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TECHNICAL MEMORANDUM 1767

VALUE RESPONSIBILITY OF THE DESIGNER

ALBERT G. NASH

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DECEMBER 1965

PICATINNY ARSENAL

DOVER, NEW JERSEY

TECHNICAL MEMORANDUM 1767

VALUE RESPONSIBILITY
OF THE
DESIGNER

BY

ALBERT G. NASH

DECEMBER 1965

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FOREWORD

This report was given as a speech at the Value Engineering Seminar at Iowa Army Ammunition Plant, Burlington, Iowa on 28 October 1965.

INTRODUCTION

This presentation, "Value Responsibility of the Designer," was prepared to give the Value Engineering Seminar a realistic background picture of ammunition design. This picture -- while positive in respect to achieving further value -- also indicates many of the limitations and pitfalls which must be faced if successful work is to be accomplished.

Experiences which the author gained at Picatinny Arsenal in many major ammunition programs were summarized and recommendations offered.

A realistic picture of the development framework should aid the overall Value Engineering Program in obtaining substantive and responsible proposals.

VALUE RESPONSIBILITY OF THE DESIGNER

As Product Designers, we recognize that we bear a major responsibility for Value Engineering. While the designer must balance many conflicting requirements during the development stage, the achievement of necessary functions of the lowest cost or value has to be a major consideration.

The creativity of the designer and the wisdom of the initial design selections are the basic stuff of product value. The initial creativity also determines to a large extent whether the program will be successful in meeting basic performance. In addition, it is the type of design framework chosen which will determine whether the ammunition will finally emerge in the $15-$25 range or let's say $50-$75 class. In the current climate, selections of ammunition programs are based on a comparison of lethality/dollar cost. A design concept which cannot compare favorably in this category will be discarded. So you see, even in the beginning, value vs. function must be considered a fundamental objective.

Many of you work in organizations where you see the ammunition well toward standardization or production. As you are aware from your discussions here, Value Engineering is applicable throughout the life cycle of the product. However, it is necessary for the successful application of Value Engineering that an understanding of the basic framework under which ammunition is developed be thoroughly understood.

Picatinny Arsenal has major mission functions in the development of ammunition. Those contributing directly to the product design are:

FIGURE 1. PICATINNY ARSENAL MISSIONS

Research	Basic ideas and laws.
Development	Translation of ideas into hardware to function.
Industrial Engineering (Engineering for Production - Value Engineering)	Translation of Development Prototypes into Functional Systems Tailored for Economical Production Techniques.
Inspection Engineering	Development of Production Technical Data Packages
Maintenance Engineering	Training Manual and Maintenance Instructions
Reliability	Measurements of Stockpile Quality
Pilot Manufacture	Prove out of Technical Data Package prior to Mass Production

All these functions are focused into the Product Design as an item moves through its successive stages of development.

Let's look at how ammunition is developed:

1. First comes a need either originated by Picatinny Arsenal or by the military services resulting in a qualitative military requirement (QMR).

2. A Feasibility Study is then conducted -- such as supporting research -- to determine if accomplishment of the QMR is within the state-of-the-art. Suggested approaches are outlined and parametric analysis performed. In conjunction with this, the entire program from Development-to-Production is programmed and estimated as well as it can at this embryonic stage.

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FRAMEWORK

If the Feasibility Study is approved as worthwhile on a Function vs. Cost basis, it is then initiated as a new starter program and the Design Stage begins. At this point, the framework within which the development will take place is erected. This framework is structured like a tripod by these elements.

FIGURE 2. THE DESIGN FRAMEWORK

PERFORMANCE
TIME
FUNDS

This framework is not unusual -- it relates to real structures we encounter.

The first of these elements is Performance. In ammunition these representative requirements define what is meant by performance. They are defined in the QMRs, Military Standards and Basic Ammunitions Design Practices.

FIGURE 3. AMMUNITION PERFORMANCE FACTORS

Function	Safety
Achieve Lethality and Reliability in Weapon System	Achieve Safety in Weapon System all Conditions (Idiot Proof)
Temperature Environments -65°-160°F	In Transportation Malfunction Parachute Drop 40-Foot Drop Jolt Jumble Aircraft Vibration 5-Foot Drop Packaging Rough Handling Parachute Drop
All Terrain Environments Jungle Beach Snow Frozen Ground Etc.	
Transportation Environments Aircraft Vibration 5-Foot Drop	In Manufacture Assembly and Explosive Loading Mass Production Conditions
Transportation Vibration Packaging Rough Handling Parachute Drop	
Storage Environments Temperature and Humidity Sand and Dust Water Immersion Long Term Storage High Temperature Storage	

To assure greater safety, the following practices were recently added:

1. Two separate and independent safety features.
2. Critical Defect Monitoring System.

The second leg of the tripod is Time (Figure 4). In recent years, increased attention has been focused on reducing the development-to-first-production-time cycle. At present, as a matter of Department of Defense policy, this entire period is limited to four years. As you can see from the chart, all phases of the program are necessarily overlapped. To support the Vietnam forces, acceleration far beyond this timeframe is a must.

The Engineering Design phase must define design parameters and come up with a working model. Extensive testing has to be carried out to engineer the prototype and meet the many and rigorous performance requirements. The many test series and design studies must be rapidly conducted, since a design must be available in 18 months so that hardware for the Engineering Test phase can be initiated.

As a result, this prototype design in many, many cases incorporates the type of parts which require short tooling lead times, and must be of such a type that changes in part design can be easily accomplished. Prototype design therefore leans heavily toward the processes depicted in Figure 5.

FIGURE 5. PROTOTYPE DESIGNS

Machined Parts
- Turret Lathe
- Mill
- Drilling Threading

Stamping
- Simple Types
- Individual Dies

Investment Casting

Sand Casting

Spinning

Gear Hobbing

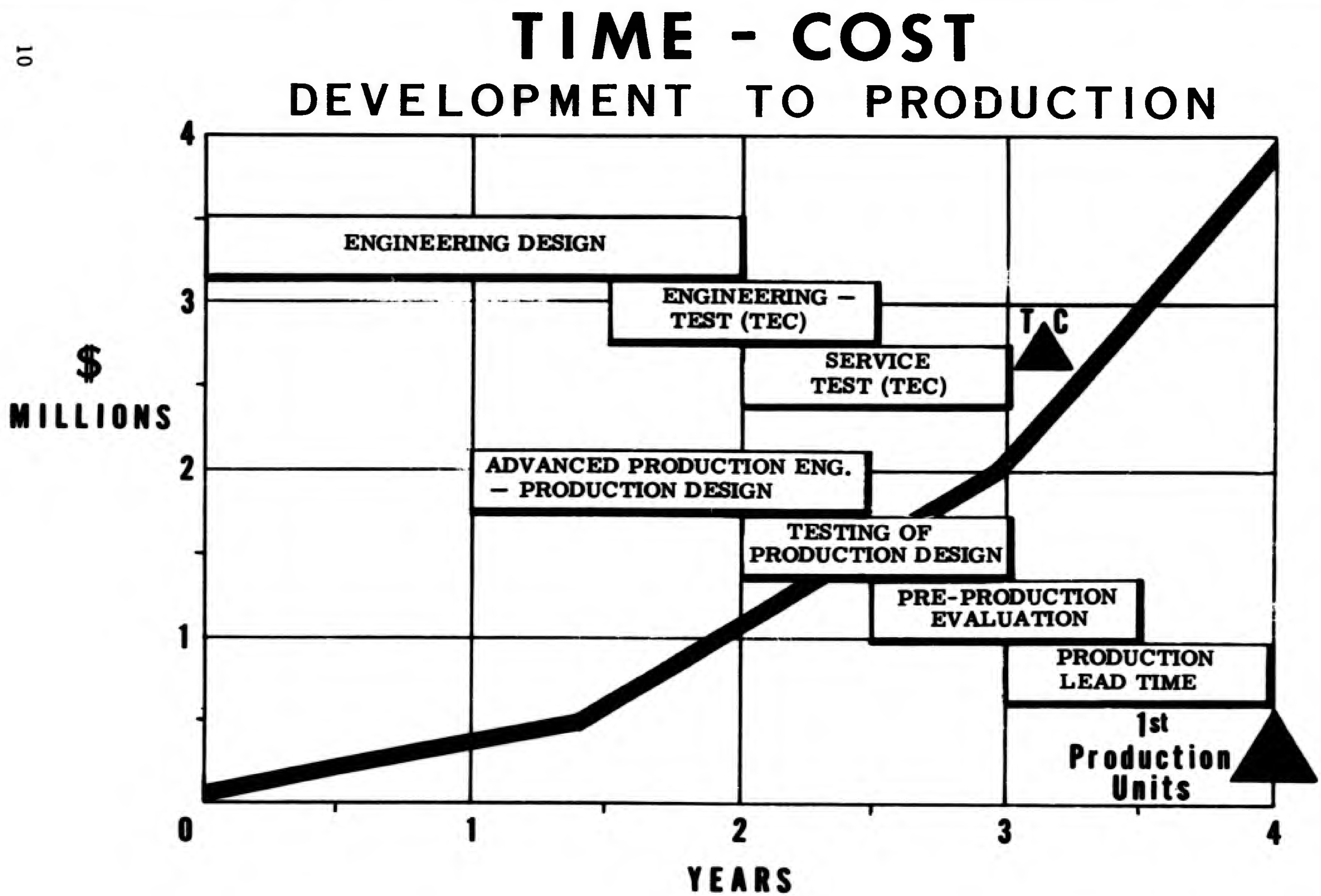
TIME - COST
DEVELOPMENT TO PRODUCTION
$
MILLIONS
4
3
2
1
0
ENGINEERING DESIGN
ENGINEERING –
TEST (TEC)
SERVICE
TEST (TEC)
T C
ADVANCED PRODUCTION ENG.
– PRODUCTION DESIGN
TESTING OF
PRODUCTION DESIGN
PRE-PRODUCTION
EVALUATION
PRODUCTION
LEAD TIME
1st
Production
Units
1
2
3
4
YEARS

FIGURE 4

Prototype design also endeavors to define design parameters as distinctly as possible with a relatively small number of test samples. To do this, tolerance interplay must be held to a minimum since this would mask the effects being studied. As a result, precision tolerances are often characteristic at this stage.

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ADVANCED PRODUCTION ENGINEERING

After 12 to 18 months of the Engineering Design phase, the basic prototype has taken shape (Figure 4). Concurrent effort begins -- this phase is called Advanced Production Engineering. This type of program is vital with ammunition which will be mass-produced. Since the purpose of Advanced Production Engineering is to systematically interject production and value considerations, an extremely close relationship to Value Engineering exists.

If we look at the Time/Cost Relationship of Figure 4, it is clear that the major program investment of funds has not yet been committed. In addition, if budgeted properly, sufficient funds are available for the extensive test programs required to insure performance characteristics. This type of testing must be accomplished if there is any significant change in the design which normally does occur.

Therefore, the Advanced Production Engineering phase -- culminating in the production design -- is ideal for the injection of a major Value Engineering effort and is completely compatible with the other major objective of the program: "The Design for Mass Producibility." Value Engineering techniques applied at this stage of the program can have considerable scope and include: design vs. function, process development and automation.

However, like everything else, this portion of the development program also has to meet the framework of Performance, Time and Funds. A design must be selected for complete performance testing within 12 to 14 months. Performance has to match the prototype and incorporate all feedbacks from the engineering tests. The program must remain within its funding limitations which was programmed well in advance. Do these limitations appear confining? They need not be if the program is conducted energetically by an experienced organization.

The third major structural element is Program Funds. It is sufficient for our discussion to say this is vital, its need must be conceived far in advance (18 months) and it must be strongly justified with constant follow-up.

As we have seen, there were two major areas during development when Value Engineering is considered by the designer:

1. When the original concept during the Feasibility Study must be evaluated on a Function vs. Cost Basis.

2. During the Advanced Production Engineering phase when all elements are given a second look for both value and producibility. We in Ammunition Design have included Value Engineering in our programs in some form since the Korean War. Although fairly crude as originally practiced, our concepts have evolved over the years and today Value Engineering is incorporated in the form outlined in this presentation.

Based on our experience (the successes and failures over several generations of ammunition developments), I would like to comment on some additional considerations (not covered in detail in the literature) which I regard as necessary to insure success in design-value engineering:

1. Personnel with a sound and broad background in ammunition development and production are required. Form a team to acquire the necessary skills and experience.

2. To select optimum designs and processes, the Production Environment -- which in many cases has not yet been established -- has to be accurately estimated. These include monthly production rates, type of facilities which will be available, restrictions on base caused by security and even the probable type of contracts. Another important aspect will be the production life of the design before it is replaced by another generation. In recent years, the production life of ammunition has been steadily reduced based on accelerated technology. We normally estimate a three-to-four year production life on high quantity manufacture before the next generation comes along.

3. Energetically and creatively explore the full range of Function vs. Cost in the initial stages of the Engineering-for-Production period. However, after this has been done, formulate the actual program only after a critical and conservative examination of ideas and data. Remember, the program selected must fit into the design framework of Performance, Time and Funds. Too many well-intentioned programs founder by trying for too much or taking risks unwarranted by the rewards. Eighty percent attained is much better than 100 percent failure.

4. In certain respects, ammunition is a breed apart from many other types of hardware. The Safety Performance aspects have a sensitive criticality -- where one incident can jeopardize the entire stockpile. In this area testing can only provide data for an experienced judgment. The correctness of the judgments can only be empirically ascertained. Therefore, when you consider the Value/Function relating to safety features of ammunition, take full note of the high risks.

5. In regard to a high volume production design and associated manufacturing processes, several trends have been exploited in our designs in recent years which have led to significantly increased value.

These designs avoided (wherever possible) screw machine parts. We tried to design for stampings and chipless machining types of processes such as Cold Heating, Cold Extrusions or Impact Extrusions. Die castings were used where applicable. Although considerable tool development was required, these processes paid off in sharply reduced costs.

Product and Process Engineering were integrated and considered together. Due to this integration, automated assembly is considered early in the design and compatibility assured. As a result, automation was increasingly incorporated in ammunition design and production. Picatinny Arsenal established a small Automatic Machine Laboratory to provide guidance in this area. Our aim has been the introduction of simple types of automatic equipment early in the production cycle to assure maximum savings. Experience with more ambitious undertakings indicated that a trained and competent staff has to be developed first on the simpler machines. Automatic machines of this type are being used extensively in the Selected Ammunition Metal Parts Plants and are successful at Joliet, Lone Star and Louisiana.

In summation, the designer must recognize his responsibility for value. This function at Picatinny Arsenal is integrated into the developmental effort. The concept and improvement of its practice has evolved and expanded over a number of years and is still being improved.

I will end my talk with a short film which shows some of the concepts just discussed applied to achieve Cost Reduction in the Selected Ammunition Program.

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13. ABSTRACT

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