking, observed in the public sector. The major costs, as pointed out in Chapter III, for an R&D test center would be for manpower and travel. As expected, manpower and travel comprise the bulk of the marketing function cost in the private sector as well.[1] The nine companies queried to determine a cost for the marketing function in private industry also represent the essence of what pure industrial funding is all about. Thus, marketing in the private sector has been and continues to be of major significance. Based on the cost figures presented here, an estimate of budget allocations of at least five percent of total company budgets represents a reasonably conservative

estimate of what private industry spends for the guidance and navigation system marketing function.

As R&D test centers move away from institutional funding towards industrial funding, their marketing functions will necessarily become more significant if they are to survive based on merit and not politics.

Cost of Marketing in an R & D Test Center

Most R&D test centers are structured such that the implementation of a modern marketing approach would require minimal additional funding and in some cases no additional funding. This is particularly true for test labs within the U.S. Air Force.[2] This comes about as a result of the budget process. The identification of future work, estimated funding requirements and defense of the requested funds can serve as a basic tool for the marketing function. The budget process for most R&D test centers is well defined and structured for optimum information exchange. However, at least with respect to development testing, it appears as if information exchange is a long ways from being optimum. Thus, it may be that R&D test center managers in general must both recognize the advantages of a sound, well planned marketing orientation and provide substantial directed emphasis towards that goal.

In establishing a typical cost of the marketing function this section of the thesis addresses the estimated cost of

marketing for the Central Inertial Guidance Test Facility in Chapter III and also reports the actual costs involved in an R&D test center which currently employs a marketing concept.

Estimated Cost for Employing a Marketing Concept Within the CIGTF

The CIGTF as described in Chapter III would require an insignificant amount of dollar resources in implementing a sound and directed marketing approach.[3] Thirty-eight thousand dollars as a first-year cost is all that would be required to establish a directed marketing orientation. Second and third year costs were estimated at $16,000 per year, dropping to $2,000 or $3,000 a year after three years. These costs were attributable for the most part to training and travel and represent even in the first year only a fraction of one percent of the $6,000,000 annual operating budget of the CIGTF.[4]

The significance of the marketing function has been recognized by some of the R&D test centers within DOD. The High Speed Rocket Test Track Division located at Holloman Air Force Base, New Mexico, is one such group. This group as a direct result of industrial funding found it necessary and worthwhile to employ marketing as a part of their everyday operation.[5]

Actual Cost of Marketing In an R & D Test Center

In February 1974 the U.S. Air Force Rocket Test Track Division restructured their organization to include an Improved Capabilities and Development Office answerable directly to the Test Track Division Chief. The office is presently comprised of three positions, a GS-14 general engineer, a GS-10 aerospace technician, and a GS-7 administrative specialist. When the office was originally established it included a fourth position filled by a U.S. Air Force Major who served as the office chief until his transfer in November 1975. Since that time the GS-14 has served as the office chief and there are no plans to bring a fourth person back into the office.[6]

The mission of the office is best described by the following extract taken from the official U.S. Air Force Position Description for the GS-14:

> The office is responsible for identifying, forecasting, and prioritizing all future Test Track projects and Test Track improvements to assure the compatibility of test requirements with Test Track facility capabilities, and to extend the track's present capabilities. . . .The purpose of this position is to conceive, formulate, and implement new engineering approaches to increase the beneficial utilization of the track. Incumbent performs and implements studies which are determining factors as to whether track capability projects are initiated.[7]

This mission statement, according to the office chief, is made up of three basic elements: advanced planning, establishment and defense of the Test Track's test instrumentation

budget, and marketing. Advanced planning, the instrumentation budget including military construction programs, and the marketing function are all closely related requiring about ten percent, twenty percent and seventy percent respectively of the office resources.[8]

According to Dr. Mixon, Office Chief, marketing must necessarily precede advanced planning and budgeting. It cannot, however, be ignored or forgotten once accomplished. It must be continually emphasized with what could be described as a two-way feedback network tied to both advanced planning and the test instrumentation budget. Dr. Mixon believes that under the industrial funding concept, marketing as a means of information exchange may be the only tool available that allows for adequate planning in time to develop cost effective test capabilities to meet the nation's development test needs.[9]

In the first six months of the Test Track's marketing effort a ten percent increase in the reimbursible budget was realized. The following full year of marketing was responsible for twenty percent of the reimbursible budget. The ten and twenty percent increases came from new customers. Work realized from past customers was not included in the calculations, even though marketing was applied to all potential customers.[10]

The track's reimbursible budget represents approximately twenty-five percent of its total budget. For fiscal year 1975

and 1976 the track received $1.6 and $1.8 million dollars respectively for testing accomplished. Thus, the total operating budget for each of these two years was approximately $6.5 million--very close to the CIGTF's operating budget.

The cost involved in implementation of the marketing function at the Test Track for their first two years of operation has been almost insignificant. There were no new slots authorized, only a restructuring of existing positions with an increased emphasis on a marketing orientation. Thus, salaries do not represent an additional cost.

The only major additional cost, and it can be debated as to whether or not this represented additional cost, was the travel needed to accomplish the new marketing orientation. Fewer than twelve trips per year were made for less than $6,000 per year.

As was the case estimated for the CIGTF, the actual expenditures at the Test Track in implementing their successful marketing orientation represented less than one-tenth of one percent of the track's operating budget across the two years it has been in effect.

When Dr. Mixon was asked what he felt had contributed most to the success of his office, he replied, "Full and complete support from the boss {Track Division Chief}."[11]

Potential Benefits from Marketing

The potential benefits available from a marketing approach that emphasizes a customer needs orientation are described in detail in Chapter IV. These benefits with respect to avoiding the cost of duplication, lost productivity resulting from workload instability, the cost allocated to ineffective testing, and the cost benefit resulting from effective testing are summarized below.

Cost of Duplication Avoided

Although duplication costs are probably the hardest cost to assess, sufficient examples were indicated by the literature search and the CIGTF project record review to establish that a significant amount of duplication does exist in the area of development testing.[12]

The project record review at CIGTF for one year alone showed a clearly unnecessary duplication cost of $330,000. This figure exceeds the cost of implementing better communication through a marketing orientation that potentially could have alleviated this unwarranted cost by a factor of ten. The other less clear cases of duplication, if they are indeed valid, represent duplication costs which far exceed the $330,000 figure.[13] In fact, the establishment of a second aircraft flight test facility for guidance and navigation test within the Air Force could approach an unwarranted duplication cost in the tens of millions of dollars.

It stands to reason that the avoidance of test capability duplication DOD wide still requires strong consideration. Information exchange via a customer needs orientation at the proper level certainly has a high potential of effecting a significant savings in this respect.

Lost Productivity from Workload Instability

Marketing has not proven to be a cure-all for workload instability in the private sector, and it should not be looked to as a perfect solution to workload instability in the public sector. However, it does provide a basis for improved advanced planning at high enough levels to at least reduce the workload instability problems that presently exist.

The ten percent reduction in the test capability utilization rate that occurred at the CIGTF in calendar year 1974 represented a dollar loss in civilian salaries alone of approximately $162,000.[14] Here again, this cost is about four times that of implementing a marketing orientation which potentially could have avoided this problem by affecting more appropriate and adequate planning through improved information exchange.

Cost Allocated to Ineffective Testing

Ineffective development testing, or more precisely, a lack of effective development testing has proven to be extremely costly for this country.[15] Example after example has been given which show unwarranted costs in the millions

and probably billions of dollars. However, to maintain a boundary to this paper only those costs which were developed from the CIGTF project records pertaining to after-the-fact testing to fix previously unnoted guidance and navigation system problems with stockpiled weapons will be presented here.

Of the fourteen projects reviewed at CIGTF three could be designated as after-the-fact testing. That is, they were found not to work properly after they had been accepted into the inventory. The cost of this testing ran to a little under two million dollars. The cost to effect a fix for the entire set of stockpiled weapons exceeded $400 million.[16]

Had a marketing orientation been in effect throughout the DOD test labs, a potential savings of at least the $400 million might have been realized.

Cost Benefit from Effective Development Testing

The savings produced by just one of the fourteen projects reviewed at the CIGTF amounted to an estimated $50 million. This savings alone was three times the cost of conducting all fourteen test projects.[17]

Significant dollar savings were also estimated from each of the other projects that were well into their test phases. However, reasonable estimates of savings were not yet documented for those cases.

When the cost benefit observed from guidance and navigation system development testing at the CIGTF are considered,

along with the multi-million dollar savings occurring from development testing as reported by such noted individuals as Dr. Robert C. Seamans and by highly respected sources such as the Defense Science Board, the ultimate value of effective development testing highly favors an information exchange media which results in more testing and even greater cost savings.[18]

Summary of Potential Benefits

The cost of marketing in government test centers can be insignificant compared to the savings that can result from less duplication, more productive utilization of test resources, and more effective developmental testing early in the development cycle by the implementation of a marketing orientation.

The cost of marketing for most R&D test centers should not exceed one percent of their operating budgets. Yet, the return on this investment can be tremendous when consideration is given to whether or not a weapon system works properly when it is needed.

The value of R&D was recently stressed by Norman R. Augustine, Undersecretary of the Army when he stated that ". . .in terms of combat capability, R&D has provided an almost 25 percent increase over the past ten years." Statements such as this are not unusual in the literature. Imagine what the return could be if the cost associated with

duplication, workload instability and ineffective development testing could be avoided.

Hypothesis Revisited

> Marketing as a method of information exchange by test agencies can decrease weapon systems development cost.

If the principles established in Chapter III are applied to the problem areas discussed in Chapter IV, a significant reduction in DOD weapons systems development cost can reasonably be expected.

However, the marketing function for each specific government test center must be clearly defined and implemented ethically. To be successful, the marketing plan should be developed in accordance with the basic principles promoted by C. West Churchman in his book The Systems Approach.[20] Great care should be taken in establishing the marketing system objectives, for as Churchman so clearly states:

> We all hide our real objectives because in some cases they are hardly satisfactory ones from the point of view of other people; if they are widely publicized they may be harmful in terms of our prospects of attaining various kinds of support in our lives.[21]

Like the holding of power, marketing will require moral integrity and responsibility on the part of managers to insure that this very strong and potentially effective tool is not misused. It will not be misused if continued emphasis is placed on responsiveness to the organization's external publics rather than to itself. This requires moving towards

a user benefit orientation which suggests the following important questions posed by Dr. Jordon D. Lewis, director of the Experimental Technology Incentives Program:

- How well are user needs understood? How shall these needs be segmented and aggregated to be effectively addressed?
- What are the social and economic priorities of the market? What are the trends?
- What are the alternative ways the user needs might be met?
- What technologies, facilities and manpower will be needed to handle these alternatives? What is presently available?
- What are the barriers to technological change in this market? What might be done about them? What assurance is there that the contemplated R&D will be used?
- What are the social and economic costs, timing and probability of success of alternatives available to the agency? Is the timing of the forecast R&D results compatible with events in the market?
- How should R&D contractors be selected so as to increase the chances that the R&D results will be employed?
- Do the goods producers who would use the R&D results have the resources and incentives to do so?[22]

Dr. Lewis claims that the answer to these questions which are not unlike those suggested by Churchman comprise the guiding framework for an effective marketing approach in an R&D environment. He suggests that they be vigorously pursued in two ways:

- Within an agency by a staff of senior professionals having the same status, respect and clout as other senior professionals.

- Externally by seeking, on an advisory basis, substantial involvement of the relevant producer community in the design and evaluation of the R&D program.[23]

David I. Cleland and William R. King's description of the role of a military project manager (weapon systems developer) is not unlike that required of a test agency in implementing a sound marketing orientation. If in their description the words "test agency" are substituted for "project manager" and appropriate pronouns are used, it would apply equally well to describe what a marketing oriented R&D test center should be:

> One of the project manager's greatest sources of authority involves the manner in which he builds alliances in his environment--with his peers, associates, superiors, subordinates, and other interested parties. The building of alliances supplements his legal authority; it is the process through which the project manager can translate disagreement and conflict into authority (or influence power) to make his decisions stand. Sometimes the power and control of the project manager represents a subtle departure from his legal authority.[24]

Most R&D test centers are not dismayed to find that there is less than complete and enthusiastic support for their recommended test programs within their service and the Office of the Secretary of Defense. Every weapon system competes with all the others for limited resources, and this competition is especially fierce in periods of tight budgets. At every level in the hierarchy, commanders and staff personnel are confronted by demands from weapons development offices for far more money than is available or

can reasonably be obtained. Thus budget recommendations and decisions are being made that inevitably favor some programs over others. More often than not the squeeze is applied to the development test funds in order that programs can remain competitive for the available monies.[25]

The R&D test centers that have done their homework and kept key people informed about their capabilities and their problems will improve the odds that testing funds from a project will not be cut. This is not to suggest that test agencies affect a hard-sell stance or set up lobbies within the weapons development offices. What is being suggested is that test agencies should become more attuned to the information needs and biases of the people who influence budget decisions. They should strive for a greater role in assisting the weapons development offices in establishing and defending that portion of the budget concerned with test funds.

R&D test centers must keep in touch with what is going on above them. They have to be aware of what is expected by higher authority and they should know the typical questions being asked at major program review points by high level managers of weapons development offices. And foremost, the test centers must recognize that the requirements for information by higher authority are constantly changing.[28] If an R&D test center is to accomplish its

mission in the most effective manner, it must know its major customers; their history, organization, people, and the way they do business. To understand the customer a test agency needs to know something about the specific industry that the customer is involved in; its growth or decline, its problems, and what motivates the customer's business in general. In private industry a weapons development contractor goes to great lengths and spends a substantial amount of money to learn everything it can about its customer, the government.[27] R&D test centers should do no less in learning about their major customers, the weapons development offices within the military services.

The military services have established a number of research and development laboratories covering a wide range of technical and scientific fields. Government laboratory personnel often serve as technical monitors for weapons development offices on contracted research and development work. They also do research, design and development work in their own right, utilizing valuable capabilities which are often overlooked in weapon systems acquisition.[28] For the weapons developers, these labs represent resources which can be used in the development of a weapon system. Some of the labs and test centers have outstanding capabilities in their scientific fields and are far superior to those offered by weapons contractors. They can normally respond faster

than a contractor in private industry for two reasons: first, the lead time for negotiation and award of a contract is eliminated; second, the technical team is in being--it does not have to be assembled.[29] However, these facilities are not being fully utilized due in part to a lack of awareness on the part of weapons developers that they exist.[30] An information gap between test centers and their potential users is real, but it can be substantially reduced with a well planned and directed marketing program.

The Blue Ribbon Defense Panel touched on a very crucial point with respect to development test and evaluation when they reported:

> . . .{a} lack of policy guidance, monitoring and evaluation of the test and evaluation functions. This deficiency has contributed to a number of instances of needless dissipation of resources. In connection with test and evaluation, it should be emphasized that responsibilities for any evaluation function must be exercised independently. When they are subordinated to or combined with responsibilities for the development of the item or subject being evaluated, the requisite objectivity is seriously jeopardized.[31]

Under the concept of industrial funding R&D test centers must be especially careful not to be unduly influenced by weapons developers in terms of test and evaluation objectivity. By understanding the weapons developer's needs and establishing a clear channel of communication with him and his superiors R&D test centers can maintain their objectivity. However, they must work at it diligently and not lose sight of the real reason for their existences,

keeping in mind that, "There is no R&D chain of command from bench to policy level."[32]

If an R&D test center seriously implements a marketing program as defined by Dr. Philip Kotler's Marketing for Nonprofit Organizations,[33] and established on the concepts advocated by C. West Churchman's Systems Approach,[34] more effective communications between the test center and its publics is sure to follow.

This more effective communication between test centers and the weapon systems development offices can lead to earlier and better planning for both parties. Better planning in turn can result in the avoidance of a large measure of costly duplication, reduced workload instability at R&D test centers, and effective development testing in a larger number of cases. This, of course, ultimately can foster a lower cost for weapon systems development--a goal shared by all.

There is one last word of caution that was stated very clearly and concisely by the Blue Ribbon Defense Panel's Report to the President and Secretary of Defense on the Department of Defense in July 1970 that must be carefully considered when implementing a marketing plan:

> Not even the best organization and management procedures will improve effectiveness of defense operations {or marketing operations} unless qualified personnel are matched to the requirements of the jobs.[35]

END NOTES

[1]Telephone interview with Fred C. Monier, Marketing Manager Litton Industries for Southwestern U.S.: Guidance and Navigation (retired), 8 January 1976.

[2]U.S. Air Force Systems Command Regulation 23-1, Organization and Mission-Field, 29 January 1972.

[3]See Chapter III, pages 64 and 65 for detailed description of the estimated cost of a CIGTF marketing orientation.

[4]See Chapter II, page 36 for CIGTF operation costs.

[5]Interview with Dr. Larry Mixon, Chief Improved Capabilities and Development Office, Test Track Division, Holloman Air Force Base, New Mexico, 12 January 1976.

[6]Ibid.

[7]U.S. Air Force Form 1378, Position Description, General Engineer, GS-801-14, Test Track Division, Improved Capabilities and Development Office, Holloman Air Force Base, New Mexico, 5 February 1974.

[8]Mixon.

[9]Ibid.

[10]Ibid.

[11]Ibid.

[12]U.S. Air Force Test and Evaluation Center, "OT & E Master Instrumentation/Capabilities Program," Kirtland Air Force Base, New Mexico, 10 October 1975.

[13]See Chapter IV, pages 87, 88, and 89.

[14]Ibid., page 104.

[15]Ibid., pages 104-110.

[16]Ibid., pages 112 and 113.

[17]Ibid., pages 115 and 116.

[18]Ibid., page 114.

[19]Norman R. Augustine, "Military R & D: There is a Return on the Investment," Government Executive, November, 1975, p. 43.

[20]C. West Churchman, The Systems Approach (New York: Dell Publishing Co., Inc., 1968), pp. 28-47.

[21]Ibid., p. 31.

[22]"Effectiveness Means Knowing the Real Market," Government Executive, September 1975, pp. 47, 48.

[23]Ibid., p. 48.

[24]David I. Cleland and William R. King, Systems Analysis and Project Management (New York: McGraw-Hill Book Company, 1968), p. 239.

[25]U.S. Department of Defense, Introduction to Military Program Management (Washington, D.C.: Logistics Management Institute, 1971), pp. 12-13.

[26]Ibid., p. 13.

[27]Monier

[28]U.S. Department of Defense, Introduction to Military Program Management, pp. 64-65.

[29]Ibid., p. 65.

[30]Ibid.

[31]The Blue Ribbon Defense Panel, Report to the President and Secretary of Defense on the Department of Defense, 1 July 1970, p. 29.

[32]Ibid., p. 87.

[33]Philip Kotler, Marketing for Nonprofit Organizations (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1975).

[34]Churchman.

[35]The Blue Ribbon Defense Panel, p. 136.

BIBLIOGRAPHY

Adams, John R., Jr. "Put Profit in its Place." Modern Marketing Thought, 3d ed., pp. 3-7. Edited by J. Howard Westing and Gerald Albaum. New York: Macmillan Publishing Co., Inc., 1975.

Albaum, Gerald and Westing J. Howard, eds. Modern Marketing Thought, 3d ed. New York: Macmillan Publishing Co., Inc., 1975.

Alchain, Armen A. A Commentary on Defense Management. Washington, D.C.: Industrial College of the Armed Forces, 1967.

Alexander, R. S. "The Death and Burial of Sick Products." Modern Marketing Thought, 3d ed., pp. 235-243. Edited by J. Howard Westing and Gerald Albaum. New York: Macmillan Publishing Co., Inc., 1975.

Augustine, Norman R. "Military R&D: There is a Return on the Investment." Government Executive. November, 1975, pp. 43-47.

Boileau, O. C. "I Dreamed We Went Nowhere in Our Solid Gold Airplane." Defense Management Journal 12 (January 1976): 5-9.

Boyd, Harper W., Jr. and Massey, William F. Marketing Management. New York: Harcourt Brace Jovanich, Inc., 1972.

Brown, Fred R. Management Concepts and Practice. Washington, D.C.: College of the Armed Forces, 1967.

Carter, Reuben M., and Cavender, Pauline P. Special Report ASC Funding Structure Study. U.S. Army Missile Command, Redstone Arsenal, Alabama, March 25, 1975.

Central Inertial Guidance Test Facility. "Aircraft Testing of Inertial Navigation Systems." Test Planning Information, MDC-TR-70-9, June 1970.

_____. "Laboratory Testing of Guidance Systems." Test Planning Information MDC-TR-70-23, June 1970.

_____. "Sled Testing of Guidance Systems and Components." Test Planning Information, MDC-TR-70-10, June 1970.

_____. "Problem Areas and Design Deficiencies Identified and Major Test Accomplishments by Sled Test Programs." Holloman Air Force Base, New Mexico, August 1975.

Churchman, C. West. The Systems Approach. New York: Dell Publishing Co., Inc., 1968.

Cleland, David I. and King, William R. Systems Analysis and Project Management Chicago: McGraw-Hill Book Company, 1968.

Conner, Capt. Frank A. Holloman Air Force Base, New Mexico. Interview, January 6-12. 1976.

Cooley, John W., and Saylor, James W. "New Funding Policy Established for Test and Evaluation Activities." Defense Management Journal (April 1974): 15-19.

Crawford, John W. Advertising: Communications for Management. Boston, Mass.: Allyn and Bacon, Inc., 1960.

Danhof, Clarence H. Government Contracting and Technology Change. Washington, D.C.: The Brookings Institute, 1968.

Defense Science Board. Report of Task Force on Reducing Costs of Defense Systems Acquisition. Washington, D.C., March 15, 1973.

Director of Defense Research and Engineering. Memo to Assistant Secretaries of the Air Force, Army and Navy. "Test and Evaluation of Aircraft Inertial Navigators," 6 July 1965.

Drucker, Peter F. Management. New York: Harper and Row, 1974.

"Effectiveness Means Knowing the Real Market." Government Executive, September 1975, pp. 47-48.

Foster, John S., Jr. "Defense Systems Acquisition--As Seen by the Director of Defense Research and Engineering." Defense Management Journal 7 (Fall 1971): 8-11.

_____. Thirteenth Annual Air Force Science and Engineering Symposium. Arnold Engineering Development Center, Tennessee, September 27, 1966.

Green, Paul E. and Wind, Yoram. "New Way to Measure Consumers' judgments." Harvard Business Review. 53 (July/August 1975): 107-109.

Hanan, Mark. "Reorganizing Your Company Around Its Markets." Harvard Business Review. 52 (November/December 1974): 66-77.

Hanson, Harry L. "A General Marketing Strategy." Modern Marketing Thought, 3d ed., pp. 205-207. Edited by J. Howard Westing and Gerald Albaum. New York: Macmillan Publishing Co., Inc., 1975.

Hodges, Capt. Terry. Holloman Air Force Base, New Mexico. Interview, January 6-12, 1976.

"Industry Overview." Aviation Week and Space Technology, November 1975, p. 11.

Jaenke, Martin J. CIGTF Technical Director (retired), Holloman Air Force Base, New Mexico. Interview, July 1975.

Jones. R. P. Section Chief of CIGTF, Holloman Air Force Base, New Mexico. Interview, July 1975.

Kotler, Philip. Marketing for Nonprofit Organizations. Englewood Cliffs, New Jersey: Prentice-Hall, 1975.

_____. "A Marketing Man Takes Marketers to Task." Business Week, 28 July 1975.

_____. "Defining the Limits of Marketing," Modern Marketing Thought, 3d ed., pp. 510-523. Edited by J. Howard Westing and Gerald Albaum. New York: Macmillan Publishing Co., Inc., 1975.

_____. "The Use of Mathematical Models in Marketing," Modern Marketing Thought, 3d ed., pp. 448-468. Edited by J. Howard Westing and Gerald Albaum. New York: Macmillan Publishing Co., Inc., 1975.

Laird, Melvin R. Final Report to the Congress of Secretary of Defense January 1969-January 1973, January 8, 1973.

Magda, SMSgt. Emory. Holloman Air Force Base, New Mexico. Interview, January 6-12, 1976.

Meter, George. The Holloman Story. Albuquerque, New Mexico: University of New Mexico Press, 1967.

Mixon, Dr. Larry. Chief Improved Capabilities and Development Office, Test Track Division. Holloman Air Force Base, New Mexico. Interview, January 12, 1976.

Monier, Fred C. Marketing Manager Litton Industries for Southwest U.S.: Guidance and Navigation (retired). Telephone Interview, 8 January 1976.

Mozer, G. R. Testing Philosophy and Methods of Guidance and Control Systems and Subsystems. Nevilly Sur Seine, France: Advisory Group for Aerospace Research and Development, 1972.

_____. Chief Laboratory Test Branch. Holloman Air Force Base, New Mexico, Interview, January 9, 1976.

Packard, David. "Toward Better Management of--The Development and Acquisition of New Weapons Systems." Defense Management Journal 7 (Fall 1971): 2-7.

_____. "Improving R&D Management Through Prototyping." Defense Management Journal 8 (July 1972): 3-6.

Peterson, Walter, Jr. "The Impact of Direct Cost Funding on Test Center Management." Master's Thesis, U.S. Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, 1974.

Ray, Fred P. Holloman Air Force Base, New Mexico. Interview, January 6-12, 1976.

Reynold, William H. Products and Markets. New York: Appleton-Century-Crofts, 1969.

Robinson, Clarence A., Jr. "Civil Role in Weapon Efforts Scrutinized." Aviation Week and Space Technology, November 17, 1975, pp. 18-20.

Rumph, Richard E. Holloman Air Force Base, New Mexico. Interview, January 6, 1976.

Sanders, Ralph, Ed. Defense Research and Development. Washington, D.C.: Industrial College of the Armed Forces, 1968.

Sandlin, Capt. Larry F. Holloman Air Force Base, New Mexico. Interview, January 6-12, 1976.

Seamans, Robert C., Jr. "Air Force Policies in the Field of Guidance Testing." Fifth Bienniel Inertial Guidance Test Symposium, Holloman Air Force Base, New Mexico. Address, October 14, 1970.

Schlesinger, James R. Annual Defense Department Report FY1976 and FY197T, February 5, 1975.

Shillito, Barry J. "Defense Logistics: Challenge of the 1970's." Defense Management Journal 9 (January 1973): 3, 4.

Smallwood, John W. "The Product Life Cycle: A Key to Strategic Planning." Modern Marketing Thought, 3d ed., pp. 228-234. Edited by J. Howard Westing and Gerald Albaum. New York: Macmillan Publishing Co., Inc., 1975.

The Blue Ribbon Defense Panel. Report to the President and Secretary of Defense on the Department of Defense, July 1, 1970.

The Budget of the United States Government Fiscal Year 1976. Washington, D.C.: U.S. Government Printing Office, 1975.

U.S. Air Force Form 1378, Position Description, General Engineer, GS-801-14, Test Track Division, Improved Capabilities and Development Office. Holloman Air Force Base, New Mexico, 5 February, 1974.

U.S. Air Force. Regulation 80-14. Test and Evaluation, 1972.

U.S. Air Force. Regulation 80-14. Test and Evaluation, 1973.

U.S. Air Force Systems Command Regulation 172-8. Budget-Test and Evaluation Support, April 18, 1974.

U.S. Air Force Systems Command Regulation 23-1. Organization and Mission-Field, 29 January 1972.

U.S. Air Force Systems Command Regulation 23-11. Organization and Mission of Air Force Special Weapons Center, 29 December 1972.

U.S. Air Force Systems Command. Organization and Functions Chart Book. Kirtland Air Force Base, New Mexico, March 1972.

U.S. Air Force Test and Evaluation Center. "OT & E Master Instrumentation Capabilities Program." Kirtland Air Force Base, New Mexico, 10 October 1975.

U.S. Department of Defense. Introduction to Military Program Management. Washington, D.C.: Logistics Management Institute, 1971.

Zagone, Peter V. Chief Operational Test Branch at Holloman Air Force Base, New Mexico. Interview, January 6, 1976.