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PROGRAM MANAGEMENT COURSE
INDIVIDUAL STUDY PROGRAM

AN ANALYSIS OF THE NEED FOR
INDUSTRIAL ENGINEERING CAPABILITY IN PRODUCTION
AT ELECTRONIC SYSTEMS DIVISION.

STUDY PROJECT REPORT
PMC 74-2

Charles Edward Hardaway
LT COL USAF

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DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE: AN ANALYSIS OF THE NEED FOR INDUSTRIAL ENGINEERING CAPABILITY IN PRODUCTION AT ELECTRONIC SYSTEMS DIVISION

STUDY PROJECT GOALS: To analyze the changing environment of production to show how today's cost emphasis on the DOD acquisition environment requires early involvement of the production function in the acquisition process to enable early producibility analysis.

To analyze ESD to determine if the production function has the necessary industrial engineering capability to meet the requirements of current directives and policies and to provide recommended solutions to obtaining required capability.

STUDY REPORT ABSTRACT

This study examines the need for industrial engineering capability within production at Electronic Systems Division (ESD). Production is locked at from World War II to the present time to show why production management is perceived today by many program managers and high level functional managers as only the classical production management techniques of tracking, monitoring and expediting deliverables. The current emphasis on cost is then examined to show why this classical approach is no longer a viable approach to production management. It is shown that production management must include close interface between industrial engineering and design engineers to make early determination of producibility and manufacturing feasibility when the design is most flexible and trade-offs are least costly.

ESD is analyzed to determine if the production management functions within the Deputates have appropriate engineering capability to perform these functions. Factors causing resistance to obtaining industrial engineering capability in program production offices are discussed with a recommended plan for overcoming these resistance factors.

This study was accomplished by document research and interviews of key personnel involved in DOD acquisition. It shows that more engineering capability is required in the production functions of ESD.

Although this study focuses principally on production management requirements within ESD, its implications can be useful to all personnel in the DOD who have a responsibility in assuring that weapon systems are made available to adequately fulfill their functional requirements on time and at affordable costs.

KEY WORDS

MATERIEL PRODUCTION INDUSTRIAL ENGINEERING DESIGN-TO-COST COST CONTROL

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AN ANALYSIS OF THE NEED FOR INDUSTRIAL ENGINEERING CAPABILITY IN PRODUCTION AT ELECTRONIC SYSTEMS DIVISION

Study Project Report

Individual Study Program

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by

Charles Edward Hardaway
LT COL USAF

November 1974

Study Project Advisor
Mr. Albert Moore

EXECUTIVE SUMMARY

This paper is devoted to a better understanding of the role of production management and its relationship to today's cost acquisition environment in the Department of Defense (DOD). Although it focuses principally on the production management requirements within the Electronic Systems Division (ESD) of the Air Force Systems Command (AFSC), its implications can be useful to all personnel in the DOD who have a responsibility in assuring that weapon systems are made available to adequately fulfill their functional requirements on time and at affordable costs.

Since production costs consume a major portion of the DOD acquisition dollar, it is paramount that DOD provide prudent action to minimize costs in the production phase of the acquisition cycle. If we don't control the cost, we will be unable to acquire the necessary weapons to provide adequate national defense. With our decreasing DOD budget, increasing inflated prices and more complex and highly technical weaponry, cost must become a coequal acquisition parameter along with schedule and performance.

Examination of the role of production management as it evolved from World War II provides an understanding as to why many program managers and high level functional managers view this as only the classical production management techniques of tracking, monitoring and expediting deliverables. This study stresses the need for more industrial engineering talent in the government production function to provide the necessary design engineering interface early in and continuing throughout the acquisition cycle. Through this early interface, producibility decisions can be made when the design is most flexible and trade-offs are least costly.

An analysis of production functions within ESD emphasizes the fact that even though current policies and directives require industrial engineering capability within production, this capability is not actively sought and employed within the program office production management functions. Resistance to changing the scope of the production function to early involvement in the acquisition cycle and the need for industrial engineering talent to provide this early involvement are discussed, along with recommended actions to overcome these resistance factors.

This study was accomplished by document research and interviews of key personnel involved in DOD acquisition. In brief, the results of this study indicate implementation of the following: (1) Reeducate key DOD acquisition managers to the new role of production management, emphasizing the need for available industrial engineering capability in production throughout the acquisition cycle. (2) Achieve a better balance of industrial specialists and industrial engineers by hiring additional industrial engineers and converting vacant industrial specialist positions to industrial engineering positions. (3) Provide realistic career progression and career broadening plans for production personnel. (4) Change the name of "production" to more clearly represent its intended function, such as "manufacturing technology," "product manufacturing" or "manufacturing operations."

ACKNOWLEDGEMENTS

I wish to acknowledge my sincere gratitude to the many individuals who made this paper possible. Major General Fred Ascani, USAF (Retired), a member of the University of Southern California faculty collocated at Defense Systems Management School (DSMS), was instrumental in establishing the approach to this paper. Specific DSMS faculty who provided information and constructive criticism which was extremely beneficial were Mr. Albert Moore, Mr. William Cullin and Dr. Donald Hurta. In addition, many members, civilian and military, within the Air Force Systems Command (AFSC) provided a considerable amount of their time and effort during the research phase of this study. Specific acknowledgement is appropriate to Colonel H. L. Fitzpatrick, Director of Development and Production Policy, Hq AFSC; Colonel Paul Schultz, Chief, Production Management Division, Hq AFSC; and Mr. Myron Files, Industrial Engineer, Production and Industrial Resources Division, Electronic Systems Division, AFSC. Finally, I wish to thank my wife for her unending help and understanding in developing this paper.

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SECTION I

INTRODUCTION

Purpose of the Study Project

The purpose of this paper is to emphasize the importance of industrial engineering capability to reduce production costs in defense acquisition programs. Due to the broad scope of this subject, this study will be confined to the production management requirements within the Air Force Systems Command (AFSC), more specifically to the Electronic Systems Division (ESD) at Hanscom Air Force Base, Massachusetts.

In Section II the changing Department of Defense (DOD) acquisition environment will be reviewed from World War II up to the present time frame. Today's acquisition environment is discussed with its shifting emphasis on cost as a prominent consideration (previously surrogated by schedule and performance). Since production costs consume a major portion of the DOD acquisition dollars, focus is centered on the importance of reducing cost in the production function.

Section III shows the need for greater industrial engineering capability in the government production function. It explains how the industrial engineer can provide the necessary interface between design and production early in the acquisition cycle in order to afford a realistic assessment of producibility and production risk, thereby reducing cost to optimum levels. The distinctions between an industrial specialist and an industrial engineer are outlined. Each phase of the acquisition cycle is addressed, depicting necessary and prescribed duties of the production manager. Those areas principally requiring industrial engineering capability are identified.

Section IV will assess ESD to determine what industrial engineering capability exists within the production program offices to accomplish the industrial engineering functions of production management. A brief analysis of each production activity will be provided, highlighting those functions not having industrial engineering capability.

Section V deals with obtaining the necessary industrial engineering capability within ESD to meet the requirements of modern production management. Resistance factors inhibiting change of the status quo are discussed and suggestions given as to how to overcome these resistance factors.

It is my opinion that all production managers should give serious and prompt consideration to the recommendations of this study report. The task of cutting production costs can and must be implemented with expediency.

Definition of Terms

Aggregate Project Organization: An organization that has basically all departments and activities required to accomplish a project report directly to the project manager.

Basket-Type Program Office: An organization having two or more System Program Offices (SPOs) within a Deputate which are supported by a functional staff project organization.

Manufacturing Methods: The manufacturing processes, techniques and equipment that must be developed and made available for the timely, reliable, economical, quantity/quality production of material.

Producibility: The composite of characteristics which, when applied to equipment design and production planning, leads to the effective and economic means of fabrication, assembly, inspection, test, installation, checkout and acceptance of systems and equipment.

Producibility Analysis: The study of the composite of characteristics which, when applied to equipment design and production planning, leads to the effective and economic means of fabrication, assembly, inspection, test, installation and checkout of systems and equipment.

Production: Includes all processes and procedures designed to transform a set of input elements into a specified output element.

Production Feasibility: The ability to produce systems of equipment within the existing state of the production art and within the cost parameters established for the specified development effort. A production feasibility assessment should first be accomplished in the conceptual phase of the acquisition cycle, prior to program decision, and then continuously throughout the spectrum of events leading up to production.

Production Management: The art and science of properly and efficiently using men, money, machines, materials and processes to economically generate goods and services.

Program and System: These terms are used interchangeably in this paper to mean a weapon system to be acquired by the program office.

Staff Project Organization: The project manager has a staff to exercise control through other functional organizations' SPOs within the Deputate.

SECTION II

COST ACQUISITION ENVIRONMENT

Review of Changing DOD Acquisition Environment from World War II to Present

> There has been a gradual diffusion of the production management function within the Air Force from its World War II stature to today. In recent years the majority of manpower and organizational attention has been directed toward research, development, and design engineering. Many elements of the production process are largely left in the hands of the prime contractor and contract administration. Current organization reflects this trend with the majority of Air Force Systems Command production management and quality assurance talent assigned to the Air Force Contract Management Division (AFCMD) and its Air Force Plant Representative Offices (AFPROs). Functional staffs at the intermediate commands and program office level are generally of token strength . . . (2:6).

These words, although extracted from a study initiated in 1970, clearly represent a situation which has evolved since World War II. In the years following World War II, systems acquisition management has tended to focus attention on the technical problems associated with development at the expense of production efficiency. The Korea and Vietnam eras demanded many weapon systems be close to, or at the state of the art. The two major parameters used to evaluate a weapon's successful acquisition were the technical capability of the weapon and obtaining the weapon as rapidly as possible. A third parameter, cost, was often neglected. The result of this evaluation technique was often accompanied by serious cost inefficiencies.

Additionally, as a result of the heavy emphasis on technical facets and time schedules, more and more design oriented engineers were added to the System Program Office (SPO) staffs with production considerations during pre-production acquisition phases being relegated to a lower priority. This de-emphasis of production interface early in the acquisition process, in many instances, resulted in excessive production costs, extensive schedule slippages and, in some cases, major design changes during the production phase. Major General Fred J. Ascani, USAF (Retired), System Program Director of the B-70 from 1961 to 1964, vividly described the results of this de-emphasis of early production interface when he stated:

> B-70's might be flying today in operational numbers if good producibility analyses had been conducted early in the acquisition cycle.

General Asconi was referring specifically to a design decision to use stainless steel honeycomb panels on 60 percent of the airframe. This decision caused numerous setbacks, delays, rework requirements and cost increases during fabrication (4).

Cost Emphasis in Today's Acquisition Environment

During the late 1960's and early 1970's, the shrinking defense dollar caused increasing concern that costs must be reemphasized as an important parameter in acquisition management. William H. Cullin aptly expressed this shrinking purchasing power when he said:

> . . . in terms of real purchasing power the fiscal year 1973 spending for national defense represents the lowest level for more than 20 years and the DOD manpower is less than for any year since 1950 (6:1).

The Honorable Kenneth Rush, when he was Deputy Secretary of Defense, put it in terms of the Gross National Product (GNP) when he said:

> . . . the FY 73 (DOD) budget request is 6.6 percent of GNP. Given the current international atmosphere, it is possible that the Defense portion of GNP will decline over the next decade to perhaps 5.5 percent (14:2).

In addition to the shrinking purchasing power, the DOD weapon systems continue to increase in complexity, pushing the state of the art and, due to technological knowledge increasing at an ever increasing rate, a weapon's useful life span before obsolescence is decreasing. James Barr expressed the obsolescence problem clearly when he stated:

> By the end of the mid-twentieth century, modern weapons had become so complicated that men received medals for developing a weapon in seven or eight years. Then if sufficient funds were available, the new weapon might be produced in quantity and placed in the hands of the troops--within another three years. Usually by this time the weapon bordered on being obsolescent. In some cases, it already was (5:42).

The Honorable Kenneth Rush expressed his concern when he pointed out that:

> . . . because the unit cost of modern equipment is going up faster than inflation we find that we cannot afford to buy enough units to modernize existing forces at the same force levels. . . . aircraft have become so costly, we will be able to buy only 50 percent of the numbers we need, over the next five years, to replace our existing force (14:4).

Evolving from this concern are several concepts presently receiving highest management attention. Dr. John S. Foster, Jr., past Director of Defense Research and Engineering, Department of Defense, summed the general policies into seven categories:

1. Reducing concurrency
2. Designing to cost requirements
3. Using prototypes
4. Requiring hardware competition
5. Reducing radically the size of industry design teams
6. Minimizing the number of detailed weapon system requirements
7. Increasing independent operational test and evaluation prior to a procurement decision (10:7).

In addressing these policies, Dr. Foster further stated:

> These policies will place upward pressure on our Research and Development expenditures. . . . However, these Research and Development funds will not be made available unless they can realistically provide weapons that have significantly reduced production costs (10:8).

Reducing Cost in Production

To focus on production costs is prudent since a major portion of the DOD acquisition dollars are consumed in the production phase of the acquisition of a system. AFSC spent 60 percent of its FY 74 program dollars for production (15:Chart 1). For too long we have acquired all systems in DOD without adequate consideration to cost. The policies mentioned above by Dr. Foster are, in the main, addressed at reducing the production cost of a weapon system. The main theme of these policies has been incorporated into two key policies: Design-to-Cost and Fly-Before-Buy.

Design-to-Cost

Although often misused and misunderstood, Design-to-Cost is designed to place emphasis on early consideration of production costs. A Design-to-Cost dollar goal is required for acquisition of major systems prior to approval by the Defense Systems Acquisition Review Council (DSARC II) to enter the full-scale development phase of acquisition. This dollar goal is a production cost fly-away/roll-away/sail-away bogie, based on real dollars, a specific production rate, and a specific production quantity. The cost does not include operation and maintenance costs. Design-to-Cost attempts to force the contractor and the government to place heavy consideration on production costs while the system is still in the validation phase (21).

Fly-Before-Buy

This policy stresses that before a system enters into a production commitment, the government must provide for Development Test and Evaluation (DT&E) and independent Operational Test and Evaluation (OT&E). DOD Directive 5000.3 explicitly requires the OT&E testing of pilot production items wherever possible prior to the commitment to major production. If it is not prudent to use pilot production items, the final prototypes must be reasonably like the expected production items. Fly-Before-Buy further encourages fly-off competition between two or more developers of a system before a selection is made on the contractor to receive the production contract (20:6).

These two policies, Design-to-Cost and Fly-Before-Buy, reemphasize the importance of government production as something more than schedule status reporting. Greater emphasis must now be exerted in consideration of and planning for manufacturing during the design and development phases of the program. Two such areas of major consideration throughout the acquisition life cycle should be producibility analysis and production feasibility. In the past the DOD has relied heavily on the contractor to make these judgments. In my judgment, which is also substantiated by an Air Force Production Management Study initiated by Philip N. Whittaker, the then Assistant Secretary of the Air Force (Installation and Logistics), DOD goals cannot be achieved by complete reliance on the contractor for at least three reasons:

1. The contractor's point of view is not always in line with that of the Air Force.

2. The Air Force must make many decisions independent of the contractor.

3. Not all contractors have an operating philosophy that provides a coordinated effort between design and manufacturing during the proposal and development phase (3:3-6, 3-7).

The Honorable Kenneth Rush recognized the need for government involvement in early interface between design and production when he stated:

> I agree that the Defense Department must assume a share of the blame for increasing systems costs. After all, we are both the architect and the buyer. . . . In the main we get what we ask for (14:4).

This redirection of cost as a major and coequal parameter with schedule and performance, requires government production personnel to provide consideration and planning for the manufacturing during the design and development phases of the program. Hence, the need for industrial engineering capability as discussed in the next chapter.

SECTION III

INDUSTRIAL ENGINEERING CAPABILITY IN PRODUCTION

Why Industrial Engineering Capability is Required

The previous chapter discussed how the complexities of weapon systems, increasing costs, decreasing DOD purchasing power and rapidly changing technology contribute to early obsolescence of weapon systems. All of these factors interact to maximize attention to costs. It has been pointed out that 60 percent of these costs are expended in the production function. In order to make the production function more effective and, consequently, reduce costs, the importance of government production management must be assessed throughout the entire acquisition cycle to assure that the design of the system, as it develops, takes into account analysis of contractors' capability, producibility of design and production feasibility. It is the industrial engineer who can provide the necessary interface between design and production early in the acquisition cycle.

At this point, it is appropriate to discuss the two major categories of government production management personnel: the industrial specialist and the industrial engineer.

Industrial Specialist

The industrial specialist is primarily skilled in surveillance, monitoring, expediting and tracking techniques. He is primarily a manager whose expertise in production management has been attained through on-the-job training, having worked in varied administrative areas with technical knowledge attained through experience in such functions as scheduling, supply and program control. He may or may not have a degree from a college or university (12).

Industrial Engineer

The industrial engineer as referred to in this paper is a professionally trained engineer, having graduated from a recognized engineering school. The industrial engineer has been schooled in areas, such as producibility analysis, production feasibility assessment, production planning, manufacturing methods and processes, plant layout, production control and manufacturing techniques. The industrial engineer's talents are primarily addressed to:

1. Analyzing producibility criteria
2. Production feasibility analysis
3. Cost to produce analysis
4. Assessing production risks
5. Providing technical expertise and assistance directed toward production problems
6. Acting as the focal point between production and engineering design
7. Looking for manufacturing technology improvements
8. Make-or-Buy analysis

In order to adequately interface with both government and contractor design engineering, the program office production function must have industrial engineers. Only through the industrial engineer can the flow of information between design and production be viable. Only a trained engineer can properly assess another engineer's design and properly communicate the need for trade-offs between design as seen in the eyes of the designer, and design as seen by the professional who is analyzing its producibility.

Major Phases of Acquisition Cycle Where Industrial Engineering Capability Should be Applied

Production management within AFSC is directed towards a SPO operating as the focal point for production management of programs. Production management programs within AFSC are established in accordance with directives from AFSC Manual (AFSCM) 84-3 (1). Basically, the guidance from this manual establishes the responsibility of production in these areas:

1. To accomplish production planning during the conceptual, validation and full-scale development phases of acquisition.

2. To document, analyze and review pertinent production criteria prior to the decision to produce.

3. To monitor the production phase of the program after that decision has been made.

Following is a discussion of each of the acquisition phases:

Conceptual Phase

Production management during the conceptual phase is primarily devoted to an analysis of design and engineering of the proposed technical approaches in order to detect production risks which may impact program cost or schedule thresholds, as well as analyzing production engineering techniques to benefit the program. Briefly, the major production management tasks performed during the conceptual phase are:

*1. Analyze design engineering

*2. Perform production feasibility analysis

*3. Establish and analyze producibility criteria

*4. Assess production risks

*5. Make a cost-to-produce analysis

*6. Integrate production and design

*7. Provide production inputs to program and contractual documentation

Validation Phase

During the validation phase, production should provide a continuing analysis of producibility, production risks and track the contractors' progress. Significant tasks during this phase are:

1. Review contractors' accomplishments

*2. Assess the production plan

*3. Update production feasibility analysis

*4. Continue to assess producibility

*5. Insure test plans reflect production processes

*6. Integrate production engineering with design engineering

*7. Consider manufacturing technology improvements

8. Review and update documentation

Full-Scale Development Phase

During full-scale development the production management effort should be maximized in preparation for the Production Readiness Review (PRR).

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*Those areas indicated by an asterisk are considered best accomplished by an industrial engineer.

Specific tasks are:

1. Surveilling contractors' progress
2. Ensuring timely delivery of Government-Furnished Equipment (GFE)
*3. Analyzing contractors' manufacturing system
*4. Providing technical expertise and assistance directed toward production problem solving
*5. Performing production readiness reviews
*6. Make-or-Buy analysis
*7. Continue to assess producibility, feasibility and manufacturing technology improvements

Production Phase

During this phase the classic functions of tracking, expediting, monitoring and surveilling become dominant with the industrial engineer's role primarily one of problem solving and evaluating the effect of engineering changes.

As can be noted, the conceptual and validation phases are heavily dependent upon industrial engineering support. The full-scale development phase is still dependent upon this expertise; however, there is an increasing need for surveillance and monitoring of contractors' progress. Finally, during the production phase there is a heavy dependency upon the tracking, expediting, monitoring and surveillance function which can be accomplished with the industrial specialist expertise. This shift in the

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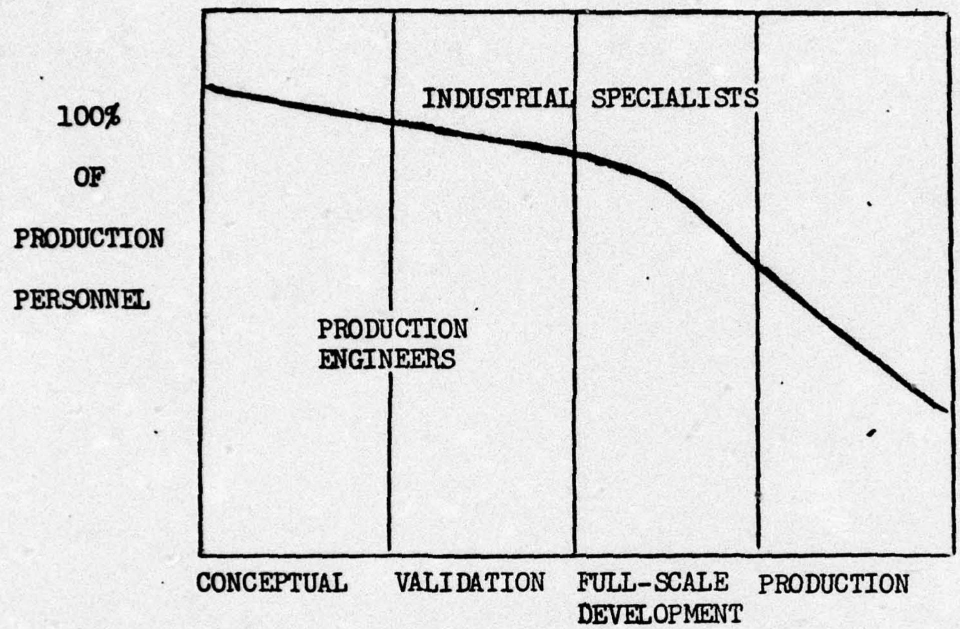
*Those areas indicated by an asterisk are considered best accomplished by an industrial engineer.

recommended qualifications of production personnel can be graphically depicted on the following chart:



This chart is used only to illustrate the large requirement for industrial engineers early in the acquisition cycle and a decreasing requirement as the program nears production.

With the distinctions of the industrial specialist and industrial engineer in mind, an analysis of each program phase of production against the responsibilities of production management, provides a recognizable need for professional industrial engineering capability.

SECTION IV

ASSESSMENT OF INDUSTRIAL ENGINEERING CAPABILITY WITHIN ELECTRONIC SYSTEMS DIVISION

Organizational Overview of Production

Appendix A shows an organizational chart of ESD. There are six deputy program offices containing a procurement and production function. In addition, there is one Directorate of Procurement and Production (PP) which provides staff guidance and assistance to the six deputy program offices. The deputy program offices are:

Deputy for Surveillance and Control (OC)

Deputy for Communication and Navigation Systems (DC)

Deputy for Command and Management Systems (MC)

Deputy for Iranian Program Office (FA)

Deputy for Advanced Airborne Command Post (YS)

Deputy for Airborne Warning and Control Systems (YW)

Only two of these Deputates, YS and YW, are aggregate organizations. The other four Deputates are basket-type program offices.

The Production and Industrial Resources Division (PPD) within PP is authorized nine personnel. Four of the spaces are utilized in Production, three spaces in Industrial Resources, plus one secretary and one division chief. Until January 1974, there were no industrial engineers on this staff; all spaces were filled by industrial specialists and military officers with no engineering background. During January 1974, a GS-14 and GS-13 position were converted from Industrial Specialist to Industrial Engineer and both positions filled with qualified personnel.

The present mix on the Production staff are two industrial engineers and two military personnel. This would appear to be an appropriate ratio of industrial engineers to industrial specialists.[1]

Recently, PPD initiated a program to: (1) emphasize the need for production engineering, and (2) develop additional industrial engineering capability within the Deputates. Additional impetus was given to developing the need for industrial engineers in a 29 April 1974 letter from the Vice Commander, AFSC to the four procuring divisions within AFSC. In this letter, Lieutenant General John B. Hudson stated:

> Of particular concern is the fact that we do not have enough personnel with in-depth experience in management operations, production planning, manufacturing engineering or manufacturing management (18).

Major General Benejamin N. Bellis, Commander, ESD, in a 16 May 1974 letter to Vice Commander, AFSC, supports the contention that:

> Much remains to be done to strengthen production visibility and involvement throughout the acquisition process. . . . (It is) my desire to accelerate the introduction of integral SPO production/industrial engineering talent to help maximize the probability of successful, on-time delivery of quality items at the lowest possible cost (19).

Brief Analysis of Each Production Activity

The following is an assessment of each of the Deputate Production Offices within ESD, including opinions of the individual production division chiefs:

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[1]For simplification of terms, a military officer occupying a production management space and not having an engineering background will be considered an industrial specialist.

Deputy for Surveillance and Control (OC)

There are eight SPOs assigned to OC; the majority of their programs are in the conceptual, validation and full-scale development phases. In only a few cases do their programs enter a production phase. Some manufacturing does take place, but is limited in quantity. Most of their programs are one-of-a-kind electronic/radar systems.

The production function (OCP) has six authorized spaces with a GS-13 Industrial Specialist in charge. One space is military; however, the officer slotted to this position is being used as a buyer. Of the four remaining spaces (one GS-9, one GS-11 and two GS-12s), all are Industrial Specialists. Three of the Industrial Specialists were assigned to this area as a result of a Reduction in Force (RIF) action. None of these personnel have a background in production feasibility analysis, producibility, production risk analysis or basic production planning. Their experience lies in tracking and monitoring deliverables.

OCP does not have the expertise to adequately accomplish the tasks, as discussed in the previous chapter, associated with the conceptual, validation and full-scale development phases. Over a period of time, functions associated with these phases have been assumed by, but not delegated to, the individual SPOs. As a consequence, production personnel become involved in production problems after the fact, diminishing their effectiveness. Most of the efforts of the production office are expended in the area of tracking and monitoring deliverables.

In discussions with the Chief, OCP, he recognizes the need for production expertise and is actively pursuing a reorganization plan which includes the hiring of two industrial engineers (9).

Deputy for Communication and Navigation Systems (DC)

There are ten SPOs assigned to DC. Unlike OC most of their programs are in the full-scale development and production phases of the acquisition cycle.

The production organization (DCP), servicing the ten SPOs, has eleven authorized spaces with a GS-13 Industrial Specialist as Chief of Production, five GS-12s, three GS-11s, one GS-9 and one military position. All civilian positions are Industrial Specialists; the military position is filled by a Captain not trained in engineering.

A summary of DCP response to this study is that although there are no industrial engineers in DC, it is felt that all AFSCM 84-3 functions are capable of being performed by the incumbent industrial specialists since their work experience includes production planning and industrial engineering. DCP feels that since most programs are in the full-scale development and production phases, and industrial engineering is applied principally in the conceptual/validation phases, they wish to assure that full utilization of an industrial engineer is possible before commitment to filling a current vacancy with an industrial engineer. If convinced, they propose to fill this vacancy with a GS-7 or GS-9 trainee position (7).

An analysis of DCP's response revealed that the industrial specialists' industrial engineering experience is primarily a result of having previous experience performing work as Naval shipyard planner/estimators. While employing some industrial engineering techniques, the duties performed by planner/estimators are limited to those applied during the production phase in the areas of production planning and control. These positions are not involved with the deliberate analysis of the design from a producibility point of view. DCP is aggressively and effectively accomplishing the classical production phase management functions; however, they do not currently have the capability to conduct producibility analysis and production risk assessment.

The DCP point of view, which stresses that most of their programs are in full-scale development or production phases and they are not sure they can adequately utilize an industrial engineer, indicates a basic misunderstanding of the role of the industrial engineer. The most important phase of any item's life cycle from a producibility point of view is the full-scale development phase (7). Industrial engineering expertise must be brought to bear in this phase to assure that the detailed design is optimum from a production point of view. Further, the most critical assessment with respect to production risk is included in the Production Readiness Review (PPR) which occurs prior to DSARC III. What is more, the desirability of a trainee position, in this instance, is not supportable. If DCP possessed a balance of industrial engineers and industrial specialists, then a trainee position would be appropriate. In this case, however, industrial engineering capability does not exist. DCP cannot afford to wait for the designated trainee to be trained. A trainee would not be able to interface effectively with Air Force Plant Representative Offices (AFPROs), Contract Administrative Services (CAS), contractor engineers and government design engineers; nor would he be in a position to provide the necessary leadership and control. In addition, industrial engineers are capable of performing industrial specialist functions associated with tracking and expediting; consequently, utilization should not be an issue.

Deputy for Command and Management Systems (MC)

MC is organized similarly to DC and OC; that is, they are a basket-type Deputate supporting nine SPOs. Their programs are mixed throughout the acquisition cycle with a predominance of their programs in the validation and full-scale development phases.

The production function (MCP) has six authorized positions. The Chief of Production is a GS-13 supported by one military Major position, three GS-12s and one GS-7. All civilian positions are industrial specialists and the military position does not stipulate an officer with a formalized engineering background. Fortunately, the military position was manned by a Major with an engineering background; however, his position is now vacant and there is no assurance that the replacement will be so qualified. Only five military officers in AFSC with Development Engineering/Program Management duty Air Force Service Codes are serving in production management jobs (15:Chart 15).

In response to this study, the MCP position was that an adequate mix of industrial specialists and industrial engineers are available within MCP to accommodate the requirements of AFSCM 84-3 (12).

In consideration of this response, it is evident that until MCP fills the now vacant military space with a qualified military industrial engineer, an adequate mix does not exist. The identification of military production officers qualified as industrial engineers is difficult, since officers are identified primarily by their job codes. In the case of a production officer, his identification is an Air Force Service Code 1524, which may or may not be an industrial engineer code.[1]

MCP must carefully screen the potential military replacement to this position to assure that the individual has the necessary industrial engineering background. If MCP is successful in obtaining this qualification, then an initial capability will exist to accomplish the industrial engineering responsibilities as previously discussed. However, due to the varied stages of MC programs within the acquisition cycle, emphasis should be addressed to converting a civilian industrial specialist position to an industrial engineering position. This would enable one-third of the MCP force, a better mix, to direct its attention to industrial engineering responsibilities and would provide a more permanent continuity of industrial engineering requirements, since the civilian position is less subject to turnover than in the case of the military.

Deputy for Iranian Program Office (FA)

This is a new Deputate presently being formulated. Its basic function is to support foreign military sales to the Iranian Government. At the time of this analysis the production function (FAP) is still in the formulation stage. Positions are currently being identified within production, and consideration is being given to industrial engineering capability (9).

Deputy for Advanced Airborne Command Post (YS)

YS is an aggregate organization. This Deputate has dedicated resources in all areas assigned directly to the program manager to

[1]Management attention should be directed towards sub-categorization of this job code (i.e., 1524(a) industrial engineer, 1524(b) industrial specialist) to provide better selection and placement of production affairs. This problem should be addressed by AFSC and coordinated through USAF (11).

accomplish the YS mission, which is in the full-scale development phase of the acquisition cycle. The production organization (YSP) is presently authorized only two positions: one GS-13 Industrial Specialist (Chief, YSP) and one GS-12 Industrial Specialist. Two additional spaces are currently in manpower validation for an on-board time in late October, with additional planning for a third space to be filled by December 1974.

The new manpower requests were originally made for industrial specialists. However, YSP has subsequently recognized the necessity for industrial engineering talent and has changed its direction to provide for one industrial engineer position (8). YSP's positive approach to obtaining the talent required is commendable. This will provide only one industrial engineer, however, out of the projected staff of five. If the manpower spaces are approved in total, it is recommended that YSP consider filling two of the three spaces as industrial engineers.

Deputy for Airborne Warning and Control Systems (YW)

YW is organized similarly to YS in that it is a self-contained program office. YW is in the full-scale development phase of acquisition.

The production function (YWP) has seven authorized personnel, consisting of: a Major as Chief, YWP; a Captain with electronic/industrial engineer experience; two GS-12 Industrial Specialists; a Lieutenant Production Officer; and a non-commissioned officer, Air Force Service Code 65xxx.

Discussions conducted with the Chief, YWP indicate that, for continuity purposes, a currently authorized Air Force Service Code 6524 space will be converted to a civilian industrial engineering position (8). With this conversion and subsequent placement, YWP will have two qualified industrial engineer positions, which should provide good coverage of responsibilities.

Summary of Evaluation of ESD Production Activities

Except in the case of YW, the Deputate concepts for production management are generally limited to the accomplishment of classical production oriented functions. Production management involvement during all phases of the life cycle is primarily from this point of view. Producibility analysis, necessitating continuing involvement with design and formal production risk assessments during conceptual, validation and full-scale development phases, is not being accomplished.

Discussions with production chiefs in the Deputates revealed, in most cases, an inadequate understanding of industrial engineering and its role in production management. Although not specifically stated, there appears to be an underlying resentment to this emphasis on industrial engineering capability, possibly stemming from fears that professional industrial engineers will supplant technical specialists in the management of production. Deputate production personnel seem to feel that introduction of engineering in production management will result in limiting career progression opportunities of incumbent personnel and eventually eliminate the industrial specialist.

PPD is actively pursuing development within the Deputates of an understanding of production management and the role of the industrial engineer. It would appear that considerable headway is being made. There are two industrial engineers in PPD, and each Deputate production function has agreed to provide for at least one industrial engineer on their staff. However, this must be actively monitored to assure that the somewhat reluctant agreement is actively achieved.

SECTION V

OBTAINING NECESSARY INDUSTRIAL ENGINEERING CAPABILITY

Resistance Factors

As was discussed briefly at the conclusion of the previous section, there exists an attitude at ESD that is resistive to changing the status quo. During interviews with management personnel, key points became evident that this paper will refer to as resistance factors.

It should be understood that over the years production personnel evolved through a system that, since World War II, placed production in the category of monitoring, tracking, expediting and reporting. For the most part, they have obtained their expertise through experience and progression on various jobs that emphasized this classical approach. From a formal educational standard, most do not have college degrees (7, 11). The industrial specialist can be classified as a "pick and shovel" man with years of experience and probably little education beyond high school (15:Chart 15). In AFSC, 60 percent of the industrial specialists are over age 50 and 30 percent will be eligible for retirement by the end of FY 75 (15:Chart 18).

Although it is impossible to positively assess the feelings of the industrial specialists in ESD, it can be stated with relative certainty that their attitudes reflect the following:

1. A general distaste for hiring professionally trained personnel: They are not impressed by formal training and the attitude most manifested is: "The best way to get into this field is as I did, through the school of hard knocks."

2. __Fear__: Fear that the introduction of industrial engineering talent will limit their job progression opportunities and, perhaps, a general feeling that they could not adequately supervise the engineer, thus putting their jobs on the line.

3. __Too difficult to initiate change__: More than once, this attitude was expressed by production supervisors in referring to the problems inherent in the civil service system, with all the paper work, job descriptions and justification required to convert a job from an industrial specialist position to that of industrial engineer. The following quotation describes some of the frustrations encountered:

> John Jones, civil servant, may want to transfer from his present post to another that has been offered him in a new agency. His present agency may raise no objection. The transfer may be most desirable for the national welfare. But, under the law, first comes paper work; and then, usually months later, comes action.
>
> The Civil Service Act forbids the hiring of a man for a government post until the job has been described in detail on an official form and classified in relation to federal pay scale. . . . Not everyone can do this classifying of what other people are expected to do. This work is done by professionals from the Civil Service Commission. . . . Speed is not something for which they are noted (5:45).

4. __Waiting to retire__: This, of course, is extremely difficult to generalize; however, again there seemed to be a feeling that the system has survived all these years without change: "Let the next guy change it when I leave."

Time has made its mark on the program managers, as well, in molding their concepts of the production function. All too often in discussions with the program manager, an impression was given, and sometimes outrightly expressed, that production personnel are "nothing but bean counters." They are not sure, in some cases, that production personnel are even needed in the program office, indicating that "program control can do that for me." It is not difficult to see how this attitude developed. Typically, as the program manager progressed to his position, he had witnessed only the classical approach to production. His attitudes are founded on years of witnessing the job of production performed in that specific manner.

Overcoming Resistance Factors

Merely recognizing that the attitudes addressed above do exist, at least by many of the key personnel involved, is moving a long way toward overcoming the problem. Robert A. Sutermeister in his book, People and Productivity, devoted a large portion of one chapter to why people resist change (17:409-427). Basically, through numerous experiments, it was pointed out that participative planning for a change receives the most productive results. Stated in perspective to this analysis, it must be insured that the deputy production chiefs participate in developing individual deputate plans for obtaining industrial engineering talent. Initially, it may take longer to develop such a plan, but once conceived, the supervisor will feel a part of the decision and be more concerned to insure its successful implementation. ESD is attacking the problem in this manner. However, for successful participation, some of the fears and biases of the deputate production chiefs must be overcome. There is no magic panacea for accomplishing this task, but the following ideas are offered:

1. Gather a meeting of all production chiefs at Headquarters AFSC, whereby attitudes and feelings can be freely expressed.

2. Provide strong policy guidance from Headquarters AFSC, emphasizing the need for both industrial specialists and industrial engineers. Point out that the problems of surveillance and tracking of production progress are increasingly demanding. Indicate how the Cost Schedule Control System criteria will place increasing demands on industrial specialists. In other words, emphasize the continuing need for competent industrial specialists, as well as the growing need for competent industrial engineers.

3. Headquarters AFSC should establish career progression and career broadening plans for both industrial specialists and industrial engineers. These plans should offer the opportunity for career advancement in both fields for exceptionally qualified persons.

4. Publicize the fact that AFSC is studying the possibility of using lower grade production technicians to offload the routine paper processing workload from the industrial specialist, so that the industrial specialist can perform his expertise more effectively (15:Chart 15).

5. Indicate the importance for industrial specialists to continue their training. Publicize the fact that AFSC is leading the Air Force in establishing a new nine-week course aimed at helping all production management personnel, including industrial specialists, develop more expertise in their increasingly complex field (15:Chart 19).

6. Since the paper-work problem is real, a standardized position description for an industrial engineer should be made available. A suggested example is included as Appendix B.

The attitude of program managers toward production management must also be addressed. Top management must continuously pursue this matter by emphasizing the real functions and importance of production management. This can be done through correspondence, through program management training programs, such as the Defense Systems Management School, and through local on-base Systems Program Management Seminars. In addition, the Headquarters AFSC Production Management Division (SDDP) should consider a briefing to program managers at each division level (i.e. ESD), aimed at showing the program manager how a new look at production management can achieve quantifiable results to his program through:

1. Performance of industrial engineering analysis of producibility concurrently with preliminary design and development engineering.

2. Developing overall production feasibility assessment for inclusion with the SPO feasibility analysis of the program and coordinating the Air Force Material Laboratory participation in both in-house and contractual evaluations of production feasibility.

3. Assisting the program manager in the determination of realistic production management planning which will support proposals to DSARC.

4. The use of industrial engineering expertise in evaluating for the SPO such matters as Make-or-Buy, manufacturing methods and processes, plant layout, production control, product improvement, and manufacturing techniques available to meet product requirements or needing new advances in the state of the art in manufacturing technology.

5. Participation in industrial management surveys of contractor's systems to determine the contractor's ability to meet the program requirements from a management and a manufacturing standpoint.

6. Assistance in resolving contractor production problems.

Finally, I recommend that the name "production" be changed to more clearly represent its intended function. I suggest such terminology as: "manufacturing technology," "product manufacturing" or "manufacturing operations."

SECTION VI

SUMMARY

Summary of Conclusions

The purpose of this study was to emphasize the importance of industrial engineering capability in reducing production costs in defense acquisition programs. A review of the changing DOD acquisition environment pointed out that, until only recent years, schedule and performance considerations were dominant over cost. A discussion of today's acquisition environment indicated that with the present circumstances of a limited real dollar budget, technology pushing the state of the art, increasing cost of weapons and shrinking weapon system life due to obsolescence, the DOD has been forced to recognize cost as an important parameter. An examination of the acquisition cycle revealed that AFSC spent 60 percent of its FY 74 dollars for production. Therefore, to reduce costs, a new awareness of the importance of effective production management has evolved. Such concepts as Design-to-Cost and Fly-Before-Buy are continuously stressed in government procurement.

In order to have effective production management and implement such policies as Design-to-Cost and Fly-Before-Buy, the requirement for industrial engineering capability in production was demonstrated. The functions of the industrial engineer were delineated as opposed to the industrial specialist. The major areas where industrial engineering capability should be applied were identified in the conceptual, validation, full-scale development and production phases of the acquisition cycle. It was shown that there is a greater need for industrial engineering capability in the early phases and a lessening requirement for this talent as the program enters production.

ESD was analyzed concerning the current status of its industrial engineering capability. First, an organizational overview was presented, focusing on its production functions. Then, each Deputate containing the production function was assessed according to its present industrial engineering capability, its requirements for this capability, and attitude toward future acquirement of this capability. It was painfully obvious that although some progress has been made, there is a long way to go before achieving adequate industrial engineering capability to perform the technical analysis and contractor evaluation envisioned by AFSCM 84-3.

It is one thing to recognize what should be done, however, and another to actually implement it. Resistance to change was discussed and areas highlighted which, if addressed from the appropriate level and in a coordinated manner, could significantly overcome the factors inhibiting the hiring of industrial engineering talent. AFSCM 84-3 provided explicit guidance in 1971 when it was amended to carry out many of the criticisms of the production function delineated in an Air Force Production Management Study released in early 1971. AFSCM 84-3 clearly defines the requirement for professional industrial engineering capability; yet almost four years later we still have production functions with either no industrial engineering capability or only token capability.

Recommendations

1. Reeducate program management and production management personnel to the importance of obtaining industrial engineering talent. Assure that program managers recognize the need for industrial engineering expertise to adequately assess manufacturing feasibility, producibility and realistic production risk early in the acquisition cycle.

2. There are strong resistance factors to any change in the status quo among the industrial specialists presiding in the production functions. In obtaining additional industrial engineers, either through hiring to new authorized spaces or converting industrial specialist positions to industrial engineer positions, care must be exercised to recognize just how strong this resistance is. To force a change on the Deputate production supervisors by directing replacement of industrial specialists with industrial engineers would hasten the conversion process; however, it could possibly disrupt the production organization to such an extent that it would be less effective.

3. It is my opinion that a concentrated plan of action to change the entire image of production management is the best approach, up to and including changing the name of "production" to more clearly represent its intended function. Realistic career progression and career broadening plans for both industrial specialists and industrial engineers should be developed. Opportunities for further educating the industrial specialists in new techniques should continue to be pursued. Specific ESD Deputate recommendations are provided in Section IV.

4. If it is Air Force policy to carry out the intent of the Whittaker Study (2, 3), each DSARC should require program managers to include

documentary evidence of industrial engineering and production management support and studies as outlined in AFSCM 84-3.

5. Last but not least, Command Management must continually stress the implementation of production management and industrial engineering as outlined in AFSCM 84-3.

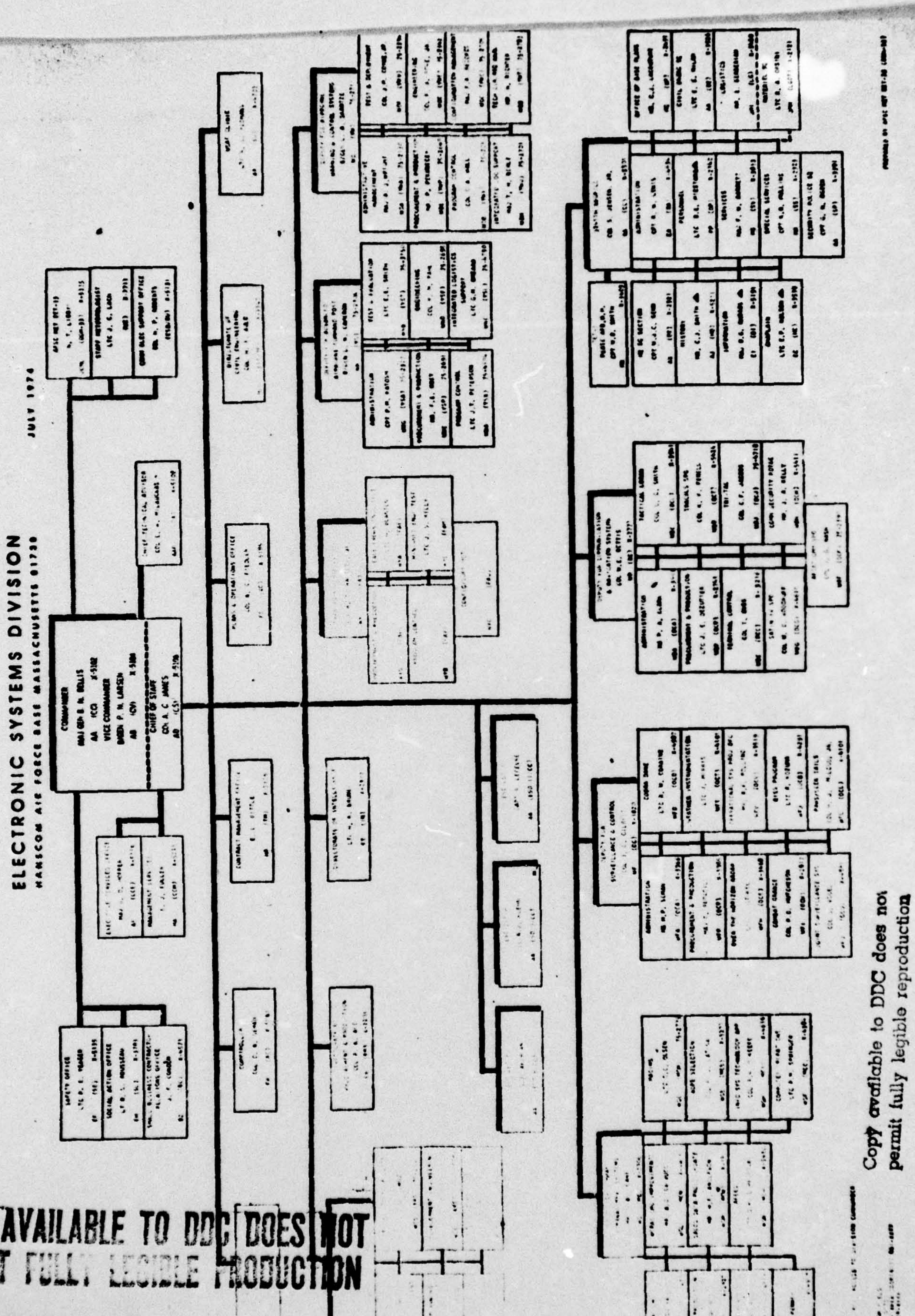
Implications

Attention is invited to those in the Department of Defense who have a stake in the maximization of the probability and producibility of successful, on-time delivery of quality items at an affordable cost. Top level management needs to devote continuous effort to acquiring adequate industrial engineering capability. The necessary industrial engineering talent must be obtained as it is too costly to our country not to have this talent. Modern techniques and skills are required in order to have effective production management. The intricacies and complexities of 1975 cannot be managed with 1945 skills.

APPENDIX A

ORGANIZATIONAL CHART OF ELECTRONIC SYSTEMS DIVISION

Attached is an organizational chart of ESD. Those areas with a production function are color coded blue.


ELECTRONIC SYSTEMS DIVISION
HANSCOM AIR FORCE BASE MASSACHUSETTS 01730
JULY 1974
COMMANDER
VICE COMMANDER
CHIEF OF STAFF

APPENDIX B

SAMPLE POSITION DESCRIPTION FOR INDUSTRIAL ENGINEER

Attached is a sample position description suggested for an industrial engineer.

DEPARTMENT OF THE AIR FORCE **POSITION DESCRIPTION**		1. NUMBER OF IA'S	2. POSITION NUMBER
3. ORGANIZATION LOCATION	4. POSITION TITLE Industrial Engineer		
	5. CLASSIFICATION	6. CLASSIFIED BY	7. DATE

8. DUTIES AND RESPONSIBILITIES *(Indicate time percentages, where required)*

I. INTRODUCTION

A. This position is located in the organization identified in Block 3 above, the function of which is described in the organization and function chart book and AFSCM 84-3.

B. The purpose of this position is to plan, organize, direct and control production/industrial engineering responsibilities for all projects within the Deputate.

II. DUTIES AND RESPONSIBILITIES

A. Provides overall technical production cognizance of all projects in the area of ________________________. Translates production requirements and limitations into technical characteristics (producibility criteria) and prepares technical production specifications for the design, fabrication and testing of ____________________________________ systems. Conducts production feasibility studies of design alternatives to determine which are consistent with sound Industrial Engineering principles and within state-of-the-art knowledge. Performs continuous industrial engineering analysis of producibility throughout the life cycle identifying and evaluating, in appropriate depth, items which constitute production risks. Must consider, from the production point of view, often divergent and contradicting technical and management requirements.

B. Participates in high level conferences and design reviews with senior System Program Office (SPO), contractor and AFSC engineering and management personnel. Presents technical findings, advises on production/industrial engineering policy and influences and negotiates production/industrial engineering aspects of design.

C. Leads, coordinates and participates with senior contractor, SPO, CAO and AFML technical and management personnel, in the review of technological developments in production affecting producibility and design direction. Ascertains status and deficiencies of the production base required to support assigned programs and institutes appropriate remedial actions.

D. Conceptualizes and prepares contractual documents for the production/industrial engineering aspects of production management during the conceptual, development and production phases of the life cycle. Brings to bear specific knowledge of industrial engineering and production management to monitor and direct, as appropriate, contractor accomplishment of specified requirements.

9. THIS IS A COMPLETE AND ACCURATE DESCRIPTION OF THE DUTIES AND RESPONSIBILITIES OF THIS POSITION		10. REAUDIT CERTIFICATION				
SIGNATURE AND TITLE OF IMMEDIATE SUPERVISOR	DATE	DATE				
		SUPERVISOR				
		CLASSIFIER				

E. Provides staff advice and rendors technical consulting services to the Deputy for ______________________________ in the production/industrial engineering area. These technical judgments/ recommendations and conclusions are authoritative and seldom subject to technical review.

F. Promulgates plans and procedures for, and accomplishes, formal Industrial Engineering analysis of the developed engineering design to determine that all important production engineering problems have been resolved prior to the decision to produce (Production Readiness Review prior to DCARC III or equivalent).

G. Makes presentations to Air Force Systems Command, Air Force Material Laboratory and other agencies concerning production capability status and manufacturing technology requirements for cognizant programs.

H. Evaluates Make-or-Buy, manufacturing methods and processes, plant layout, production control, and similar production-oriented systems and processes for effectiveness and adequacy.

I. Performs other related duties as assigned.

III. CONTROLS OVER WORK

Works under the general administrative control of the Production Division Chief who identifies overall program objectives. Work is not subject to technical review other than for conformance with broad directives and policies, and from the standpoint of evaluating attainment of objectives.

IV. OTHER SIGNIFICANT FACTS

Requires periodic travel which may be by military air.

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