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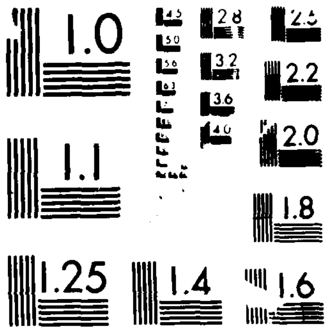

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AN EVALUATION OF MODELS AND TECHNIQUES USED FOR DETERMINING OPTIMUM SUPERVISORY/EMPLOYEE RATIOS IN DEFENSE LOGISTICS AGENCY (DLA) ORGANIZATIONS

THESIS

Stuart D. Scott, B.S.
GM-13, DLA

AFIT/GLM/LSR/87S-67

DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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THESIS

Presented to the Faculty of the School of Systems and Logistics

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Stuart D. Scott, B.S.

GM-13, DLA

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Stuart D. Scott

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Abstract

The purpose of this study was to determine what models or techniques exist that can assist DLA Supply Centers in identifying and maintaining "optimum" supervisory/employee ratios within their first-line organizational elements. Basic objectives of the study were (1) to identify all existing simulation models or other techniques, (2) assess their adaptability or suitability to governmental organizations, (3) compare existing DLA first-line supervisory/employee ratios with those obtained from applying suitable models or techniques, and (4) survey first-line DLA supervisors to obtain their reaction to the products of the models or techniques.

Results of the research revealed four existing models (Lockheed, waiting line, Keren/Levhari, and Dewar/Simet) for determining "optimum" supervisory/employee ratios. All were judged suitable for application to DLA organizations, but because of complexity, the Keren/Levhari and Dewar/Simet models were eliminated from further consideration in this study. Application of the Lockheed and waiting line models to DLA first-line organizations produced "optimum" ratios that were very close to those actually existing in the organizations. When surveyed, first-line supervisors showed a preference for their organizations'existing ratios versus

the 'optimum' ratios produced by the models. Between the two models, they showed a preference for ratios produced by the waiting line model over the Lockheed model.

Among the recommendations made to DLA were (1) field testing of the Lockheed and waiting line models at the first-line level, (2) consideration of funding for further research on the Keren/Levhari and Dewar/Simet models, (3) possible adoption of dual guidelines to accommodate the natural variations in ratios between different types of organizations, and (4) incorporation of useful models into a Specific Decision Support System (SDSS) for use on office personal computers (PCs) by all first-line organizations.

AN EVALUATION OF MODELS AND TECHNIQUES USED FOR DETERMINING OPTIMUM SUPERVISORY/EMPLOYEE RATIOS IN DEFENSE LOGISTICS AGENCY (DLA) ORGANIZATIONS

I. Introduction

General Issue

The Defense Logistics Agency (DLA) is a component of the Department of Defense (DOD) that functions as a joint-services command and reports directly to the Office of the Secretary of Defense (OSD). DLA's mission is to provide effective and economical supply support, materiel management, contract administration, and scientific/technical information support services to the Military Services, other DOD components, civilian agencies and foreign governments (3:XV). To accomplish the preceding, DLA maintains four main types of field organizations (Supply Centers, Depots, Service Centers and Defense Contract Administration Services Regions), as illustrated in Appendix A. This study focuses on the Supply Centers, which include the Defense Construction Supply Center (DCSC), the Defense Electronics Supply Center (DESC), the Defense Fuel Supply Center (DFSC), the Defense General Supply Center (DGSC), the Defense Industrial Supply Center (DISC), and the Defense Personnel Support Center (DPSC).

Like all successful public or private sector organizations, DLA strives to accomplish its mission in the most efficient and cost-effective manner possible (6:I-1). At the present time, the United States' continuing large budget deficits have heightened awareness to the economical spending of public funds and have caused shrinking budgets at a time when expanding missions are putting greater demands on DLA's limited resources. This fact, combined with the new Gramm-Rudman-Hollings budget process, has made it imperative that DLA obtain maximum productivity from its personnel resources. Finding a method(s) for determining optimum organizational structuring, manpower authorizations, and skill mixes for various types of DLA organizations is one means of accomplishing this. Because of DLA's large size, the effect of even a small percentage decrease in the operating costs of its workforce has major dollar implications (6:VII-7).

Specific Problem

In examining organization design and position management in DLA, one of the most frequent areas of controversy has been the question of what constitutes adequate supervisory/employee ratios or spans of supervision at the first-line organizational level (the primary operating level at which a supervisor oversees productive workers, not other supervisors). The terms "supervisory/employee ratio" and "span of supervision" are synonymous and mean the ratio of supervisors and clerks to all other employees, or the number of subordinates who formally report to a supervisor. Because minimal guidance was provided to DLA field personnel, supervisory/employee ratios vary widely across different types of organizations, and this variation may not optimize DLA resources. The individual Primary Level Field Activities (PLFAs) within DLA are responsible for instituting sound position management programs and for setting guidelines to evaluate the effectiveness of their programs (5:1-2). These guidelines have traditionally included ratios of supervisory to nonsupervisory positions, and relationships between the number of clerical, technical and professional level positions. Because these guidelines were established many years ago, it is important to reassess their continued applicability and to identify areas where improvement may be possible (6:I-2-I-3). Concurrently, it is important to identify models or techniques for determining "optimum" supervisory/employee ratios that might produce dollar savings for DLA.

Specific Question

What (if any) models or techniques exist that can assist DLA Supply Centers in identifying and maintaining "optimum" supervisory/employee ratios within their first-line organizational elements?

Investigative Questions

Identifying models or techniques that may be useful to DLA in controlling supervisory/employee ratios and reducing costs requires answers to several specific questions:

1. What (if any) simulation models for determining "optimum" supervisory/employee ratios exist?

2. What other techniques (if any) exist for determining "optimum" supervisory/employee ratios?

3. If existing techniques or models for determining "optimum" supervisory/employee ratios are non-governmental, can they be applied to or modified for use within the various types of organizations/professions of DLA?

4. What are the features of DLA's organizations/ professions that must be considered in evaluating goodness-of-fit (applicability) of existing models or techniques?

5. How do existing supervisory/employee ratios within DLA compare with the "optimum" ratios obtained from applying the models or techniques?

6. If the current and the theoretical ratios are different, how do first-line supervisory personnel in DLA react to this difference and to the models or techniques?

A more detailed explanation of the steps involved in answering the above questions and the evaluation criteria applied to make decisions are provided in Chapter II.

Research Scope and limitations

For the purposes of this research, determinations of applicability were limited to organizations within DLA, and surveys were limited to DLA personnel with first-line supervisory responsibilities or experience. Although focused on DLA, the research findings presented may have potential DOD-wide application but would require additional tests for applicability.

II. Methodology

Introduction

This chapter outlines the methodology and data collection approaches that were used in answering each of the investigative questions presented in Chapter I. It also presents the analysis and the evaluation criteria that were applied.

Investigative Questions 1 and 2

What (if any) simulation models for determining "optimum" supervisory/employee ratios exist?

What other techniques (if any) exist for determining "optimum" supervisory/employee ratios?

Methods of Approach. A literature review was selected as the best method to identify any existing methods, techniques or simulation models for determining "optimum" supervisory/employee ratios within different types of organizations. The findings of the literature review are reported in Chapter III.

Data Collection Plan. In order to locate current literature on the questions, Defense Technical Information Center (DTIC) and Dialogue searches were requested, and the Business Periodicals Index was consulted. Recent graduate-level text books on organizational theory and development were also reviewed.

Investigative Questions 3 and 4

If existing techniques or models for determining "optimum" supervisory/employee ratios are non-governmental, can they be applied to or modified for use within the various types of organizations/professions of DLA?

What are the features of DLA's organizations/ professions that must be considered in evaluating goodness-of-fit (applicability) of existing models or techniques?

Methods of Approach. To judge the goodness-of-fit or adaptability of existing methods, techniques, and models to non-profit governmental or public sector organizations, the following selection criteria or decision rules were applied:

1. Any instrument selected must have been developed for use with or be adaptable to a nonprofit organizational environment.

2. In calculating "optimum" supervisory/employee ratios, the instrument must be directed towards cost minimization (versus profit maximization) or must allow the user to focus on achieving cost reductions.

3. Since organizations within DLA vary widely in the type of work supervised (professional, technical, administrative and clerical), the instrument must be adaptable to these different conditions. If not, it must be identifiable to a specific type of organization.

4. To be selected for further evaluation in this study, the instrument must be both easily understandable by DLA position management or supervisory personnel and be suitable for immediate application without complex computer simulation modeling.

Investigative Question 5

How do existing supervisory/employee ratios within DLA compare with the "optimum" ratios obtained from applying the models or techniques?

Methods of Approach. Comparison of actual DLA ratios to "optimum" ratios required accomplishment of the following two steps:

1. Collection of factual information from DLA position management reports. This data was used to determine the actual DLA supervisory/employee ratios that exist within various organizations at four DLA Supply Centers.

2. Application of selected methods, techniques, or simulation models to various DLA organizational elements to obtain the ratio that would result if the theoretical models were adopted. The results were then compared to the actual supervisory/employee ratios.

Data Collection Plan. To accomplish the preceding, data collection was divided into the following two phases:

1. Collection of factual information. Existing DOD/DLA manuals, regulations, and procedures for field activities were researched to determine the extent of guidance on formulation of "optimum" supervisory/employee ratios. In addition, personnel resource data records were collected from the DLA Supply Centers and used to compute existing spans of supervision. Mr. Larry Juul (DLA-LP) served as the HQ DLA contact point, and facilitated provision of full support and assistance for this research effort. A letter of introduction and support for this

research (Appendix B) was provided by DLA-L and furnished to the four Supply Centers used as data sources in this study.

2. Application of identified models. Based on the specified decision criteria, selections were made from the identified methods, techniques, and models, and applied to existing DLA organizations. The theoretical or "optimum" ratios that resulted were then compared to those currently present in the organizations.

Investigative Question 6

If the current and the theoretical ratios are different, how do first-line supervisory personnel in DLA react to this difference and to the models or techniques?

Method of Approach. To answer this question, a survey was administered to selected first-line supervisory personnel at three of the Supply Centers (DCSC, DESC and DGSC). The results of the selected methods, techniques, or simulation models tested were furnished to the first-line supervisory personnel, who then completed a questionnaire regarding the perceived appropriateness of the different ratios to their organization.

Data Collection Plan. When investigative questions 1 through 5 had been answered, the results from application of the selected methods, techniques, and models were provided to supervisory personnel at DCSC, DESC and DGSC. These personnel were then given a written survey to obtain their opinions on the appropriateness of the ratios. The survey questions concerned topics such as possible implications, and what would be jeopardized if the selected methods, techniques, and models were implemented within DLA first-line organizations. These validation surveys (Appendix C) were composed of a cover letter, a survey questionnaire form, and a self-addressed return envelope.

General Data Analysis Plan

The first step in analyzing the collected data was to apply the models or techniques that appeared to fit DLA organizations and determine the theoretical ratios they identified as "optimum". Existing DOD/DLA guidance was then compared with the results from the selected methods, techniques, and models, and the implications were evaluated at all points where the theoretical ratios and DOD/DLA guidance did not agree. Next, the DLA actual ratios were compared with the results from the selected methods, techniques, and models, and the implications were evaluated. The primary reason for making this comparison was to determine whether there was a reason to believe a problem actually existed within DLA, as would be the case if the PLFAs were not working within the guidance or existing guidance was not adequate or correct. The study also evaluated the potential of the identified instruments to serve as useful new tools for DLA position management and supervisory personnel. Finally, recommendations were made based on the results of the research findings and the validation surveys, regarding implementation of any changes to DLA guidance or the need for further study.

III. Literature Findings and Analysis

Introduction

This chapter presents the results of the data collection and analysis methodologies for Investigative Questions 1 and 2, as outlined in Chapter II. The research results are displayed for these questions and the chapter concludes with a summary of the findings. Conclusions and recommendations based on these findings are presented in Chapter V.

Investigative Questions 1 and 2

What (if any) simulation models for determining "optimum" supervisory/employee ratios exist?

What other techniques (if any) exist for determining "optimum" supervisory/employee ratios?

Literature Review. As noted in Chapter II, a review of technologies in existing literature was selected as the method to answer the first two questions. A chronological review of the literature regarding research on technologies for formulating "optimum" supervisory/employee ratios clearly revealed the following two facts:

1. Interest in this subject extended back as far as the 1920's to research and traditional theory attributed to such classical theorists as Sir Ian Hamilton, Henri Fayol, Lyndall Urwick and V.A. Graicunas (2:46).

2. Research initially provided general guidelines based on uncomplicated assumptions and then evolved to complex formulas and simulation models as increasing

importance was attached to supervisory/employee ratios. Today, more generalized guidelines are returning, as profit maximization or performance against budget (the bottom line) is being relied on to keep supervisory ratios in check (6:VI-1).

Traditional thinking emphasized vertical relationships and the need to have a clearly specified chain of command within an organization. In addition, the 'unity of command' principle stated that a subordinate should answer to only one supervisor. With much of a supervisor's time being spent in coordinating and controlling a subordinate's work, it was natural that interest developed in defining what an appropriate supervisory/employee ratio should be. Due to the many types of organizations and influencing factors, the best generality for an ideal ratio that could be determined was a range of from three to eleven employees per one supervisor (1:108).

The first significant mathematical model was developed in 1933 by V. A. Graicunas to display the increasing complexity of a manager's job each time a new subordinate was added. Each additional increment in the span of supervision created many additional combinations of relationships among subordinates for a manager to deal with. The number of relationships grew exponentially with each addition and was computed using the equation

$$r = n(2^{n-1} + n - 1)$$

where

n = number of persons supervised

r = number of relationships (2:47).

The results of this equation are depicted below in Table I.

TABLE I

Relationships of Possible Significance to a Manager

Number of Subordinates	Number of Relationships
1	1
2	6
3	18
4	44
5	100
10	5210
12	24708
18	2359602

(1:109)

This model demonstrated the impact of each additional subordinate, and also illustrated that a manager's job became more complex as the span of supervision increased. Graicunas further inferred that if wider spans were to be used, other conditions must be favorable to the manager's job. Factors that affected the width of supervisory spans were listed as:

1. Competence of supervisor and subordinates.
2. Degree of interaction between the units supervised.

3. Amount of non-coordination work assigned to the manager.
4. Similarity of activities supervised.
5. Stability and predictability of the unit.
6. Extent to which standardization is possible.
7. Degree of physical separation between subordinate units (1:109-110).

Graicunas's work formed the foundation for much of traditional theory, which advocated narrow (3 to 6) spans of supervision, and a tall or pyramidal organization structure.

Traditional theory came under increasing attack in the 1950's. Critics felt that larger supervisory/employee ratios and flat organization structures offered simplified communications by eliminating excess layers of supervision. Researchers finally recognized that generalizations could not be made about organizations and spans of supervision. Also, time and frequency of contacts came to be generally recognized as the most important factors in determining "optimum" supervisory/employee ratios (2:79-88).

In 1958 the Fordham model was introduced in an attempt to bring objective criteria into making a decision on span of supervision. The objective of the model was to select the span of supervision that maximized the efficiency of the organization. Both "productive" and "nonproductive" times spent in supervisory contacts were the main factors used in determining organizational efficiency. Productive time was the time spent on activities directly related to the primary responsibility of the supervisor, while nonproductive time was the time spent on activities that were indirectly related to his primary responsibilities. The model also relied on the simplifying assumption that span of supervision remained constant throughout the organization -- that is, each supervisor had the same number of subordinates. This assumption made the model too simple to be of practical value, as there were usually significant differences in managerial talent among supervisors and variations in the social climate between organizations. This model also proved to be too deterministic for practical application because it assumed certainty (a constant span of supervision throughout the organization). Despite these problems, the Fordham model demonstrated the importance of contact time in span of supervision problems, and used objective criteria for decision making (2:88-93).

The next major development in determining 'optimum' supervisory/employee ratios was the introduction of the Lockheed model in 1962. While not perfect, this model was less abstract than the Fordham model and introduced more objectivity into the formulation of proper supervisory/employee ratios. It employed variables considered to be most significant for Lockheed, along with judgments concerning the relative importance of each. The designers of the model concluded that there were seven key variables in determining supervisory/employee ratios and then attempted to assign weights to these variables. The more critical a variable was, the more heavily it was weighted. These weights were determined at Lockheed through common sense, experience, and experimentation. The variables and possible weights are illustrated in Table II.

TABLE II

Lockheed Model Criteria for Assigning Weights to Supervision Variables

Span Variables	Degree of Supervisory Burden				
Similarity of Functions:					
	Identical	Essentially Alike	Similar	Inherently Different	Fundamentally Distinct
	1	2	3	4	5
Geographic Contiguity:					
	All Together	All in One Building	Separate Buildings	Separate Locations	Dispersed Areas
	1	2	3	4	5
Complexity of Function:					
	Simple Repetitive	Routine	Some Complexity	Complexity Varied	Highly Complex
	2	4	6	8	10
Direction and Control:					
	Minimum Super.	Limited Super.	Moderate Super.	Frequent Super.	Constant Super.
	3	6	9	12	15
Coordination:					
	Minimum Contacts	Limited Contacts	Moderate Contacts	Frequent Contacts	Extensive Contacts
	2	4	6	8	10
Planning:					
	Minimum Scope	Limited Scope	Moderate Scope	Considerable Effort	Extensive Effort
	2	4	6	8	10

(2:94)

These weights were then totaled and related to a suggested standard span through a supervisory index as shown in Table III (2:89-102).

TABLE III

Lockheed Model Middle-Management Index
and Suggested Supervisory Span

Supervisory Index	Suggested Standard Span (Number of Employees Per Supervisor)
40-42	4-5
37-39	4-6
34-36	4-7
31-33	5-8
28-30	6-9
25-27	7-10
22-24	8-11

(2:95)

The next development in modeling was the application of queuing theory and the development of the waiting line model in 1963. In the waiting line model, supervisors were considered as service stations and their subordinates as units demanding service (i.e., the supervisor's time). The object of this model was to determine the number of subordinates that would minimize the combined costs of supervision and idle subordinates. Total hourly costs per subordinate were expressed as

$$TC_c = c_s(1 - E) + c_e(M/N)$$

where

T = average supervisory contact time per subordinate

C_c = average cost per supervisory contact

c_s = cost per subordinate hour

E = percentage of subordinates working

c_e = cost per hour of supervision

M = number of supervisors (service stations)

N = number of subordinates (units demanding service)

The percentage of subordinates working (E) was further expressed as

$$E = F(1 - X)$$

where

F = system efficiency factor

X = service factor

The system efficiency factor (F) was taken from the Finite Queuing Tables, included as an Appendix to Formal Organization (A Systems Approach) by Carzo and Yanouzas, and service factors were calculated using the expression

$$X = T / (T + U)$$

where

T = average supervisory contact time per subordinate

U = average working time of subordinates

This approach was constrained by the unity of command principle that everyone in the organization has only one boss. It has since been proven that a design which allowed subordinates to report to any of a group of supervisors required fewer total supervisors. The model can be modified to accommodate this multiple-reporting arrangement, which is similar to the increasingly popular practice of matrixing organizations, in both the public and private sector (2:405-426).

Research on tall (many levels of management and narrow spans of supervision) versus flat (few management levels and broad spans of supervision) organization structures was renewed by Edwin E. Ghiselli and Jacob P. Siegel in 1972. They developed an instrument to measure leadership styles and managerial success in tall and flat organization structures. A great variation was found in leadership styles between tall and flat organizations, duc to differences in span of supervision and communications patterns. However, no significant statistical differences in managerial success were found for managers in either tall or flat organizations. This finding indicated that no one type of organization structure is best for all conditions (8:617-624).

In 1975, Michael Keren and David Levhari presented a complex model of a pure hierarchy which attempted to look at an organization as an integrated whole and computed the "optimum" span of supervision for each level of the hierarchy. The model was composed of productive units which were completely independent and assumed that no member had communications through non-hierarchical channels with the outside world. Its aim was to minimize costs (the sum of wage costs plus costs caused by delays in decision making) through minimization of total planning time. The general results from the model agreed with several existing empirical studies in that the "optimum" span of supervision was often found to be independent of the size of the organization, and that span of supervision should increase as one went from the top of the hierarchy towards the bottom. Median span of supervision increased as the size of the organization increased, but there was no support for uniform spans at all organizational levels. Based on their findings, the authors offered the following propositions:

1. The optimum span of supervision was an increasing function of wages and fixed time costs, while changes in span of supervision from one level to the next were an increasing function of wage costs.

2. The optimum number of workers at any level was an increasing function of wage costs and the planning time element, while the total number of employees in an organization was a decreasing function of both.

3. As wage costs and the fixed planning element increased, the height of the hierarchy decreased.

4. As wage costs and the fixed planning element increased, total planning time rose.

5. The optimum span of supervision was a decreasing function of the number of units (N), when time costs were increasing; and independent of N, when time costs were constant. In other words, as the number of plants increased, span of supervision was unaffected as long as time costs remained stable. If time costs did rise, then spans became smaller as the number of plants increased [10:1167-1168].

Finally, Keren and Levhari believed military organizations were an exception to the above, in that eliminating time delays should be the primary consideration. Span of supervision should be held constant, as cost considerations are secondary, especially in times of war (10:1162-1172).

Another model for predicting supervisory/employee ratios by specific levels was introduced by Robert D. Dewar and Donald P. Simet in 1981. The model considered such factors as the effects of size, routineness of work, and the number of different work specializations within a unit, to predict "optimum" ratios at the chief executive, department head, and the first line levels. The data used was collected in 1971 and was drawn primarily from public and private social service organizations (schools, hospitals, etc.). Results obtained from the model indicated the single most important factor affecting the size of supervisory/employee ratios was the amount of personnel or job specialization present in the individual organizational units. The number of specialties supervised was found to decrease ratios at lower and middle levels, while increasing them at the upper levels. Routineness of work supervised and the relative size of the organization were found to have little effect at any level. These authors recognized the limited nature of the model and noted influences from other sources such as tradition, unions, federal regulations, and individual supervisory ability, which they were not able to include (7:5-24).

With Japanese manufacturing techniques receiving world wide recognition for both high productivity and high quality, Robert M. Marsh and Hiroshi Mannari published a 1981 study on the effects of size and technology on organizational structure in Japanese factories. In examining supervisory/employee ratios at the first line or foreman's level, they found that as the size of an organization increased, a foreman was able to supervise increased numbers of subordinates, mainly due to the introduction of work specialization. However, as increased technology and automation were applied, the number of subordinates required lessened and supervisory/employee ratios decreased. Even with smaller ratios, the cost of supervision remained about the same due to increased efficiency. At the chief executive level, increased technology also had a positive effect, but in the opposite direction. A larger number of subordinates reported directly to the chief executive in firms with automated technology than in firms with less advanced technology. The increasingly complex, interdependent nature of the production process made it necessary for the chief executive to check directly with a wider range of personnel. The authors concluded that in Japanese factories, the number of subordinates under control of the foreman was influenced equally (though in opposite directions) by size and technology, while the number under the chief executive's supervision was much more a result of technology than size (11:47-50).

Later in 1981, an article appeared in Business Week which highlighted increasing interest by private sector organizations in controlling overhead costs by reducing the numbers of supervisors and supervisory levels. Excessive overhead costs were cited as the main reason for American companies' losing their competitive edge. During previous slow periods, management had often cut operations across the board to economize. The results were that most of the corporate staff was left intact, the ratio of managers to workers rose, and the organization became even more sluggish. In offering guidelines for reducing bloated corporate staffs, it was emphasized that a meat axe approach should not be used. Each department and division should be forced to pinpoint where cuts could be made in operations and then decide whom to retain and whom to fire. An additional guideline was that there should be no more than one salaried staff position for every three hourly production workers (13:69-73+).

Also in 1981, SMC Hendrick, Inc. offered a technique to combat "executive fat" through a method known as organizational analysis by computer. The data for the analysis was collected on questionnaires filled out by company managers and used by Hendrick to generate a "house like" organization chart. Each unit of the company was displayed as a room within the "house" and contained information on lines of supervision, number of employees, salaries, and percent of time used in managing staff. The model also compared actual versus ideal ratios for supervisors and employees, compared time spent in supervision, and indicated whether a manager was underworked or overworked. In addition to helping pinpoint areas of "executive fat," the Hendrick "house plot" also served as a valuable tool for planning a company's future growth (14:34-83+).

In 1984, an article by Michlitsch and Gipson appeared in Supervisory Management that seemed to signal a return to more general guidelines based primarily on local conditions. The manager's capacity to supervise was cited as the single most important factor in managing span of supervision and it was believed that most management problems had their roots in both under utilized and over utilized managerial capacity. The main factors which influenced supervisory/employee ratios were identified as:

1. Competence of the supervisor.
2. Other duties of a supervisor.
3. Supervisory assistants.
4. Competence of subordinates.
5. Rate of change.
6. Geographical dispersion.
7. Similarity of activities supervised.
8. Task complexity.

The following factors were identified as additional modern strains on supervisory capacity:

1. Meetings and committees.
2. External community affairs.
3. Recordkeeping due to governmental regulations.

In concluding, Michlitsch and Gipson advocated an analytical approach as the key to solution of supervisory/employee ratio problems (12:13-18).

Finally, as noted earlier, the recent introduction of matrix organization structures has further complicated the task of determining 'optimum' supervisory/employee ratios. Basically, the matrix superimposed both functional and program/project departments at the same organizational level. This created two chains of command, one to the functional manager, and the other to the program/project chief. The objective of the matrix structure was to encourage technical specialization, while at the same time emphasizing an overall goal. Matrix structures were most often used in aerospace and other high-technology organizations. However, in establishing two lines of authority, the basic 'unity of command' principle was violated, and coordination and control problems were created. Workers sometimes receive conflicting orders from their two supervisors, and it is sometimes difficult to trace specific problems to their sources (1:106-107). Also, previously formulated methods and techniques for determining 'optimum' supervisory/employee ratios do not fit the matrix structure. If the matrix continues to gain in popularity, existing techniques for determining optimum supervisory/

employee ratios will have to be modified or new ones developed.

In examining the numerous past attempts to formulate a technique or model for determining "optimum" supervisory/ employee ratios in all different types of organization structures, it was obvious that no one method had meet with great success. The model builders were frustrated by their inability to construct a model capable of including all the internal and external variables. As a result, both the public and private sector lost interest in further research, and professionals in the field were content to fall back on the old, more general principles as guidelines for controlling supervisory/employee ratios.

In the private sector, this loss of interest was partly due to, and justified by, a return to the reliance on the "bottom line" to insure the economic regulation of these ratios (6:VII-4). However, allocating resources in the DOD and other public organizations on the basis of the "bottom line" or as a means to survive was not appropriate. As a result, controlling expenses or costs took on a more important meaning (6:VII-5).

The primary method used by DOD to promote the economical use of personnel resources was through the implementation of a vigorous position management program. Position management was the process by which supervisory personnel were able to identify and prevent the wasteful use of resources such as poor organization structure, out-moded work methods, ineffective job design and the misuse of personnel. The responsibility for maintenance of a sound position management program was given to all managers who supervised people. A key technique used in position management was keeping the number of supervisory positions to the minimum consistent with sound principles (9:8-9). The importance of this technique made finding a tool for determining "optimum" supervisory/employee ratios even more valuable. There were many useful guidelines available, but their generalness left them open to manipulation and misapplication by individuals, as suited their personal interests. Although DOD had slightly fewer management levels and larger first line spans of supervision than private sector corporations, any tools that could be developed would further aid in reducing costs.

IV. DLA Field Data Findings and Analysis

Introduction

This chapter presents the results of the data collection and analysis methodologies for Investigative Questions 3, 4, 5, and 6, as outlined in Chapter II. The research results are displayed for these questions and the chapter concludes with a summary of the findings. Conclusions and recommendations based on these findings are presented in Chapter V.

Investigative Questions 3 and 4

If existing techniques or models for determining optimum supervisory/employee ratios are non-governmental, can they be applied to or modified for use within the various types of organizations/professions of DLA?

What are the features of DLA's organizations/professions that must be considered in evaluating goodness-of-fit (applicability) of existing models or techniques?

Answering Investigative Questions 3 and 4 required accomplishment of two steps. The first step was carried-out in the literature review reported in Chapter III. The review identified four models or techniques for determining "optimum" supervisory/employee ratios that might be potentially useful to DLA:

1. The Lockheed model, which attempts to introduce more objectivity into the formulation of proper supervisory/employee ratios. Variables affecting span of supervision are assigned weights, totaled, and related to a suggested "optimum" span through a supervisory index.

2. The waiting line model, which applies queuing theory to determine the number of subordinates that would minimize the combined costs of supervision and idle subordinates.

3. The Keren/Levhari model, which looks at an organization as an integrated whole and computes the "optimum" spans of supervision for each level of a pure hierarchy.

4. The Dewar/Simet model, which predicts supervisory/ employee ratios for specific levels (chief executive, department head and first line supervisor) within an organization.

The second research step involved application of the decision rules, developed in Chapter II, to the four models or techniques described above. These decision rules were applied to and given equal weight in evaluating the goodness-of-fit or adaptability of the identified models or techniques to DLA organizations. To be selected for further evaluation, a model or technique had to satisfy the requirements of all four decision rules. The decision rules and the results of applying them are as follows:

Decision Rule 1.

> Any instrument selected must have been developed for use with or be adaptable to a nonprofit organizational environment.

While none of the models or techniques was designed specifically for use with nonprofit or governmental organizations, all four appear to varying degrees to have the flexibility to be adapted.

The Dewar/Simet model came the closest to satisfying Decision Rule 1. At the time it was created, the model was tested using data drawn primarily from nonprofit public and private social service organizations (schools, hospitals, etc.), and this model considers a wide range of variables, which makes it flexible enough to apply to governmental organizations.

The Keren/Levhari model was also found to be highly suited for use with nonprofit organizations. It considers the widest range of variables and also models the organization as a pure hierarchy in which no member has any communications through non-hierarchical channels or with the outside world. This is a very valid assumption for personnel working in the typical chain of command structure used in non-matrixed governmental organizations.

Both the Lockheed and waiting line models also consider a wide range of key variables, a fact which allows them the flexibility to accurately reflect the local conditions that were related to governmental organizations.

Decision Rule 2.

In calculating optimum supervisory/employee ratios, the instrument must be directed towards cost minimization (versus profit maximization) or must allow the user to focus on achieving cost reductions.

As noted in the literature review, without a profit motive to keep costs in check, governmental organizations are forced to concentrate on minimizing their operating costs. This fact makes cost minimization the key to determining "optimum" supervisory/employee ratios in nonprofit organizations. Of the four models or techniques examined, only the waiting line model was specifically designed to relate minimized operating costs to "optimum" supervisory/employee ratios.

Neither the Lockheed nor Dewar/Simet models consider cost variables in any form when "optimum" supervisory/employee ratios are formulated. However, by formulating "optimum" ratios at different organizational levels and by introducing objectivity into the process, both models enable supervisors to focus on formulation of cost efficient organizations.

The Keren/Levhari model considers hourly labor costs as one of the variables in computing "optimum" supervisory/employee ratios, and minimization of profits lost, not cost minimization, is the objective of the model. As maximization of profits usually results in cost minimization, this model is also considered to have satisfied the second decision rule.

The waiting line model is the only model to have specifically linked minimum operating cost with the "optimum" supervisory/emp'oyee ratio. Hourly idle costs and supervisory costs per subordinate are also considered as variables in the model. This model most closely satisfies the intent of the second decision rule.

Decision Rule 3.

Since organizations within DLA vary widely in the type of work supervised (professional, technical, administrative and clerical), the instrument must be adaptable to these different conditions. If not, it must be identifiable to a specific type of organization.

While none of these models or techniques was identifiable to a specific organization type nor designed to be adaptable to the varying work conditions within DLA, all consider a wide range of variables in formulating "optimum" supervisory/employee ratios. This cross-section of data provides them with sufficient coverage of working conditions to allow formulation of realistic supervisory/employee ratios for varying organization types.

The Lockheed model was developed to provide general guidelines for middle managers to assist in setting spans of supervision and is not intended to provide a completely objective method. As such, it appears most appropriate for use with staffing pattern organizations (staff offices) which do not operate under measurable work standards.

The waiting line model was designed with a production environment in mind, where close supervision and frequent supervisory contact with subordinates is required. As such, this model is more suited for use in line type organizations which work under measured work standards.

Prediction of "optimum" supervisory/employee ratios at specific levels within an organization is a main feature of the Dewar/Simet model. This feature provides some flexibility for adaption to nonprofit organizations, and the model appears to be suitable for application to either production or staffing pattern type work conditions.

The Keren/Levhari model is also accepted under this decision rule, as its representation of an organization as a pure hierarchy accurately reflects the chain of command structures prevalent in governmental organizations.

Decision Rule 4.

To be selected for further evaluation in this study, the instrument must be both easily understandable by DLA position management or supervisory personnel and suitable for immediate application without complex computer simulation modeling.

This decision rule was considered important because no matter how accurate or precise the end product of a model or technique might have been, it would not have received wide acceptance by field personnel unless it was understandable and implementable.

Both the Dewar/Simet and the Keren/Levhari models are extremely complex. They were judged too complicated to receive widespread acceptance by field personnel, and would require extensive computer programming or simulation modeling knowledge to implement. Because of this fact, neither meet the requirements under this decision rule.

On the other hand, both the Lockheed and waiting line models are of moderate to low complexity, and the principles behind each are clearly understandable. Also, each of these models is easily set-up on readily available personal computer (PC) spreadsheet software. As a result, both have the potential for the widespread acceptance and easy implementation by field personnel required under this decision rule.

Summary. The results obtained when the above decision rules were applied have been summarized in Table IV.

TABLE IV

Application of Criterion/Decision Rules

Model/Technique	Criterion/Decision Rules			
	1	2	3	4
Lockheed	Yes	Yes	Yes	Yes
Waiting Line	Yes	Yes	Yes	Yes
Keren/Levhari	Yes	Yes	Yes	No
Dewar/Simet	Yes	Yes	Yes	No

With each decision rule given equal weight, only the waiting line and Lockheed models were judged to be acceptable under all four decision rules since both the Keren/Levhari and Dewar/Simet models were rejected under the fourth decision rule. Based on the preceding, both the waiting line and Lockheed models were selected for further evaluation under the next investigative question. While the Keren/Levhari and Dewar/Simet models were eliminated from further evaluation in the study, this action does not imply that these models do not merit further attention or that they might not be useful to DLA. Recommendations on further research on the models are made in the concluding chapter.

Investigative Question 5

How do existing supervisory/employee ratios within DLA compare with the 'optimum' ratios obtained from applying the models or techniques?

As previously noted, DOD/DLA guidance provided to the Primary Level Field Activities (PLFAs) on formulation of 'optimum' supervisory/employee ratios is general in nature. It concentrates on setting minimum limits at the first-line organizational level, but contains no methods or techniques for determining what the 'optimum' ratios should be within those limits. The principal source of guidance from HQ DLA is contained in DLAM 5810.1, Organization of DLA Field Activities. The following regulatory principles related to supervisory/employee ratios are to be considered in organizational design:

1. To the maximum extent practicable, Heads of DLA PLFAs will assure that organizational elements below directorate level will not be maintained or established if there are less than eight professional/technical positions assigned (i.e. supervisory/employee ratios could not be less than 1:8 for first-line elements, excluding clerical positions).

2. Work originating in a subordinate level will not pass through intermediate levels not authorized to approve, disapprove, or otherwise contribute to the work done (aimed at eliminating supervisory layering or unnecessary supervisory positions).

3. The number of organizational elements will be held to a minimum and elements performing related functions will be consolidated into manageable segments of effort.

4. Authority will be delegated to the lowest practicable organizational level to afford timely decision-making within the scope of assigned responsibility (4:I-2).

The instrument used to achieve adherence to these principles was DLAR 5820.1, Position Management Program.

This regulation charges the PLFAs with establishing an effective Position Management Program (PMP), which employs the DLAM 5810.1 organizational design principles listed above. In addition, each organizational element is to be evaluated at least once every three years for effectiveness (5:1-2).

Computation of Actual PLFA Ratios. The first step in answering Investigative Question 5 was to compute actual first-line supervisory/employee ratios from data collected at four DLA Supply Centers. This calculation also allowed a comparison of actual PLFA ratios with the DLA guidance (1:8) to help determine whether a problem existed.

The Centers selected for use were Defense Construction Supply Center (DCSC) in Columbus, Ohio; Defense Electronics Supply Center (DESC) in Dayton, Ohio; Defense General Supply Center (DGSC) in Richmond, Virginia; and Defense Industrial Supply Center (DISC) in Philadelphia, Pennsylvania. These Centers were selected for similarities in their size, mission and basic organizational structure. Data on numbers of employees versus supervisors is routinely collected from various organizational elements by the Organization and Position Management Branch (LPO) at each Center. That data was used for this study.

The supervisory/employee ratios for all first-line organizational elements at DCSC, DESC and DGSC (data was not available at this level of detail from DISC) were computed, and the results are displayed in Table V. Supervisory/

employee ratio has been broken-out into seven separate categories centered around the DLA guidance of not fewer than eight professional/technical employees per each supervisor in first-line organizations. The columns under each Center indicate the number of first-line elements which fit into each ratio category at each Center.

TABLE V

Actual First-Line Supervisory/Employee Ratios at DLA Supply Centers

Supervisory/ Employee Ratio	Number of Organizational Elements (%) DCSC	DESC	DGSC	Totals
Below 1:6	16 (9%)	42 (25%)	31 (20%)	89 (18%)
1:6	9 (5%)	11 (7%)	13 (9%)	33 (7%)
1:7	12 (7%)	10 (6%)	13 (9%)	35 (7%)
1:8	13 (8%)	13 (8%)	20 (13%)	46 (9%)
1:9	35 (20%)	10 (6%)	10 (7%)	55 (11%)
1:10	17 (10%)	10 (6%)	13 (9%)	40 (8%)
Above 1:10	71 (41%)	72 (42%)	51 (33%)	194 (40%)
Totals	173	168	151	492

The table illustrates that 335 or 68% of all first-line organizations at the three Supply Centers have supervisory/employee ratios of 1:8 or greater than 1:8. These organizations all meet or exceed the minimum ratio specified by DLA. It also shows that a majority of the supervisory/employee ratios observed at the three Centers concentrated within two of the seven ratio categories. Ratios in the lowest category (below 1:6) were recorded for 80 (18%) of the first-line organizations studied. The highest category (above 1:10) accounted for 194 (40%) of the ratios observed in organizations. Additionally, of the 492 total ratios taken from first-line elements, DCSC had 173 or 35%, DESC had 168 or 34%, and DGSC had 151 or 31%.

To help further compare actual Supply Center supervisory/employee ratios with the DLA guidance, data from all four Centers (DCSC, DESC, DGSC, and DISC) was used to compute the overall ratios for each Center, along with ratios for three mission directorates (Contracting and Production, Supply Operations, and Technical Operations) and three staff offices (Comptroller, Policy and Plans, and Telecommunications and Information Systems). Per DLA guidance, clerical positions, which accounted for about 12% of the Centers' total positions, were not counted in determining these ratios. The results of the computations are displayed in Table VI.

Evaluation of the overall ratios revealed that the average Center supervisory/employee ratios were only slightly below the DLA guideline of no fewer than eight professional/technical positions per each supervisor. When the average Center-wide ratios from each of the four Centers were combined, an overall average ratio of 1:7.37 was obtained. Examination of the data (displayed in Table VI) also confirmed that there was a noticeable variance in ratios between the different types (i.e. line versus staff) of Directorate/Staff Offices within each Center. Ratios ranged from a high of 1:9.76 in the Directorate of Technical Operations (S) to a low of 1:3.08 in the Office of Policy and Plans (L).

TABLE VI

Actual Supervisory/Employee Ratios at DLA Supply Centers

Directorate/Staff Office (D/SO)	Supply Center Ratio (1:-)			
	DCSC	DESC	DGSC	DISC
Comptroller (C)	5.93	5.78	7.04	4.28
Contracting & Production (P)	8.15	8.87	9.42	7.84
Policy & Plans (L)	5.04	3.78	3.92	3.08
Supply Operations (O)	6.81	7.99	6.56	8.76
Technical Operations (S)	9.76	9.46	8.25	6.05
Telecommunications & Information Systems (Z)	5.28	5.67	6.30	4.43
Total Non-Supervisory GS Positions	2298	2218	1851	1839
Total Supervisory GS/GM Positions	293	288	254	278
Center Average Ratio (1:-)	7.84	7.70	7.29	6.62

<u>Computation of Optimum PLFA Ratios</u>. The second step in answering Investigative Question 5 was to apply the Lockheed and waiting line models to DCSC, DESC, and DGSC, as

illustrated in Appendices C and D. Ratios determined to be "optimum" by the models for PLFA first-line organizations were then compared to the actual ratios existing in those organizations. Since these two models were designed for application to individual first-line organizations, six such organizational elements (Operations Resource Management Branch [CBO], Office of Counsel [G], Organization and Position Management Branch [LPO], Inventory Management Section B [OMAB], Intensive Management Section B [OSEJ], and Logistics Materiel Management Branch [ZSL]) were selected for comparison at each of the three Centers. This cross-section of first-line organizational types was selected to provide a representative sample, including varied functional and workload responsibilities, for use with the models. As both models require a degree of subjective input, organizations selected had to satisfy one of the following:

1. They were organizations to which the author of this study had been assigned as a worker at some time in his career with DLA.

2. In his current assignment to the Organization and Position Management Branch (LPO), the author must have had responsibility for providing position management services (organization design, position structuring, workload measurement, etc.) to the organization.

These conditions insured sufficient knowledge of the organizations' mission, structure, and workload to make informed decisions on the subjective inputs to the models.

The results of this comparison have been summarized in Table VII. The table reveals that, at the three Supply Centers, 12 (67%) of the organizational elements reviewed had actual ratios at or above the DLA guidance of 1:8. This finding is consistent with the Center-wide findings displayed in both Tables V and VI. Consequently, the finding helps to confirm the representativeness of the organizations selected for use in this portion of the study.

TABLE VII

Actual Versus Optimal Number of Employees Per Each Supervisor in Selected Organizations

Organizational Elements	Actual			Optimal	
	DCSC	DESC	DGSC	Lockheed (Range)	Waiting Line
Operations Resource Mgt. Branch (CBO)	13	8	16	5 to 8	10
Office of Counsel (G)	7	5	8	4 to 6	8
Organization & Position Mgt. Branch (LPO)	9	5	11	4 to 7	7
Inventory Mgt. Section B (OMAB)	11	14	9	8 to 11	10
Intensive Mgt. Section B (OSEJ)	8	8	7	6 to 9	8
Logistics Mat. Mgt. Branch (ZSL)	14	5	6	5 to 8	12

Based on the author's past experiences working in or for these organizations, ratios below the DLA guidance usually result from attempts by the organizations to maintain their traditional organizational structures in the face of manpower reductions. Another likely contributor to low ratios was reclassification of critical job skill positions from nonsupervisory to supervisory, in order to retain grade levels and job expertise.

Examination of the "optimum" ratios produced by the two models shows that the waiting line model produced generally higher ratios than the Lockheed model. However, the ratios produced by both models were close to the DLA guidance of 1:8, and no major variations or inconsistencies were displayed between the two models. The Lockheed model tended to produce "optimum" ratios below those actually existing at DLA, while the waiting line model produced ratios which closely reflected the current actual ratios.

Investigative Question 6

If the current and the theoretical ratios are different, how do first-line supervisory personnel in DLA react to this difference and to the models or techniques?

To answer the final Investigative Question, a survey questionnaire (Appendix E) was administered to supervisory personnel at three of the Supply Centers (DCSC, DESC, and DGSC). First-line supervisors of the organizations selected for use in Table VII were given a written survey to obtain their opinions on the appropriateness of both the actual and "optimum" ratios to their organizations. The supervisors were requested to rank order their preferences among the actual and model-generated ratios for their organizations and to indicate what they believed to be the "ideal" ratio. The results of this survey are summarized in Table VIII. The survey questionnaire also requested the supervisors to provide comments on their preference rankings and general observations, based on their years of experience, relating to formulation of "optimum" supervisory/employee ratios.

Between the three possible choices, responding supervisors identified the supervisory/employee ratio existing in their organization as either first or second preference (6-Preference #1, 6-Preference #2) in all cases. When the existing ratio was given second preference, first preference was given to an "optimum" ratio that was higher than the actual in all but one instance. Excerpts of comments provided by supervisors who selected the existing ratio as their first preference are presented below.

1. (DGSC-ZSL) One supervisor per six employees provides more time to evaluate performances, plan training, make workload adjustments, and perform other supervisory functions requiring knowledge of individual employees' capabilities.

2. (DESC-CBO) Due to the multiplicity, diversity, and complexity of functions performed by this organization, a ratio greater than 1:8 would be untenable ... conversely, a ratio below 1:6 would induce an unnecessary degree of micro-management.

3. (DGSC-CBO) 1:16 provides direct control for a wider range of functions, offers maximum flexibility for cross-training, and incorporates a wider cross-section of employee viewpoints. However, a supervisor must be careful not to be overloaded or overlook employees with a group this large.

TABLE VIII

First-Line Supervisors' Preference Rankings*
for Supervisory/Employee Ratios

Organizational Elements	Actual	Lockheed	Waiting Line	Ideal Ratio
Operations Resource Mgt. Branch (CBO)				
DCSC	--------	-------	--------	-----
DESC	(1) 1:8	(2) 1:5	(3) 1:10	1:8
DGSC	(1) 1:16	(3) 1:5	(2) 1:10	1:12-16
Office of Counsel (G)				
DCSC	(2) 1:7	(3) 1:6	(1) 1:8	1:10
DESC	(2) 1:5	(1) 1:6	(3) 1:8	1:6
DGSC	(1) 1:8	(3) 1:6	(2) 1:8	1:8
Organization & Position Mgt. Branch (LPO)				
DCSC	--------	--------	--------	-----
DESC	(2) 1:5	(3) 1:4	(1) 1:7	1:8
DGSC	(2) 1:11	(3) 1:4	(1) 1:7	1:7
Inventory Mgt. Section B (OMAB)				
DCSC	--------	--------	--------	-----
DESC	(1) 1:14	(2) 1:11	(3) 1:10	1:14
DGSC	(2) 1:9	(3) 1:11	(1) 1:10	1:8
Intensive Mgt. Section B (OSEJ)				
DCSC	--------	-------	--------	-----
DESC	--------	-------	--------	-----
DGSC	(2) 1:7	(3) 1:9	(1) 1:8	1:8
Logistics Mat. Mgt. Branch (ZSL)				
DCSC	--------	--------	--------	-----
DESC	(1) 1:5	(2) 1:8	(3) 1:12	1:5
DGSC	(1) 1:6	(3) 1:8	(2) 1:12	1:6
Mean Ranking	(1.5)	(2.6)	(1.9)	1:8.5

*Ranking order indicated by parentheses ( ).

4. (DESC-ZSL) The existing ratio (1:5) is considered best because of the complex and exacting nature of computer programming. Also, first-line supervisors are "working" supervisors, with responsibility for technical as well as administrative supervisory duties.

The Lockheed model received the least support from supervisors, being selected only once as first preference, followed by three as second preference, and eight as third preference. Comments provided by the only supervisor selecting, as first preference, a ratio produced by this model are as follows.

(DESC-G) Supervision of legal personnel is time consuming, from a technical standpoint, and entails careful monitoring of the extensive training requirements. A ratio of five or six to one allows a supervisor time to counsel staff on legal matters, provide on-the-job training, and accomplish routine supervisory functions. Increasing the ratio limits the supervisor's role to office management at the expense of legal functions.

Waiting line model ratios received five first preference selections, followed by three as second preference, and four as third preference. Comments by supervisors expressing a preference for this model's ratios are presented below.

1. (DCSC-G) Eight employees is not a difficult number to supervise, and any ratio lower than 1:8 would result in establishment of unnecessary supervisory positions. Emphasis should be on sharpening the supervisor's skills and on ensuring that workers get the necessary technical/ professional training. We need production, not unnecessary supervisors.

2. (DESC-LPO) A branch chief with a capable staff could easily supervise eight or more professional/technical employees. Also, a higher ratio could be supported through the use of work groups and team leaders. This would provide employees with technical guidance from experienced personnel, while freeing the branch chief for administrative or high priority mission work.

3. (DGSC-LPO) A 1:7 ratio is considered ideal because it provides time for the necessary face-to-face contact to properly supervise analysts performing complex/diverse center-wide functions. A higher ratio would not allow enough control, while a lower ratio would result in over-management of competent journeymen analysts.

When the supervisors were asked to provide what they believed to be the "ideal" supervisory/employee ratio for their organization, they designated a ratio that was the same as their first preference selection in nine of the twelve responses. Also, in eight of twelve surveys, the ratio identified as "ideal" was equal to or higher than the DLA minimum guidance of 1:8. The mean or average "ideal" ratio provided by the supervisors was 1:8.5.

The mean or average ranking score given by supervisors to the actual existing ratios was 1.5, followed by a 1.9 mean ranking for the waiting line model ratios, and a 2.6 mean ranking for the Lockheed model ratios. In summarizing these results, two trends are apparent:

1. First-line supervisors demonstrated a clear bias in favor of the existing ratios in their organizations. This may be attributable to one or both of the following:

a. Supervisors are more comfortable with the familiar or what has worked in the past. There is always an element of dread (fear of the unknown) in changing the status quo.

b. The existing ratios may well be the "optimum" for the supervisor's organizations. They have evolved other many years and are based on actual experience managing the organizations during periods of fluctuating budget, workload and worker skill levels.

2. For the two models tested, first-line supervisors indicated a clear preference in favor of the waiting line model versus the Lockheed model, which received uniformly low preference rankings.

In reviewing the information presented in this chapter, it was found that all four of the identified models or techniques were suitable for or adaptable to governmental organizations. However, when the decision rules developed for this study were applied to these models or techniques, only two models qualified for further evaluation. Application of these two models to selected representative organizations within DLA resulted in "optimum" supervisory/employee ratios that were close to the DLA guidance of 1:8, with no major variations appearing between the two models or existing field ratios. Comparison of actual first-line ratios at the Supply Centers to DLA's 1:8 guidance showed a wide variation in ratios across the Centers' organizations, with most at or above the guideline. Finally, a survey administered to the first-line supervisory personnel of the selected organizations revealed a bias towards the existing ratios and a preference for the waiting line model over the Lockheed model.

V. Conclusions and Recommendations

Introduction

This chapter completes the research effort by presenting conclusions and recommendations for Investigative Questions 1 through 6, based on the findings detailed in Chapters III and IV. Conclusions about each question are followed by recommendations for future actions, implementation of changes, or further research.

Investigative Questions 1 and 2

What (if any) simulation models for determining "optimum" supervisory/employee ratios exist?

What other techniques (if any) exist for determining "optimum" supervisory/employee ratios?

Conclusions. In reviewing the extensive amount of literature published over the past sixty years on "optimum" supervisory/employee ratios, the following four models or techniques for determining such ratios were identified:

1. The Lockheed model, which attempted to introduce more objectivity into the formulation of proper supervisory/employee ratios. Variables affecting span of supervision were assigned weights, totaled, and related to a suggested "optimum" span through a supervisory index.

2. The waiting line model, which applied queuing theory to determine the number of subordinates that would minimize the combined costs of supervision and idle subordinates.

3. The Keren/Levhari model, which looked at an organization as an integrated whole and computed the "optimum" spans of supervision for each level of a pure hierarchy.

4. The Dewar/Simet model, which predicted supervisory/ employee ratios for specific levels (chief executive, department head and first line supervisor) within an organization.

These four models or techniques range from uncomplicated, easily implementable guidelines to complex linear programming models which would require extensive computer simulation programming to implement. Each of the models or techniques also incorporated a large, diverse group of variables in computing "optimum" supervisory/ employee ratios.

While much research has been done on determining "optimum" supervisory/employee ratios, it appears that more may be necessary to settle the question. Unfortunately, in the private sector, interest in further research has passed its peak, as private industry has lost interest in using "optimum" ratios as a method for controlling operating costs. Governmental or non-profit organizations remain the prime candidates to benefit from further research and to make use of the four existing models or techniques. Lacking a profit motive to contain operating costs, governmental organizations need alternative strategies or programs (i.e., Position Management), including optimization of supervisory/

employee ratios, to help minimize those costs. Another related topic that has not been adequately explored is the growth of matrix organizations, which have gained increasing acceptance within research and military organizations. The impact of matrix structures on "optimum" spans of supervision is not fully understood, and only the waiting line model has an adaptability to such organizations.

Recommendations. Based on the preceding conclusions, the following recommendations are made:

1. While remaining alert to research developments and the introduction of new models or techniques for determining "optimum" ratios, DLA should also concentrate on determining the impact of implementing the four methods identified in this study. These models may provide DLA with a more efficient and consistent means of calculating ratios. In addition, these methods may be less labor intensive than current methods.

2. The suitability of adapting matrix type structures to DLA organizations and missions should be explored.

3. If suitable, further research into the impact of matrix organizations on "optimum" spans of supervision, including modification of the waiting line model, may be warranted.

Investigative Questions 3 and 4

If existing techniques or models for determining optimum supervisory/employee ratios are non-governmental, can they be applied to or modified for use within the various types of organizations/professions of DLA?

What are the features of DLA's organizations/ professions that must be considered in evaluating goodness-of-fit (applicability) of existing models or techniques?

Conclusions. Although the Keren/Levhari and Dewar/ Simet models were both developed using data from non-profit organizations, none of the four existing techniques or models identified were specifically designed for use with governmental organizations. To evaluate the goodness-of-fit or adaptability of the four instruments to the organizations/professions of DLA, it was first necessary to identify the key DLA features which must be considered by the instrument. Those key features were included in the following set of decision rules:

1. Any instrument selected must have been developed for use with or be adaptable to a nonprofit organizational environment.

2. In calculating optimum supervisory/employee ratios, the instrument must be directed towards cost minimization (versus profit maximization) or must allow the user to focus on achieving cost reductions.

3. Since organizations within DLA vary widely in the type of work supervised (professional, technical, administrative and clerical), the instrument must be adaptable to these different conditions. If not, it must be identifiable to a specific type of organization.

4. To be selected for further evaluation in this study, the instrument must be both easily understandable by DLA position management or supervisory personnel and

suitable for immediate application without complex computer simulation modeling.

When these decision rules were applied to the four existing models or techniques, only the Lockheed model and the waiting line model were judged acceptable for further evaluation in this study. However, all four models appear to possess the flexibility to be successfully adapted for use with governmental organizations. The Keren/Levhari model and the Dewar/Simet model were eliminated because of their complexity, not their lack of adaptability. It was felt that extensive computer simulation modeling would be necessary, and that it would be difficult for field personnel to implement the models without further assistance.

Recommendations. Based on the above, the following recommendations are made:

1. The Lockheed model and the waiting line model should be field-tested by position management personnel and first-line supervisors at DLA Supply Centers to project their possible impact on supervisory/employee ratios DLA-wide.

2. DLA should investigate the cost-effectiveness of funding further research on the Keren/Levhari and Dewar/Simet models. One possibility would be to program the models on computer simulation software compatible for use with office personal computers (PCs). If found to be cost-

effective, these models should also be field tested to determine their impact on DLA-wide ratios.

3. Useful models or techniques should ultimately be incorporated into a Specific Decision Support System (SDSS) for use on office PCs by all DLA first-line organizations.

Investigative Question 5

How do existing supervisory/employee ratios within DLA compare with the "optimum" ratios obtained from applying the models or techniques?

Conclusions. When actual supervisory/employee ratios were calculated for all first-line organizations at three DLA Supply Centers, it was found that 68% of those organizations had ratios greater than or equal to the DLA minimum guidance of 1:8. This finding indicates that a problem does not exist in meeting the DLA minimum guidance, as the Supply Centers are generally in compliance.

When the actual or mean overall supervisory/employee ratio for four Supply Centers was calculated, a combined average ratio of 1:7.37 was obtained. Since this overall ratio is very close to the DLA prescribed guidance, the evidence indicates that the Supply Centers are doing a good job of complying with the DLA minimum guidance. However, when the overall ratios were calculated for six representative Directorate/Staff Offices (D/SOs) at each of the four Centers, a noticeable va~iance in ratios among different types of D/SOs (i.e., line versus staff) was apparent. This difference indicates that the type of work or mission/functions assigned to an organization may have a direct impact on the most appropriate ratio for that organization. It also suggests that variation above or below the DLA guidance may even be normal and desireable for individual elements, so long as the Center-wide average ratio remains near 1:8. As a result, strict limitation of all organizational elements to the 1:8 minimum could be unnecessary. It could also be costly, both in terms of less efficient/effective organizations and the manhours spent to monitor and enforce the guideline.

Application of the Lockheed and waiting line models to six selected organizations at three Supply Centers produced "optimum" ratios that tended to center or cluster around the DLA guidance of 1:8. The ratios also spanned a wide enough range to support the preceding observation that some variation in ratios might be normal and that strict enforcement of or adherence to one artificial minimum level may be unnecessary. In addition, both the Lockheed and waiting line models demonstrated the potential to be useful tools. Position management and supervisory personnel should be able to utilize them to help maximize the return from resources in first-line organizations. The generalness of the Lockheed model combined with the opportunity for the user to make substantial subjective inputs may make it better suited for application to the nebulous work environment of staff or support organizations. On the other hand, the more quantitative waiting line model appears to be better suited to line organizations doing measured production work.

Recommendations. Based on the above, the following recommendations are made:

1. DLA should consider and investigate the possibility that a variation in ratios among individual organizational elements, based on the type of workload or mission/functions assigned, may be appropriate and desirable, so long as the overall Center ratio remains near 1:8.

2. If the preceding variation in ratios is found to be desirable, DLA should consider the possibility of establishing a dual guideline system. For example, organizations working under measurable work standards (production) might receive a minimum guideline of 1:10, while staffing pattern (support) type organizations might receive a minimum guideline of 1:6. This option would still provide specific guidance to all organizations and should allow DLA to maintain an overall average ratio near 1:8. In addition, many man hours now spent by supervisory and position management personnel in attempting to monitor and justify ratios below the 1:8 guidance could be put to more productive use.

Investigative Question 6

If the current and the theoretical ratios are different, how do first-line supervisory personnel in DLA react to this difference and to the models or techniques?

Conclusions. When surveyed to determine their preferences, first-line supervisors indicated a strong preference towards the ratios actually existing in their organizations. As these ratios have evolved over many years of experience and under various operating conditions, there is a strong possibility that they may represent the "optimum" ratios for those organizations. This would further support the conclusion that existing ratios are sound, and that some variation may be normal. Given a choice between models, the first-line supervisors also showed a preference for the ratios produced by the waiting line model over the ratios produced by the Lockheed model. This may be due to the fact that the waiting line model produced ratios that were closer to the actual existing ratios than did the Lockheed model. However, when given the opportunity to designate an "ideal" ratio, first-line supervisors selected a ratio that differed from the one produced by the waiting line model in nine of twelve cases. The Lockheed model also produced lower ratios than the waiting line model in four of the six test organizations. The fact that the Lockheed model generally produced lower ratios supports the previous observation that it may be more suitable for use with staff organizations, where lower existing ratios are prevalent. Finally, the mean or average "ideal" ratio provided by the first-line supervisors was 1:8.9, which is very close to the DLA guidance of 1:8.

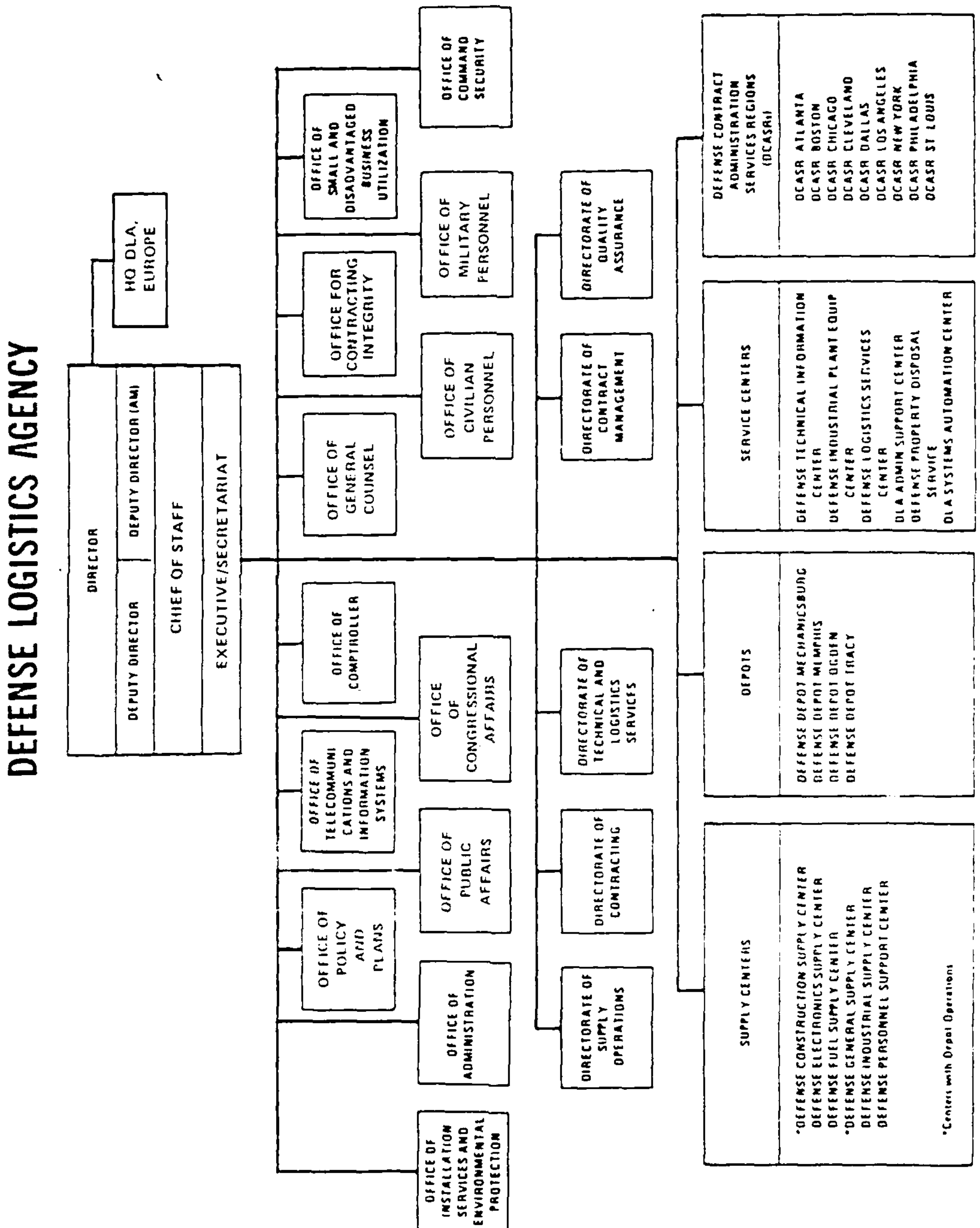
Recommendations. In light of previous observations that the Lockheed model may be more suited to staff elements and the waiting line model more appropriate for use with line elements, it is recommended that:

1. If DLA decides to allow variations in ratios among organizational elements, both the Lockheed and waiting line models should be adapted for field testing by DLA personnel at the first-line organizational level.

2. Results of the test should be carefully monitored to determine the models' impact on DLA's overall supervisory/employee ratio.

3. Suitability of either model to particular organization types should also be evaluated after the field testing.

Appendix A: Organization of DLA Field Activities



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Appendix B: DLA-LP Letter of Introduction and Support

DEFENSE LOGISTICS AGENCY
HEADQUARTERS
CAMERON STATION
ALEXANDRIA, VIRGINIA 22304-6100

IN REPLY REFER TO DLA-LP

14 APR 1987

SUBJECT: Letter of Introduction

TO: Directors
Office of Policy and Plans
DLA Supply Centers

Mr. Stuart D. Scott, an employee of the Defense Electronics Supply Center, is attending the Air Force Institute of Technology (AFIT) under DLA sponsorship and is working toward an MBA in Logistics Management. He has chosen as his thesis topic "An Evaluation of Models and Techniques Used for Determining Optimum Spans-of-Control Within Defense Logistics Agency (DLA) Organization." Your activity has been selected as a research subject. I support this project and would personally appreciate any assistance and cooperation you can provide.

ROGER C. ROY
Acting Assistant Director
Policy and Plans

Appendix C: Application of Lockheed Model to DCSC, DESC, and DGSC

LOCKHEED MODEL
****

VARIABLES	CBO	G	LPO	OMAB	OSEJ	ZSL
*********	*****	*****	*****	*****	*****	*****
1.)	4.00	4.00	4.00	2.00	3.00	3.00
2.)	3.00	4.00	3.00	1.00	1.00	2.00
3.)	6.00	8.00	8.00	4.00	6.00	8.00
4.)	6.00	6.00	6.00	9.00	9.00	6.00
5.)	6.00	8.00	6.00	4.00	6.00	6.00
6.)	8.00	8.00	8.00	4.00	4.00	8.00
	*****	*****	*****	*****	*****	*****
	33.00	38.00	35.00	24.00	29.00	33.00
SUGGESTED SPAN:	5 TO 8	4 TO 6	4 TO 7	8 TO 11	6 TO 9	5 TO 8

Appendix D: Application of Waiting Line Model to DCSC, DESC, and DGSC

WAITING LINE MODEL
****

M=	1.00
C5=	14.41
C6=	21.02
T=	0.29
U=	4.00
X=	0.068
1-X=	0.932

ORGANIZATION (CBO)	HOUR
******************	*****
Supv (1-GM13)	21.02
Pro Anal (4-GS12)	17.68
Pro Anal (7-GS11)	14.75
Pro Anal (3-GS09)	12.19
Pro Anal (2-GS07)	9.96

ADJUSTMN'T
****

4.42
6.46
2.29
1.24

14.41

N	F	E=F(1-X)	C5(1-E)	C6(M/N)	TCc=C5(1-E)+ C6(M/N)
*****	*****	********	*******	*******	************
8.00	0.953	0.889	1.61	2.63	4.23
9.00	0.943	0.879	1.74	2.34	4.07
10.00	0.931	0.868	1.90	2.10	4.00
11.00	0.915	0.853	2.12	1.91	4.03
12.00	0.902	0.841	2.29	1.75	4.04
13.00	0.885	0.825	2.52	1.62	4.14
14.00	0.866	0.807	2.77	1.50	4.27
15.00	0.845	0.788	3.06	1.40	4.46

WAITING LINE MODEL
****

ORGANIZATION (G)	HOUR
Supv (1-GM15)	29.22
Attorney (2-GS14)	24.84
Attorney (5-GS13)	21.02

M=	1.00
C5=	22.11
C6=	29.22
T=	0.32
U=	2.93
X=	0.099
1-X=	0.901

ADJUSTMN'T
****
7.10
15.01

22.11

N	F	E=F(1-X)	C5(1-E)	C6(M/N)	TCc=C5(1-E)+ C6(M/N)
4.00	0.969	0.873	2.80	7.30	10.11
5.00	0.955	0.861	3.08	5.84	8.92
6.00	0.940	0.847	3.38	4.87	8.25
7.00	0.921	0.830	3.76	4.17	7.93
8.00	0.901	0.812	4.16	3.65	7.81
9.00	0.877	0.790	4.63	3.25	7.88
10.00	0.850	0.766	5.17	2.92	8.09
11.00	0.820	0.739	5.77	2.66	8.42

WAITING LINE MODEL
****

ORGANIZATION (LPO)	HOUR
Supv (1-GM13)	21.02
Mgt Anal (2-GS12)	17.68
Mgt Anal (4-GS11)	14.75

M=	1.00
C5=	15.73
C6=	21.02
T=	0.33
U=	2.66
X=	0.110
1-X=	0.890

ADJUSTMN'T
****
5.89
9.84
0.00
0.00

15.73

N	F	E=F(1-X)	C5(1-E)	C6(M/N)	TCc=C5(1-E)+ C6(M/N)
*****	*****	********	*******	*******	************
4.00	0.958	0.853	2.32	5.25	7.57
5.00	0.939	0.835	2.59	4.20	6.79
6.00	0.917	0.816	2.90	3.50	6.40
7.00	0.892	0.794	3.25	3.00	6.25
8.00	0.863	0.768	3.65	2.63	6.28
9.00	0.830	0.738	4.11	2.34	6.45
10.00	0.795	0.707	4.60	2.10	6.71

WAITING LINE MODEL
****

M=	1.00
C5=	12.29
C6=	17.68
T=	0.25
U=	3.34
X=	0.070
1-X=	0.930

ORGANIZATION (OMAB)	HOUR
Supv (1-GS12)	17.68
Item Mgr (4-GS11)	14.75
Item Mgr (4-GS09)	12.19
Item Mgr (4-GS07)	9.96

ADJUSTMN'T
****

4.91
4.06
3.32

12.29

N	F	E=F(1-X)	C5(1-E)	C6(M/N)	TCc=C5(1-E)+ C6(M/N)
6.00	0.969	0.902	1.21	2.95	4.16
7.00	0.960	0.893	1.31	2.53	3.84
8.00	0.950	0.884	1.43	2.21	3.64
9.00	0.939	0.874	1.55	1.96	3.52
10.00	0.926	0.862	1.70	1.77	3.46
11.00	0.911	0.848	1.87	1.61	3.48
12.00	0.895	0.833	2.06	1.47	3.53
13.00	0.877	0.816	2.26	1.36	3.62
14.00	0.856	0.796	2.50	1.26	3.76
15.00	0.830	0.775	2.76	1.18	3.94

WAITING LINE MODEL
****

ORGANIZATION (OSEJ)	HOUR
Supv (1-GS11)	14.75
Gen Sup (3-GS09)	12.19
Sup Tech (4-GS07)	9.96

M=	1.00
C5=	10.92
C6=	14.75
T=	0.29
U=	2.86
X=	0.092
1-X=	0.908

ADJUSTMN'T
****

5.23
5.69

10.92

N	F	E=F(1-X)	C5(1-E)	C6(M/N)	TCc=C5(1-E)+ C6(M/N)
4.00	0.969	0.880	1.31	3.69	5.00
5.00	0.955	0.867	1.45	2.95	4.40
6.00	0.940	0.853	1.60	2.46	4.06
7.00	0.921	0.836	1.79	2.11	3.90
8.00	0.901	0.818	1.99	1.84	3.83
9.00	0.877	0.796	2.22	1.64	3.86
0.00	0.850	0.772	2.49	1.47	3.97
1.00	0.820	0.745	2.79	1.34	4.13
2.00	0.788	0.715	3.11	1.23	4.34

WAITING LINE MODEL		ORGANIZATION (ZSL)	HOUR
******************		******************	*****
		Supv (1-GM13/12)	18.77
		Comp Anal(3-GS12)	17.68
		Comp Anal(10-GS11)	14.75
M=	1.00	Comp Prog(5-GS09)	12.19
C5=	14.54		
C6=	18.77	ADJUSTMN'T	
T=	0.24	**********	
U=	4.00	2.95	
X=	0.057	8.20	
1-X=	0.943	3.39	

		14.54	

N	F	E=F(1-X)	C5(1-E)	C6(M/N)	TCc=C5(1-E)+ C6(M/N)
*****	*****	********	*******	*******	************
8.00	0.970	0.915	1.24	2.35	3.58
9.00	0.964	0.909	1.32	2.09	3.41
10.00	0.956	0.902	1.43	1.88	3.31
11.00	0.948	0.894	1.54	1.71	3.25
12.00	0.939	0.886	1.66	1.56	3.23
13.00	0.929	0.876	1.80	1.44	3.24
14.00	0.918	0.866	1.95	1.34	3.29
15.00	0.905	0.854	2.13	1.25	3.38
16.00	0.890	0.839	2.34	1.17	3.51

Appendix E: Validation Survey Package

From: DESC-LPO (Stuart D. Scott) 15 July 1987

Subject: Optimal Supervisory/Employee Ratios for DLA Organizations Survey

To: Mr./Ms. (DCSC-CBO)

1. As a DLA colleague, I am writing to request your help in a study supported by HQ DLA concerning optimum supervisory/employee ratios for DLA organizations (Enclosure 1).

2. DLA currently operates within the guidelines provided in DLAM 5810.1, which allow for no fewer than eight professional/technical positions per supervisor. The central questions addressed in the study are (1) how effective our current ratios are and (2) whether other guidelines obtained from different models would serve DLA better.

3. One essential ingredient in answering the questions is the judgments of knowledgeable DLA personnel, and it is for that reason that I request your help. Would you please provide your answers to the two questions on the attached question sheet (Enclosure 2)? Although the response will take only about 5 minutes to complete, your input is very important to the information I need.

4. Of course, all responses will be treated as confidential, and no individuals or organizations will be identified with their responses in any use of the material. The final report will be published as a Master's thesis at The Air Force Institute of Technology.

5. Please return the completed questionnaire in the self-addressed envelope within five working days of receipt. I sincerely appreciate your help.

STUART D. SCOTT
Management Analyst
DESC-LPO

2 Encl

SUPERVISORY/EMPLOYEE QUESTIONNAIRE

1. Shown below are three possible supervisory/employee ratios (clerical workers excluded) for your organization (DCSC-CBO). All were obtained by applying different models or guidelines to DCSC-CBO. Please indicate your judgement about the relative merit of the ratios by rank ordering the three items. Number 1 is most preferable; Number 3 is least preferable. Place the letter corresponding to your choice into the blank next to the appropriate preference.

Choices:

a. 1 supervisor for 10 employees (1:10)
b. 1 supervisor for 13 employees (1:13)
c. 1 supervisor for 8 employees (1:8)

Rank Order:

Preference #1.) ______

Preference #2.) ______

Preference #3.) ______

Comments: (Please provide comments about the above rankings, such as why the first preference is best or why the others aren't suitable.)

----

2. If none of the above choices matches what you believe to be the ideal supervisory/employee ratio for DCSC-CBO, please indicate your preferred ratio in the space below:

Preferred ratio ______

Comments: (Please explain the above preference and provide comments based on your supervisory experiences.)

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Vita

Mr. Stuart D. Scott was born on 27 September 1950 in South Haven, Michigan, where he graduated from high school in June 1969. He attended Michigan State University in East Lansing and graduated in June 1974 with a Bachelor of Science degree in Parks and Recreation Area Administration. In August 1978, he received a Civil Service appointment as a Professional Administrative Career Examination trainee to the Defense Logistics Agency (DLA) at the Defense Electronics Supply Center in Dayton, Ohio. While a trainee he worked in the areas of provisioning, program support, and counterfeit item testing in the Management Support Office of the Directorate of Supply Operations. In June 1982, he was selected for an analyst position in the Office of Comptroller, which was responsible for providing organization and manpower services to Center Directorates and Staff Offices. After moving to the Office of Policy and Plans in November 1984, he served as the Center Action Officer for implementation of the DLA standard organization effort, and provided position management services to the Center until entering the School of Systems and Logistics, Air Force Institute of Technology, in June 1986.

Permanent Address: 4088 Rundell Drive
Dayton, Ohio 45415

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Thesis Chairman: Charles R. Fenno, PhD
Associate Professor of Research Methods and Te hnical Communications

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ABSTRACT

The purpose of this study was to deter ne what models or techniques exist that can assist DLA Supply Centers in identifying and maintaining "optimum" supervisory/employee ratios within its first-line organizational elements. Basic objectives of the study were (1) to identify all existing simulation models or other techniques, (2) assess their adaptability or suitability to governmental organizations, (3) compare existing DLA first-line supervisory/employee ratios with those obtained from applying suitable models or techniques, and (4) survey first-line DLA supervisors to obtain their reaction to the products of the models or techniques.

Results of the research revealed four existing models (Lockheed, waiting line, Keren/Levhari, and Dewar/Simet) for determining "optimum" supervisory/employee ratios. All were judged suitable for application to DLA organizations, but because of complexity the Keren/Levhari and Dewar/Simet models were eliminated from further consideration in this study. Application of the Lockheed and waiting line models to DLA first-line organizations produced "optimum" ratios that were very close to those actually existing in the organizations. When surveyed, first-line supervisors showed a preference for their existing ratios versus the "optimum" ratios produced by the models. Between the two models, they showed a preference for ratios produced by the waiting line model over the Lockheed model.

Among the recommendations made to DLA were (1) field testing of the Lockheed and waiting line models at the first-line level, (2) consideration of funding for further research on the Keren/Levhari and Dewar/Simet models, (3) possible adoption of dual guidelines to accommodate the natural variations in ratios between different types of organizations, and (4) incorporation of useful models into a Specific Decision Support System (SDSS) for use on office Personnel Computers (PCs) by all first-line organizations.

END
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