The thesis of Martin T. Levy is approved:


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INTRODUCTION

In order to conduct research and development, developmental engineering, manufacturing, product support, sustaining engineering, or any and all other auxiliary functions in companies engaged in the aerospace field, it is essential that proper planning of manpower resources be undertaken. These companies must be prepared, in advance of receipt of actual contracts or authoritative permission to proceed, to undertake the various efforts which constitute their stock in trade and upon which they have bid and/or made proposals. To facilitate this preparedness, the manpower necessary to engage in these activities must be hired and trained prior to or coincidental with the receipt of authority to progress with specific projects.

Although the necessity for planning manpower is generally acknowledged within the industry, surprisingly little has been written concerning the methodology to be employed in making this forecast. This stems from several factors (1) the comparative youth of the aerospace industry and the consequent dearth of a well-established body of literature and information, (2) the classified nature of many undertakings within the industry, (3) the lack or breakdown of inter-company communications, and (4) the individualistic nature of the vast majority
of companies who form this industrial complex. As a result, many varied methods of manpower forecasting are now utilized by various companies.

The industry has now matured to the point where the individuality demonstrated in the past by many of these companies can no longer be allowed to transgress the mandate of efficiency. As has occurred in all other industries, standardization must take place in those functions which are not peculiar to individual companies but applicable to all companies in the industry. Thus, it was determined that a search should be undertaken to discover the most practicable methods of doing manpower forecasting, since this is a function common to all aerospace firms. The results of this survey should be analyzed, and guide lines for manpower forecasting should be established and published in order to provide a referential, definitive document in this somewhat turbulent field.

Objectives of the Study

The objectives of this study were:

1. To ascertain the need for manpower forecasting in the aerospace industry.

2. To reveal the extent to which awareness of this need existed within the various firms in the industry.

3. To determine the various methods currently utilized for making manpower forecasts.

4. To assess the advantages and disadvantages of each method.
5. To derive a methodology for manpower forecasting which would yield a degree of accuracy high enough to be of real use to companies making this application.

6. To contribute to a standardization of business methodology for a function that is common to all firms in the industry.

The hypothesis tested was that a method can be evolved within which the use of detailed and pre-established procedures in processing input data is a direct factor in yielding final manpower forecasts with a degree of accuracy high enough to be useful to companies in the aerospace field making this application.

Definition of Terms

The term "high degree of accuracy" is admittedly nebulous and indefinite since the reader may be prone to ask "What degree of accuracy is considered high?" This imprecision, however, is by intent. The degree of accuracy to be sought in manpower forecasting is one that will prove useful to the company doing the planning and compatible with the purpose of the planning. All forecasting, veritably by definition, can not be 100% accurate by virtue of its assumptions concerning the future. The validity of the forecast can be measured only after the forecasted events have actually occurred, and the degree to which it is accurate is a function of the "proving out" of the various probabilities and assumptions made in the original forecast. With this understood, the usability of the forecast may be measured by the extent to which the inherent error in the forecast imposes a
hardship upon the company. Probably no company will hire man-
power to the full extent of the forecast, therefore, the error will
ordinarily find the company with less rather than more men than
are necessary. If the additional manpower to be hired when actual
contractual authority to proceed is obtained can be employed without
cauing the company to default on any of its contractual obligations,
fall behind schedule, or require existing personnel to work overtime
or under undue pressure, the forecast has a degree of accuracy high
enough to be useful to the company. The exact degree of accuracy
would vary with each individual forecast but the methodology sought
is one that will prove consistently useful.

By "aerospace industry" is meant all companies entered into
activities dealing with manned and unmanned aircraft, missiles and/or
space vehicles, whether as prime contractors with governments
and/or private industry, or as subcontractors dealing mainly with
these prime contractors.

By "methodology" is meant the orderly procedure utilized in
achieving the intended ends.

The Test of the Hypothesis

An attempt has been made in this thesis to formulate a compre-
hensive technique that will prove useful to members of the planning
profession. The hypothesis is tested by exploring fully the existing
methods of manpower forecasting, both in theory and practical application, and determining the advantages and disadvantages of each method. In essence, each analysis of a different method for manpower forecasting has tested the hypothesis since the focus of effort has been employed toward a comprehensive technique that must include all phases of the function in its scope. With full examination of each method, it has been possible to extract some of the better portions of many of them and so arrive at a comprehensive technique that indicates, and in fact should confirm when the test of time has been completed, that the hypothesis should be accepted. An extraction from and combination of portions of existing methods, rather than a choice of one of the methods presently employed, is an additional contribution of this investigation.

Limitations of the Study

The study has been confined to the aerospace industry and therefore it is not representative of firms engaged in unrelated endeavors. A second limitation is that the study has concerned itself with companies of more than 750 employees. These are the companies that are large enough to be able to afford a specialized manpower forecasting function, even if only a part-time one, and can utilize the techniques defined in this thesis. Another limitation rests in the fact that a methodology for manpower forecasting has been suggested in this work that may have application for many different companies. The
fact remains, though, that specific conditions may apply to one company or one geographical area and may negate the use of a forecasting method that is not geared to special situations. The methodology that is suggested here must be viewed as a broad one and not expected to produce consistently high levels of accuracy under varying conditions. Such special situations must be factored into the forecasting methodology at the time the forecast is formulated. Finally, the model has been based upon a sampling of companies in the aerospace industry and does not include all firms in that industrial complex. While the number of firms included in the respondents is high enough to enable valid conclusions to be drawn based upon generally accepted sampling theory, there still may be some techniques in use that have not been discovered in this survey or some variations and improvements upon existing and reported techniques that may enhance their advantages or negate some of the stated drawbacks.

Organization of the Thesis

This thesis has been organized to provide a logical step-by-step appraisal of the subject of manpower forecasting in the aerospace industry. This introductory chapter relates the subject, scope, objectives and limitations of the study. The second chapter relates manpower forecasting to the several other primary types of planning involved in the corporate administrative process. The third chapter deals with
the determination of the qualitative make-up of the manpower force and the considerations involved in making these determinations.

Chapter four discusses the research design used to determine the present methods of quantitative manpower forecasting. The next chapter identifies those methods and appraises the advantages and disadvantages of each. Chapter six relates, in both narrative and graphic form, the results of the industry survey on utilized manpower forecasting methods. Finally, based upon an analysis of the methods illustrated in chapter five and information developed from secondary sources, the last chapter presents a suggested method for making manpower forecasts.
CHAPTER II

THE ROLE OF MANPOWER PLANNING
IN THE CORPORATE PLANNING PROCESS

Types of Planning

Planning is one of the essential components of these processes generally agreed to be the core functions of management—planning, organizing, and controlling.\(^1\) A forecast, simply defined, is a prediction of things to come. A plan, also simply defined, is a course of action to be followed in view of the forecast. The entire conception of the corporate planning process is to develop a planning system that is timely, comprehensive, and oriented toward providing for an orderly method for logical decision-making, but is not one that is tied to any particular organization. Continuous application of the process is more important than any particular plan.\(^2\)

The role of planning is perceived differently by many authorities in the field, but basic agreement exists that all planning


must involve the future, must involve action, and must contain an element of personal or organizational causation that will assure that the future action will actually be taken at the proper time.¹

All planning deals with time, but time has several aspects. First is the determination of the appropriate period of time for extension of the plan—how far into the future the plan should go.² Time is also needed for preparation of the plan, and this is affected by the complexity of the plan, the time period of the plan, the availability of data, and the human relations factors that sometimes cause resistance to develop during a plan's formulation. Third, lead time is needed for implementation of the plan.³ A certain number of days is needed to coordinate and synchronize the various elements of the plan so that its implementation will proceed in an orderly and rational manner. Many times not enough time is allocated for proper preparation of plans, and this has fostered the rise of the many quick but inaccurate methods for planning that are currently in use.

¹LeBreton and Henning, op. cit., p. 7.


There are five types of planning normally undertaken by firms in the aerospace industry. They are (1) organizational planning, (2) financial planning, (3) manpower planning, (4) product planning, and (5) facilities planning. Although many other subsidiary areas of planning exist in the organization, such as materials planning, inventory planning, sales planning (as opposed to sales forecasting), and production planning, the five mentioned here remain the nucleus of the corporate planning process. A brief review of each element is in order to illustrate the role and relationship of manpower planning to the other planning areas.

Organization Planning

Organization planning structures the business organization so that it is adequate to accommodate any functions the company will add in the future. Implicit in this is a continual scrutiny of corporate objectives, such as product objectives, market share objectives, growth objectives, social philosophy, and management philosophy objectives. The company must be so organized that it can accomplish these planned objectives, and authority and responsibility must be assigned within the company in advance. The outgrowth of organizational planning is the preparation of an "ideal" plan which does not only correct present organizational deficiencies but also

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outlines the functional structure toward which the company will strive during the period for which the plan is made and, in many cases, for the life of the company. It logically precedes manpower planning since the firm is interested in manning the future organization rather than the present one.

Louis A. Allen has written:

Organization planning is the process of logical grouping of activities, delineation of authority and responsibility, and establishment of relationships for the purpose of enabling people to work most effectively together in accomplishing the objectives of the enterprise.  

The company's organization should be planned so that it can meet the challenge of the future and serve as a means of accomplishing the firm's long-range objectives.

Financial Planning

In financial planning, the primary goal is the determination of the company's future financial objectives and the requirements and means for satisfying the firm's financial needs during a specified period of time. This involves the use of long-range pro-forma balance sheets, profit-and-loss statements, cash flow determinations, and estimates of each position at various points and periods of time.  


Manpower Planning

The manpower planning aspect of the long-range planning process has as its purpose the determination of the quantity and types of individuals that will be required by the firm in a selected future period or periods. The reasoning behind this type of planning has been succinctly stated by M. M. Olander in this manner:

The purpose of sound, objective personnel planning is to avoid 'crisis treatment' in matters affecting people. More often than not, action taken under pressure at a time of crisis is hasty, emotional, and irrational. Decisions made under such conditions are invariably difficult to live with later on.\(^1\)

Manpower planning involves several phases:

1. The determination of all quantitative and qualitative needs.
2. The analysis of the educational and skill level of the present work group.
3. The development of a program to equate long-range needs with present and estimated future supply.

The first of these phases comprises the subject matter of this thesis. The second and third are natural inputs to the first and have become more and more apparent with the onslaught of automation and new technology.

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William Newman, writing on the subject of executive personnel planning, has said:

For purposes of executive personnel planning it is desirable to think in terms of the 'ideal' organization structure ...... rather than the present structure. The existing organization may be outmoded, and at least some of the positions will have been adapted more to individual personalities than to organization principles. Moreover, during the next few years the volume and nature of company activities may change, and personnel requirements should be adjusted to these changes in so far as they can be forecast with reasonable accuracy. In other words, continuing by means of replacement is not necessarily the most desirable thing. Rather, sights should be set on a group of men that will be best qualified to direct the activities of the company in the future.¹

Regardless of the importance of manpower planning, a surprisingly large number of firms do not do an adequate job in this area.

This contention is supported by a research study conducted by the Industrial Relations Section of Princeton University. Professor Frederick Harbison has written:

For the most part, companies are preoccupied with their immediate requirements and with short-run development projects. In long-range manpower planning, most companies really do not know where they are or whither they are tending. And, they are baffled over what to do about manpower development and confused about how to do it ......... Certainly, the neglect of forward planning is an invitation to future disaster in the modern century of science.²


²Frederick Harbison, "High-Level Manpower: Needs and Resources", in Addresses on Industrial Relations, 1960 Series, Bulletin No. 28, Bureau of Industrial Relations, University of Michigan, Ann Arbor, Michigan, 1960, p. 5.
**Product Planning**

The rapid expansion of technology and the great growth in types of military markets have resulted in more and more emphasis being placed upon the area of product planning. Richard Anderson has pointed out:

Product planning coordinates the efforts of all departments in maintaining and developing the product line. The objective of product planning is to develop and maintain the most profitable product line, utilizing the company's resources in the most efficient manner. Product planning includes the addition of new products, addition of new product lines, and elimination of existing products.¹

Product planning, therefore, may provide the springboard for decision-making when management is considering which house-sponsored research and development programs to undertake. Product lines may also be added as a result of acquisitions, joint ventures, or the results of contractually authorized research and development projects.

**Facilities Planning**

Planning for facilities encompasses the determination of additions, alterations, expansions, replacements, and disposals of the company's physical plant and equipment. Richard Anderson states that the objective of facilities planning is,

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......to provide - in proper quantity, type, and location - sufficient productive facilities for maximum utilization of company resources and profitable participation in markets, both existing and projected.  

Return on investment calculations comprise an important phase of facility planning. They provide a means for an evaluation of competing facility projects. This is necessary since most firms find themselves in the position of having less sources of financial backing then there are opportunities for facility investments.

Coordination and Implementation of the Plan

If a firm is to accomplish its established goals, the portions of the forementioned over-all plan must be coordinated and integrated into an all-encompassing master plan. This can be facilitated by the use of planning staffs, planning committees, complete-loop communication devices, and the establishment and publication of planning ground-rules. There is little point in undertaking any type of planning if competent provision is not made for utilization, implementation, and execution of the plan.

Neglecting to put plans into effect seems to be a widespread failing in business practice today. A systematic review of plans at regular intervals of time accords a business the opportunity to evaluate their performance in attempting to attain their objectives.

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1 Ibid.

2 George A. Steiner, "What Do We Know About Using Long-Range Plans?", California Management Review, II, Fall 1959, pp. 94-100.
Planning Pitfalls

The sagacity and effectiveness of the planning function can easily fall into disrepute if the planner falls into any one of several traps that lie open for the novice or the unwary.

First, all plans must be made adaptable to changing conditions. While this may force the planner to delimit the parameters of the plan, the failure to include flexibility in the construction of a plan can lead to serious consequences. A change in some external condition or planning premise can render the entire process futile. An adaptable plan, however, may need only modification. George Terry states,

The ideal is to build flexibility into the plan so that if future events and contingencies turn out differently from those of the assumed conditions the same plan can be used with only slight adjustments needed.²

A capable executive, when possessed (and blessed) with a flexible plan, can maintain progress toward the objective despite variations in the external environment.

Secondly, planning and forecasting are not synonymous. In most cases a company that has compiled a long-range forecast is not possessed of a plan by virtue of having taken that action. A forecast, basically, is a prognostication or estimate of probable conditions in the future.

²Terry, op. cit., p. 127
A plan, on the other hand, has defined goals and enunciates the actions to be taken to achieve these objectives. Drucker has made the thesis that planning is necessitated precisely because we are unable to forecast with a high degree of precision. Thus, to interpret a forecast as a plan and to believe in their identity could lead to serious after-effects.

A third pitfall is the failure to put planning itself on a time schedule. Milestones and deadlines must be established and made obligatory for each phase of the planning process. Shelley and Pearson point out that the failure to do so for each stage in the planning cycle can result in ultimate failure of the activity. Unless these milestones and deadlines are established and adhered to systematically, ultimate completion of the plan may at the least be jeopardized and possibly may occur at a time too late to be useful.

A final pitfall, and one that is found too often among many quasi-professionals in the aerospace industry, is an attempt at oversophistication. The field is dominated by giants, such as Lockheed, Boeing, Grumman, Martin, and others, and these firms are able to (and in fact must) employ larger staffs and utilize more sophisticated


and definitive techniques. It is only natural for such companies to do a more elaborate, proficient, and competent job of planning than that which is undertaken by a company that employees 1,000 people. This is not to say, though, that a smaller firm can not do an intelligent and capable job of planning; many small companies can and do formulate ample and competent plans. The fact remains, however, that in this as in all other fields, the specialist can usually do a better job. The men in smaller firms are usually burdened with many other responsibilities and can not devote a proper amount of time to the function. Most smaller firms do not have managers who are trained properly to use all the modern analytical techniques of economic forecasting, financial analysis, sales planning, manpower planning, product planning, and other forms of prognostication. Also, the amounts of money that the smaller firms can allocate to the planning process tend to be proportionately less than that which is utilized by the larger companies. Effective plans, though, can still be formulated by managers of small and medium-sized firms. The entire planning process should be put in a framework that fits the requirements of each individual company. An attempt to duplicate the methods employed by another company; especially a larger one, can place the function in jeopardy.

1Ibid
CHAPTER III

QUALITATIVE MANPOWER PLANNING

Let us now turn to the dominant theme of this work—the field of manpower planning. Manpower planning is defined as including the dominant practices directed toward provision of sufficient personnel to capably carry on the successful operation of a business.

No long range planning program is complete without the inclusion of manpower planning. The best line of new products, the most expeditious of new expansions, the finest of modern equipment, and the most circumspect of financial plans can all be rendered useless if provision is not made for adequate personnel to perform the planned functions.

As J. Irwin Miller has stated,

In planning for 1970, all other considerations mean nothing in comparison with people. You have no assets of those which you can touch—plant, land, or machinery; you have no assets of those which you can see and print—balance sheets, working capital, government bonds—which mean a thing, save as they are used by intelligent, trained, and willing individual human beings. But you must go further than merely hiring good people; for success in 1970, it is not enough to obtain all the things and all the people I have suggested, unless with them you, the manager, make it your personal responsibility to create in your business an atmosphere where each man wants to do more than he is required...
to do, where each man finds satisfaction and a measure of personal fulfillment in his work. ¹

A company that does not plan its manpower requirements is not performing a vital function of management. These requirements can not be met as they become apparent. Obtaining the proper people at the proper time involves lead time--one can not just add water and get instant manpower. The manpower forecasting portion of the planning process must be granted proper cognizance if the master plan of which this is an integral part is to guide the firm to the accomplishment of its objectives.

There are several other objectives that may be accomplished by planning manpower, aside from the primary one of continuing the operation of the business. These are, (1) to be auxiliary to the accomplishment of any secondary objectives of the same, such as social or civic activities, (2) to produce and maintain an inventory of qualified persons who are capable of replacing those in present positions and to fill such new jobs as may be created by the same growth, (3) to attempt to strengthen the executive group and enhance the ability of this class to successfully challenge the future, and (4) to enable the firm to hire and maintain both the quantity and quality of manpower needed to make the firm's competitive position

more secure and, if possible, advantageous.

The responsibility of manpower planning begins and ultimately returns to the top management group who must approve finalized figures. The actual practitioners of this type of prognostication, however, may be found in many different parts of an aerospace organization. In some cases, the personnel department may be assigned the function. In other firms, this may be undertaken by marketing people as an outgrowth of the sales forecast. Some companies feel that it is a natural adjunct to the financial planning process and place the responsibility with those planners. Still other companies may create independent staffs for the purpose. Walter S. Wikström writes,

In arriving at a total manpower plan, information is usually gathered from the marketing and sales functions, from production, from design and engineering, personnel, and a number of other staff functions. In a large company, many line and staff managers are involved in this process; in the small firm, the president, perhaps with a few subordinates, does all this work. But information from all these functions is needed.¹

The determination of who actually prepares the forecast varies widely and is more or less arbitrary and open to subjective judgment. Furthermore, this is not a critical issue so long as those who are charged with the responsibility are provided with complete information and given solid management backing.

All line managers, whether in a small company where they are doing the entire forecasting job for their particular areas or in a larger company where they are simply a contributing factor, have definite responsibilities in regard to manpower planning. They do such things as conduct performance reviews, establish criteria for performance, assist in manpower and organizational studies, and in many other ways aid the planning agency.¹

The time span covered by the manpower plan is usually identical to that which is covered by other aspects of the long-range planning process, however the considerations mentioned earlier in this chapter regarding the ideal time period are also applicable to selecting the time period for manpower planning. Many firms find it desirable to extend their forecasts five or more years into the future; others find this to be impossible. There may be times when a company will find it desirable to extend their manpower planning beyond the period of the rest of the long-range forecast since more time may be required to select and train adequate numbers and the proper quality of individuals that will be needed to perpetuate company activities at a given future time.

The manpower forecast should be subjected to regular review. In the aerospace industry, with its general energy and ever-changing scopes of effort, this review should be undertaken at least semi-annually. At

each review, the first six months of the present plan should be deleted and an additional six months added. At the same time, the intervening time periods should be searchingly scrutinized to assure that any requirements that have become known since the last forecast have been included, and that events which have taken place during the six-month period have been factored into anticipations. The whole plan may have to be revised, in some cases, if occurrences have caused basic premises to change or have negated the validity of the present forecast.

True manpower planning requires the following components in order to be significantly effective:

1. Assessment of quantitative and qualitative manpower needs.
2. A performance appraisal system.
3. An in-house personnel inventory.
4. An in-house development program.

Determination of quantitative needs is at the heart of the manpower forecasting process and will be covered at length in succeeding chapters.

Qualitative needs are also a vital consideration and develop along with and as an adjunct to the quantitative determination. Endemic to this process is the preparation and analysis of position descriptions at every level in the organization. Preparation of these descriptions serve many purposes related either indirectly or directly to manpower planning. For instance, the utilization of position descriptions in making compensation comparisons indirectly acts upon manpower planning since an
unjust system can cause undue unrest in the organisation and thus belabor unnecessarily the problem of employee turnover. In a survey of 140 companies that made use of position descriptions, the American Management Association found that position descriptions were used in the following general applications:

1. **External Compensation Comparison - Position descriptions** provide a foundation on which to compare positions inside a company with others outside it.

2. **Internal Compensation Comparison - Position descriptions** provide a basis for position evaluation and represent an integral part of a soundly aligned salary administration program, since they crystallize the meaning of the jobs in the minds of the evaluators.

3. **Performance Appraisals - Position descriptions** form the foundation for a periodic appraisal of the man's performance of his job.

4. **Development - Position descriptions** are a necessary part of a development program in that they permit more accurate analysis of the requirements necessary for satisfactorily filling a position.

5. **Recruiting, Hiring, and Placement - They form the basis for written position specifications which list the requirements that are necessary for satisfactorily filling a position.**

6. **Orienting New Employees - They quickly and efficiently orient new incumbents to their positions and their requirements.**

7. **Promotion - They facilitate comparison of the present responsibilities with those in the post for which he is being considered.**
8. Self-understanding - They help the man to arrive at a clear understanding of his position's ramifications and to analyze and assess the relative importance of his various responsibilities and duties.

9. Agreement with Superior - They provide the means by which an executive and his superior may reach common understanding on the meaning and scope of a position.

10. Organization Clarification - They clarify who is responsible for what within an organization and record the relationships that exist within and between the various corporate departments.

11. Organization Planning - They are used to analyze and improve organization structure... (and)... determine whether all corporate responsibilities are fully covered and show when a re-allocation of responsibilities leading to a better balance of assignments is necessary.¹

Each of the various positions within an organization must be analyzed to determine the duties, responsibilities, accountability, relationships, and authority contained therein. This will yield a qualification prescription for minimal requirements needed by the person in that position.² When used for manpower purposes,


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however, the position descriptions should be evaluated in terms of what the job will be in the future rather than what it is today. The present position description is used (and written) for the purpose of present hiring and salary administration, not future planning. This is not to demean present usage; it is written simply to focus attention upon an area where manpower planning may go astray.

There are many ways to write position descriptions and the argument about which is the best is largely theoretical. C. L. Bennet, based upon his study of 140 companies, suggests the following five steps:

1. Gathering the information necessary to describe the position.

2. Writing the first draft.

3. Approving the first draft, usually after comparison with first drafts of other positions relating to it.

4. Writing the final version if changes are needed to make the description accord with company policy.

5. Review and revision of the descriptions whenever needed.¹

Ordinarily, the preparation of position descriptions is undertaken by the personnel department. Different organizations, however, vary in the placement of this responsibility. The present position holder and his superior should read and approve the document before

¹C. L. Bennet, op. cit., p. 80.
the final draft is written. This will have the effect of assuring truthfulness, accuracy, and comprehensive ness in each description.  

The description should spell out the function, responsibilities, authority, relationships, and specifications for the position holder.  

Position descriptions are an excellent means for determining today's manpower requirements qualitatively. Changing future requirements, however, may necessitate having a different type of man in the job than the incumbent of today. Technological change is taking place very rapidly in the aerospace industry and the state of the art at some future time may bear little relationship to what it is now.] As a case in point, McDonnell Aircraft Co. in St. Louis has diversified from aircraft manufacture to its current Gemini project which concerns itself primarily with spatial rather than atmospheric conditions. The aerospace employee of the future will have to possess skills far different from many of those utilized today. Also, as Walter S. Wikstrom points out,  

...... different products require different proportions of administrative, manufacturing, engineering, and marketing personnel. And these proportions change for different volumes of the same product....(for instance)......increasing market acceptance of a

1Ibid, pp. 81-120  

particular model of computer has a significant influence on the mix of marketing personnel. As sales increase, the engineers who provide customer service gain additional experience. This enables them to anticipate and forestall problems, and thus they can often service more customers. The same sales increase, however, creates a need for more programmers and other sales assistance people who help the customer plan for the use of his equipment. The mix of employees in the total marketing function obviously relates to constantly changing factors and therefore must remain fluid.

David G. Moore has highlighted probable qualitative changes that can be expected in the executive ranks by stating,

As companies become more complex--move into automation, become more and more involved in the new computer technology, get caught up in new marketing techniques, grow larger--the quality of executive performance is going to increase for these reasons alone. But the quality will increase also as a result of the greater demands being made on business leadership in this country; business is the dominant social institution of our time and, as a consequence, must broaden its definition not only of its role and function as a socio-economic institution but, more especially, of the role and function of its executives who must and are moving into the broader community into leadership positions of great social significance which take them far beyond the very important, but nonetheless provincial problems of production and profit-making.²

Another type of change that is occurring within the organizational structure of today is perceived by Dale Yoder when he writes,

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1Walter S. Wikstrom, op. cit., p. 3.

2David G. Moore,"High Talent Manpower", Addresses on Industrial Relations, 1960 Series, Bulletin No. 28, Bureau of Industrial Relations, Univ. of Michigan, Ann Arbor, Michigan, 1960, p. 1
In a sentence, the most impressive trend in management is that which involves increasing dependence on specialized staffs. It is most apparent in the growing numbers and proportions of staff managers. Even more impressive, however, is the manner in which specialists have come to dominate managerial decision-making. The master-mind of the desk-pounding captain of industry has been replaced today by the staff meeting in a firm or agency.  

Thus one can see the differences that are becoming apparent between the qualitative composition of today's work force and that of a former era. Eli Ginzberg, Director of Conservation of Human Resources Project at Columbia University again notes this trend when he states,  

One of the country's leading industrialists pointed out some time ago that he and his colleagues were providing his company with a strong competitive drive which was being reflected in, among other things, striking gains in sales and profits. He went on to note, however, that the management which was to follow a decade or two hence might be selected for other qualities, possibly for its ability to deal effectively with government and the public. At least he had no reason to believe that the present top executive group should be duplicated. This observation points up the error of many personnel departments that are attempting to identify the qualities of those currently at the helm in the hope of selecting younger men cast in the same pattern. They fail to realize that, if they succeed, they will deprive the enterprise of the leadership of men with qualities which may be required to cope effectively with the future.  

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Anticipation of the qualitative composition of the work group
is by no means an easy task. A concerted effort, though, must be
made to pinpoint the necessary attributes. In determining these
qualities, a beginning might be made by analyzing the historic changes
in the composition of the firm's (or the industry's) manpower, and to
identify the causal factors which prompted those changes so as to
define a trend. In a study recently made at Princeton University by
the Industrial Relations Section, the changing trends in the utilization
of manpower were carefully scrutinized and analyzed. Concluding
from this study, Frederick Harbison has written,

Most companies have neglected to estimate accurately
their future manpower requirements. The majority of
the companies we studied (50) have made no serious
attempt to estimate the occupational composition of
their future labor forces. The few that did make esti-
mates, moreover, based them on quite erroneous
assumptions. They assumed that occupational compo-
sition will not change in the future, which is tantamount
to assuming that there will be no major innovations. For
example, one company made a five-year forecast of man-
power requirements in 1955. By 1957 the number of
managerial and professional employees estimated to be
employed by 1960 had already been exceeded. Here,
obviously no attempt had been made to study past changes
in occupational structure as a possible guide to future
needs. We did find, however, that a large number of
companies were making rather careful plans for the
introduction of new processes, new products, and even
new systems of administration. Yet in no case did we
find any serious attempt to relate requirements for
human resources to such plans.1

1Frederick Harbison, "Manpower and Innovation", Personnel,
A second step in making qualitative determinations might be reference to the company's long-range plans and objectives. This would be of assistance insofar as it would reveal what the organization should be, instead of what it is, and would identify the types of men needed to execute the plans and fulfill the objectives.

Employees of today and of the future will have to work in diverse environments. In attempting to identify the characteristics needed by future personnel, the use of environmental analysis should not be overlooked. By utilizing this tool, the planner may be able to determine some of the characteristics the men of the future must possess if they are to function effectively in their various positions. Moore lists the most important environments as:

1. Value Environment - (People in business organizations) operate not only within the evolving values of time, but also within an historical framework of past values which are embodied in their institutions.

2. Institutional Environment - (People in business organizations) are usually keenly aware of the competition which they have with other industries, but they are not so aware of their competition with other institutions in our society--religious, educational, unions, governments, communities, etc.

3. Company Environment - A third important environment in which (people in business) operate is the culture of their own firms. Each company has a history, a way of doing things, a set of conventions, customs, social habits which constitute its character as a business.
4. Organizational Structure Environment - ... Each individual, with the exception of the president and those at the very bottom, operates within an interacting triad of relationships in which some people are viewed as being in higher positions, some in lower, subordinate positions, and some at the same level.

5. Occupational Environment - An occupation... is more than a function; it is frequently a way of life. It directs the interests of incumbents, shapes their values and attitudes, determines their relations with others, brings people of like interests and oftentimes of like personalities together and thus intensifies interaction among them.

6. Decision Environment - The ideal, of course, is that his decision somehow enhance the competitive position of the firm bringing to its greater growth, profit stability, and all the other good things a well-run business is supposed to have. Furthermore, the choice of means to these various ends is presumed to be pinpointed, efficient, and precise.¹

A fifth means for making qualitative determinations is for the planner to confer with present operating department managers and allow them to expound their beliefs as to what characteristics should be possessed by future employees and managers in that capacity. These are the men who are closest to the situation and therefore can probably supply the most discriminating and introspective input concerning future qualifications.

A final method, and one that should not be overlooked, is the research into previously compiled information in this area.

¹David G. Moore, op. cit., pp. 2-6.
Familiarity with the field will facilitate making the determinations as to the qualitative composition of future manpower.  

Aside from the more generalized areas of manpower forecasting, the practitioners in the field must concern themselves with the necessary adjuncts to successful prognostications. In order to determine, for instance, whether proper information is received in relation to the numbers of employees needed in particular departments in order to efficiently perform assigned work, the planner must have some criterion for judgment. This would involve institution of and reliance upon techniques for work measurement. While this may not be a planning responsibility, it still behooves the planner to make sure that proper work measurement methods are utilized so that predictions can be made upon an accurate base. This has long been an accomplished fact for production workers, whose output may be measured by the criterion of numbers of units produced. Ever since the time of Frederick Taylor, time and motion study has been an integral part of the management tool kit. In the aerospace industry, though, a large proportion of the effort is creative. The non-repetitive aspects of the work do not lend themselves to these historic methods and new techniques have had to be developed to schedule and

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measure creative, non-repetitive effort. PERT is probably the most publicized of these methods but many others exist, such as PEP (the Air Force version of PERT), establishment of work centers.\(^1\) SCANS (Scheduling and Control by Automated Network System), Critical Path, etc. These are useful tools but in many cases must be broken down even further into individual responsibilities. Work management broken down into work logs to measure output and performance of individuals may be necessary in order for the planner to derive accurate information about probable numbers of men needed to perform future assignments.\(^2\) In this way better information may be obtained by the manpower planners and more reliable forecasts may be forthcoming. Other considerations include understaffed departments demanding excessive overtime hours from skilled employees, thus distorting determinations of manpower needs, masses of semi or unskilled employees utilized to overcome skill shortages, equally


distorting previous over-estimates of manpower requirements in particular departments which develop a pool of employees working on non-essential jobs, and hoarding by supervisors who believe that the more employees they have the greater their individual power and their impression upon their superiors. These are some of the considerations that must enter into the manpower planning function in order that its output can be comprehensive, valid, and successful in standing the test of time.

CHAPTER IV

THE RESEARCH DESIGN

Certain assumptions had to be made and accepted before it was feasible to undertake the central purposes of this study.

It had to be determined if there was a need for manpower planning in the aerospace industry, whether awareness of the need existed, that attempts had been made within the industry to satisfy that need, and that information concerning current manpower forecasting techniques could be obtained.

An examination of existing literature was undertaken to confirm these assumptions. Periodical literature yielded a wealth of information relative to the field. It became apparent, however, that while various practitioners and academicians were writing in connection with certain aspects of manpower forecasting, no definitive, referential work in this field had been published that synthesized the entire picture. Every writer, however, did devote one or several paragraphs to acknowledging the value to the business entity of planning the work force.

While these were indications of an actual need and of the existence of awareness of that need, it did not necessarily include the aerospace industry since, as has been noted previously, it is a comparatively new entrant to the area of business.
It was then necessary to confirm that this need and awareness did actually exist in the industry. This was accomplished by means of personal conversations with members of the industry, by telephone interviews, and most forcibly by interviews with a majority of the membership of the Controls and Planning Association (CAPA), a professional organization whose membership is comprised predominantly of practitioners in the aerospace industry. These discussions not only assured the awareness and need but the fact that many attempts were being made to fulfill the function as well. Almost everyone consulted, however, discussed a different method or technique for doing so.

The next step was to obtain information relative to current manpower forecasting methods. It was intended that a list of current methods be developed to confirm that diverse techniques were actually in use. This stage of the investigation revealed that the following methods of forecasting are commonly employed:

1. Sales per employee computed on the basis of total employees required at the end of the year.

2. Sales per employee computed on the basis of the average number of employees required during the year.

3. Sales per employee computed by determining the direct labor percentage of total sales and dividing that figure by the average annual direct labor wage rate.

4. The estimate-to-complete method.

5. Extrapolation of trend lines (regression analysis).
6. Past history of the company (including intuitive judgment).

7. A general category including military, political, and/or economic indicators.

These methods will be described in further detail in Chapter V.

Scope of the Study.

The next logical step was the determination of the extent to which these and other methods were employed on a wider (i.e., national) scale. A survey of firms in the aerospace industry was planned and made to establish whether these were the methods commonly utilized or whether other methods were in equal or more common usage.

In order to determine the extent of the survey, the population of the aerospace industry had to be defined. A recent aerospace firm census conducted by Aerospace Management Magazine revealed that there are 6,089 plants in the United States engaged in aerospace pursuits.\(^1\) Of these, 619 reported a sales volume of $5,000,000 or more.\(^2\) Employment of 1,000 or more people was reported by 323 firms. It was decided to use the 323 firms with employment of 1,000 or more as a point of departure since these were firms most likely to have a formalized and comparatively sophisticated manpower forecasting function. The decision to limit the study to these firms was

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\(^2\)Ibid.
necessary in order to make the study manageable and keep the accumulation of data within the writer's physical and financial resources. The smaller companies are not necessarily excluded from applying the results of this study by the imposition of this limitation. The principles and practices applicable to the larger firms in most cases have equal application to the smaller businesses. The difference is simply in scope of application.

The names of plants engaged in aerospace pursuits and which employed more than 1,000 employees were obtained from the Western States Electronics Directory and Buyer's Guide, the World Aviation Directory, the Los Angeles Chamber of Commerce, and the Aerospace Industries Association publications.¹

Choice of the Mail Questionnaire Method

The mail questionnaire method was used to elicit the data because it was the only practicable approach to collecting the needed information due to the widespread geographical dispersion of the firms who were to be queried. The use of the questionnaire method had several other advantages as well. All interviewees could be asked

¹When returns were received, 16 firms reported employment of less than 1,000. This could be attributed to normal fluctuations in employment, a disparity in the method of gathering statistics by the referenced publications, or a difference in the reporting year and the year in which this data was obtained.
the same questions in exactly the same way; no bias of the interviewer would be present. The respondents could be more candid in their answers since they were assured of anonymity. They could also take more time in filling out the mail questionnaire and thus be more accurate than they would or could be in answering questions put to them in a personal interview. Finally, the mail questionnaire was the cheapest way to reach the diversified statistical universe.

Each questionnaire that was mailed out cost approximately sixteen cents. On the basis of responses received, each answer cost approximately forty-eight cents.

The limitations to the mail questionnaire, though, were that all responses were obtained at the sufferance of the respondent and there probably exists a latent unwillingness to respond in many persons who could be induced to respond in a direct interview, in many cases the questionnaires may have been sent to the wrong persons in the various companies and they may have been unable to respond and unwilling or neglectful of passing it to the right party, there may be an element of bias in the responder which is undetectable in the mailed form and which will cause inaccuracies to appear in the final study, and finally, despite all efforts to the contrary, there may have been some misunderstanding on the part of the respondent as to the purposes of the study, the type of information sought, or the preservation of anonymity.
Goode and Hatt have given four criteria for deeming the mail questionnaire form appropriate.

The appropriateness of the mailed questionnaire will depend upon the requirements of the research problem with regard to (1) the type of information required, (2) the type of respondent reached, (3) the accessibility of the respondents, and (4) the precision of the hypothesis.¹

These criteria were met. The type of information required was applicable to the entire industry and was not of such a nature as to be entirely proprietary. Even so, no requirement was made that the names of the responding companies be included on the questionnaire. Thus, even if a company was unwilling to divulge its method because of fear of criticism and consequent embarrassment, for fear that higher executives might not approve the disclosure, or for any other reason, it was protected.² Also, an accompanying letter was sent with the questionnaire in order to clarify the purposes of the investigation and induce the respondents to cooperate in the survey. It was readily seen that this type of inquiry, when the results were published, would be of benefit to all practitioners


²Despite this safeguard, many companies responded in company envelopes, jotted down their company names on the questionnaire, or enclosed business cards even though stamped, self-addressed envelopes were provided with the questionnaire.
in the field. Since these practitioners were the people to whom the letters were addressed within the various companies, the type of respondent reached was usually sympathetic to the problem and amenable to cooperation. There was a valid reason, from the point of view of the busy executives who received the questionnaire, for taking the trouble to answer it.  

The accessibility of the respondents was not a stumbling-block, although it was not known precisely, in most cases, which person or persons within a particular company were charged with the responsibility for this function. In most cases the questionnaires were sent, by name, to the Manager or Director of Planning (as first choice) or to the Manager or Director of Personnel. To judge from the high percentage of responses to the first mailing, this was the correct course to pursue. In the larger companies, planning (and even manpower planning) was usually a separately identifiable function, while in the smaller firms the manpower planning activity was usually undertaken as an adjunct to the activities of the personnel function.

Finally, the hypothesis was one that proved to be clear, understandable, and of interest to the respondents. The cover letter, which

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is attached as Appendix A, explained to each potential respondent the purpose of the interrogation, the aims of the investigation, the type of work to which the information would be directed, and contained a personalized request for assistance and cooperation. Thus a mutuality of interest was established, rapport was facilitated, and responses were forthcoming. It was because the study was sharply focused and covered an area of vital interest to respondents that the use of the questionnaire was feasible and the results rewarding.

Construction of the Questionnaire

Construction of a questionnaire that would evoke the information sought by the survey was the next task. The purpose of the questionnaire was simple—to determine which methods of manpower forecasting were presently being used by firms in the aerospace industry and to see if a correlation existed between the size of the individual firm (in terms of sales dollars or number of employees) and the method of forecasting utilized. It was not necessary for a correlation to exist, although if one did appear it would prompt the formation of another sub-hypothesis and stimulate further inquiry into the reason for its existence. For example, if firms with less than 5,000 employees utilized predominantly the method of extrapolation of trend lines while those with more than 5,000 employees used, in the majority of cases, the sales per employee method, what factor or factors common to each category of business dictated this
utilization or made employment of that particular technique most practicable?

In addition to these factors, the construction of the questionnaire was influenced by several other considerations. The questionnaire had to be short enough so that the answering party would not reject it completely and so that it would not involve an inordinate amount of time in its completion. To satisfy this requirement, it was decided to limit the form to one side of one page, although those queried were encouraged to use the blank reverse side to enlarge upon their responses if they so desired. The questionnaire had to be of sufficient interest and appeal to induce replies. It had to be subjective enough to provoke thoughtful evaluation but objective and impersonal enough to encourage factual and unbiased responses. The questions had to be clear, definite, and unambiguous. To assure this, a formula as well as a word description was given to clarify some of the techniques being described. Finally, the questionnaire had to be organized so that the responses would not be descriptive of an individual or any one firm. For this reason it was decided to eliminate any requirement for a signature or a company name. Individual companies were important only insofar as they could be classified as to size in terms of sales dollars or number of employees.

Structured Versus Unstructured Questions

Most of the information being sought was clear-cut and factual,
therefore there was little point in using unstructured questions to obtain overly-expansive replies. It was decided to utilize structured questions that could be answered easily, factually, and definitely to elicit information concerning the types of firms responding. In order to obtain information concerning the methods of manpower forecasting employed by those firms, it was decided to utilize structured questions concerning those methods already known and a final unstructured question at the end which would allow the respondents to explain in brief or in detail any methods they utilized but which were not listed in the questionnaire, to annotate a method they had affirmed they applied, or to expand upon any of the structured questions.

Composition of the Questionnaire

The actual questionnaire is attached as Appendix B. Part I is simply a check-the-box or fill-in-the-number type of structured inquiry since the information sought is clear and straightforward and there is little danger that these questions could be leading or ambiguous. The number of employees and sales volume were necessarily included in order to segregate the responding companies by approximate size and to leave open a possible avenue of investigation as to whether a correlation existed, as previously mentioned, between the size of the company and the particular technique(s) of manpower forecasting employed. Current company efforts, type of
contractor, and major products were included to assure identification with the aerospace industry and for possible further correlation with the method utilized. Information concerning the number of employees engaged in manpower forecasting within the company and the approximate number of man/hours devoted to the manpower forecasting activity was sought in order to yield input on how extensive the function was within each company. The results of the survey subsequently indicated an unanticipated ambiguity in the man/hours question: some respondents expressed their answers in terms of man/hours per week, some in man/hours per month, and a few defined it in terms of man/hours per year. It was a relatively simple exercise, though, to reduce this varied input to a common denominator (man/hours per month was used) and this diversity of input proved to be no major impediment to the research.

Part II - Manpower Forecasting Methods - was the more meaningful portion of the questionnaire. The various methods that had been determined in the non-quantified aspect of the research process were listed in structured form so that the respondents needed simply to check the one(s) applicable to their particular situation. A final category, labeled "Other", was included that allowed those questioned to describe any methods they employed that were not previously listed. The responses to this latter category were necessarily in unstructured form since no information concerning
them was known to the investigator prior to the time the survey was instigated. The purposes to which the forecast might be utilized were also listed so that the length of time covered by the forecast could be determined and the use to which it was applied could be seen. Finally, the degree of accuracy that the particular forecasting method(s) checked or described had actually yielded was sought by the survey. This was expressed in percentages and computed in light of actual experience. This question furnished information concerning the actual usefulness and validity of the particular methods attested by the respondents.

In all cases the respondents were asked to assume that a sales forecast had been prepared and was available for use in making the manpower forecast. This was based upon the belief, which is still held, that needed personnel cannot be determined until the numbers of units of product and/or scope of effort for non-hardware items have been defined and specifically described to those responsible for the manpower forecasting effort.
CHAPTER V

METHODS OF MANPOWER FORECASTING

The survey revealed many methods and techniques for manpower forecasting now in vogue with various firms in the aerospace industry. In order to gain a fuller understanding of these methods, and eventually to derive a suggested method generally applicable to companies in the industry, it is now necessary to briefly examine these techniques and their apparent advantages and disadvantages. The results of the survey, indicating the number of firms who actually utilize the various techniques and other pertinent information, will then be discussed in Chapter VI.

The various techniques to be discussed are:

1. Sales Per Employee Computed on the Basis of Total Employees
2. Sales Per Employee Computed on the Basis of Average Employees
3. Direct Labor Percentage of Total Sales
4. The Estimate to Complete
5. Extrapolation of Trend Lines (Simple Regression)
6. Intuitive Judgment

7. General Military, Political, and Economic Indicators

8. Probability Forecasting

9. Other Miscellaneous Methods

Sales Per Employee Computed on the Basis of Total Employees

The sales per employee method of computing manpower requirements is, simply stated, a correlation between manpower and sales over an ascertained period of time. The formula for making this computation is:

\[
\text{Total Sales for the Year} \div \frac{\text{Anticipated Sales Per Total Employees at End of year}}{\text{Total Number of Employees Required}}
\]

The total sales for the year figure is obtained from the sales forecast. The factor to be used for the anticipated sales per total employees at the end of the year, however, must be derived from a prior analysis. The total company sales for a specified period of time (usually a minimum of five years) are compared with the total number of employees in the company at the end of each of the years. Total sales divided by the number of employees equals sales per employee. For example, if $174,000,000 of sales were generated by 20,241 employees, the sales per employee figure would be $8,600.

The charts and graphs on the following pages reflect a study made of two groups of firms in the aerospace field and the resultant figures of sales per employee.
employ this technique. It can be readily understood by management at all levels and is particularly applicable to forecasting on a "crash" basis.

There are several disadvantages to this method of manpower forecasting. Chief among these is the assumption that the future will be an extension of the past. One cannot assume, without further corroboration and analysis, that the composition of future sales will be the same as that of historical sales. A difference in the product mix will have a definite effect upon the sales per employee. There is also the learning curve to consider. As employees become more proficient in the performance of their tasks (when these tasks concern the same product), their productivity increases. Consequently, the sales per employee figure also increases and the company is able to achieve the same amount of sales with the same or a lesser number of employees. ¹ A third disadvantage is that the resultant figure from this analysis represents the total number that must be employed at the end of the year but does not give the number per month. Thus if there may be peaks and valleys in the employment figures within

¹Generally speaking, sales per employee should rise each year. Each employee must produce more goods and services to assure that wages remain the same relative percentage of sales.
needed must be set back in time to allow for hiring prior to the time that the sale is made. Usually, the length of time for training and actual production determines the interval between the time of hire and the time of sale. Finally, sales dollars must be deflated to eliminate price increases that have occurred solely as the result of inflation in order to get a realistic appraisal of the number of employees needed to produce a given volume of sales.  

The sales per employee analysis is exemplified in Table 1 and Figures 1, 2, and 3 on the following pages.

It can readily be seen from these graphs that sales per employee cannot always be used as an indicator of what the company will do in the future. If the curve is fairly consistent over a long period of time, such as those in the companies portrayed in group one, it is reasonable to assume that the sales per employee factor will indeed be a plausible one. If, however, there is a wide fluctuation in the curve, such as those of Lockheed, Republic, and North American in

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1 For a further discussion concerning how this method has been employed at Minnesota Mining and Manufacturing Co., see Wendel W. Burton, "Forecasting Manpower Needs: A Tested Formula" in Labor and Management Face the Future, Personnel Series No. 172, (New York: American Management Association, 1957) pp 11-20.
### TABLE 1

**SALES PER EMPLOYEE IN TWO SELECTED GROUPS OF COMPANIES**

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas Instruments</td>
<td>Lockheed</td>
</tr>
<tr>
<td>Robertshaw Fulton</td>
<td>North American</td>
</tr>
<tr>
<td>Bendix</td>
<td>Northrop</td>
</tr>
<tr>
<td>Beckman Instruments</td>
<td>Republic</td>
</tr>
<tr>
<td>Sperry</td>
<td>Aerojet General</td>
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<tr>
<td>Minneapolis Honeywell</td>
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</tbody>
</table>

#### Group 1

<table>
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<tr>
<th>Year</th>
<th>Company</th>
<th>Sales (Millions)</th>
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**Group 2**

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</tbody>
</table>

*Source: Moody's Industrials
FIGURE 1

GROUP 1 COMPANIES

SALES PER EMPLOYEE (000)

YEAR

SALES PER EMPLOYEE
11-YEAR AVERAGE

YEAR


SALES PER EMPLOYEE (000)

GROUP 1

GROUP 2

This method of computing the net sales per employee is simply

the net sales divided by the total number of

sales per employee in any given year. A slight premium

is added, however, to the estimated number of employees that

the company has in service at any one time. The result of this

varies slightly from one year to another, but the general trend is

the same. In the early years, the sales were low, but have

increased steadily in recent years.
group two, the credibility of the sales per employee factor becomes dubious. In cases such as these, another correlative factor, such as units produced per employee, may have to be utilized.

Sales Per Employee Computed on the Basis of Average Employees

This method of computing manpower requirements is simply a variation of the method just described for determining dollars of sales produced by number of employees. A slight refinement is added, however, in that instead of using the total number of employees in-house at the end of each year, the total number employed each month is added and the sum is divided by twelve. This is done in an effort to overcome the effects of peaks and valleys in the employment figures that are due to monthly fluctuations in production or other contractual requirements. The resultant figure will be one that describes the average number of employees that the company will employ during the course of the year.

The formula for making this computation is:

\[
\frac{\text{Total Sales for the Year}}{\text{Average Number of Employees for Year}} = \frac{\text{Anticipated Sales per Employee}}{\text{Average Number of Employees Required}}
\]

The chief advantage of this method over the total employees method is that if there is a sudden surge in employment at the latter end of the year, the computation will not be distorted unduly. Other advantages are identical to those for computations based upon total
employees: information is easy to obtain, the technique is readily understood, and it is a method apt for utilization when only a limited amount of time is available for preparation of the forecast.

Disadvantages of this method are the same as those for the computation based upon total employees, with the exception that the objection based upon no allowance for peaks and valleys in the employment cycle is largely negated by use of the average number of employees rather than the total number.

Direct Labor Percentage of Total Sales

This again is a variation of the sales per employee technique, but the approach taken is different in concept. The question that is asked here is "What percentage of our total sales is represented by direct labor costs?". In order to make this computation, the total sales for a specified period of time (usually a minimum of five years) are compared with the direct labor costs for each year under study. The calculation of direct labor costs must include not only wages but fringe benefits, training costs, overhead costs, and any other expenditures necessary and incidental to the maintenance of direct labor (with the provision that they must be directly related to direct labor or, if a general overhead expense, proportionately attributable to direct labor). This figure is divided by the average annual direct labor wage rate. This wage rate number includes not only hourly-rate or salary wages but again the costs of fringe benefits, overhead
and all other apportionable dollar amounts that the firm expends for direct labor. The quotient derived from this calculation is the number of direct labor employees. This in turn is multiplied by the ratio of indirect to direct labor employees to obtain the total number of people required.

The formula for this computation is:

\[
\frac{\text{D/L \% of Total Sales}}{\text{Avg. Annual D/L Wage Rate \times Ratio of Indirect Employees to D/L Employees}} = \text{Total D/L Employees} \times \text{Emp.}
\]

There is some disagreement among practitioners in the field as to whether or not the general and administrative personnel should be included in the indirect:direct employee ratio. It is felt that inclusion of G & A people in the ratio distorts it disproportionately since there is usually not a direct correlation between increments in the direct labor work force and increases in G & A personnel. When these people are not included in the ratio, one additional step is required to compute total manpower requirements—the factoring-in of the general and administrative personnel.

The advantages of this type of manpower forecasting are (1) a qualitative breakdown of personnel, on a broad scale, is built into the procedure so that when it is accomplished an indication is given of the relative proportions of direct and indirect personnel that will be needed, (2) all information and statistics needed for formulation of this forecast are obtainable internally, both from perusal of
company records and analysis by the forecasting staff, (3) management
can readily see whether the direct labor percentage of total sales is
increasing or decreasing, which can give an indication of productivity
and efficiency, (4) the factor developed for the direct labor percentage
of total sales can be useful in other applications, such as facilities
planning, and (5) a searchlight is placed upon an important management
control tool—the indirect:direct ratio—to illuminate an area where
greater efficiencies may be effected.

This technique must be used with particular care. Although all
pertinent statistics are available within the company, they must be
extracted with experienced judgment by the responsible planner. It
is all too easy to poorly define what is and is not direct labor and
what are or are not direct labor overhead charges, fringe benefits,
or the proportions of other general expenses that are applicable to
personnel that are charged as direct. Thus the assimilation of
information concerning the direct labor percentage of total sales,
the average annual direct labor wage rate, and the ratio of indirect
to direct labor employees becomes a critical issue. This type of
analysis should not be undertaken by the inexperienced practitioner
or at the lower planning levels within the company.

A second disadvantage is that a relatively longer period of time
is needed to compile the information needed to make this technique
practicable. Thus it will not ordinarily be possible to utilize the
method when a forecast is required in a short period of time unless the various factors are updated at regular, short intervals.

A third drawback is that a ratio of indirects to directs that has been disproportionate during a past period of time will cause the technique to yield an incorrect figure if the imbalance is due to be corrected. Here again, we run into the old bugaboo of the forecaster. One cannot prognosticate the future based solely upon the past. As E. B. Rickard says, "The past is history...... The future is planning".¹

If all factors remain constant, the past can be used as an indicator of future occurrences, but this is rarely the case. The planner must exercise careful judgment when making these predictions so that any conditions that will exist during the forecasted period will be taken into account and factored into the expectations. Finally the forecaster must be sure to increase the average D/L wage rate in each succeeding time period in accordance with the inflationary trend.

It must be emphasized that all three of the techniques just discussed that relate sales dollars to number of employees are general indicators that should not be used for making detailed and definitized breakdowns concerning the composition of the work force. They are useful in arriving at a top number and, if analyzed and

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¹E. B. Rickard, "The Past is History...... The Future is Planning", Controller, XXX, October 1962, p. 478.
calculated diligently, within a fairly high degree of accuracy. Further refinements, though, must be made by employing more finely honed techniques.

Estimate to Complete

The estimate to complete method, simply stated, attempts to determine the number of man-hours required to complete tasks (by contract) currently in-house and to perform those tasks that the sales forecast predicts will be coming into the firm in the future. Basically, it is a simple determination. How many workers of a certain type are necessary to produce a specified volume of product? The qualifications of the types of workers are stated in the job descriptions, what remains is to make the quantitative decision as to how many workers of each type are necessary.

This conclusion can be derived only in terms of the reasonable or probable production that can be anticipated from each worker. In other words, the decision is intricately entwined with the original task of setting work standards or goals of production.

Probably the most widely utilized procedure by which such determinations are made is a review and analysis of experience. Production records will ordinarily show the volume of output produced by a given number of employees in a given department. By dividing the total output by the total employees, a simple average showing
the usual production per employee can be calculated; this average can then be utilized for estimating employee requirements for various levels of output. If further refinement is desired, the total hours for the job can be divided by the number of men on the job to get man/hour requirements.

Dale Yoder describes two methods of obtaining these estimates as follows:

For production jobs held by hourly-rated employees, current practice generally regards the desirable procedure as that of time study. Jobs are analyzed and each task is timed to discover what appears to be reasonable standards. In that process, means of simplifying the job and economizing the energy and effort of the employee may become apparent. Thus, job simplification may permit increased output without unreasonable effort or hazard to the employee. Time study may be used for clerical workers also, but a more common procedure varies the method to provide time-budgeting and work-load analysis. Employees are asked to maintain careful notes on the tasks they perform and the amount of time devoted to each of them. Total and individual production is measured, for example, in terms of the numbers of letters answered, accounts posted, or similar activities. On the basis of such studies, output standards of work loads are established.

It should be noted that the estimate-to-complete method, in contrast to the sales per employee method, is gauged in terms of cost and time, rather than in terms of sales dollars. When used for the purpose of making quantitative determinations of manpower, the time

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factor assumes primary importance. Based upon the numbers of hours it will take to perform specific tasks, how many men will be needed to complete the assignment within a definite period of time? Since the contractual commitment is a fixed factor, the only numbers that can be juggled are those pertaining to men.

Compilation of the estimate-to-complete is a laborious task requiring computations contract by contract and task by task within each contract. The results must then be summarized by time intervals so that the total man/hours required during each period of time can be seen. From this, the quantitative manpower requirements can be determined and the qualitative refinement extracted.

The biggest advantage of the estimate-to-complete method, from a manpower planning standpoint, is that its orientation is toward manpower from start to finish. It begins with men (man-hours) and ends with men (total). There is no need for any correlative factors or the use of any formulae. The estimate-to-complete (which is sometimes called the cost-to-complete) method is a finely detailed breakdown of personnel, task by task, for each item of work now possessed or anticipated by the company and yields definite numbers of people required. Quantitative and qualitative estimates are prepared simultaneously since the task-by-task analysis not only determines the numbers of people required but naturally depicts the types of workers needed to perform the tasks being analyzed.
The big disadvantage in the employment of this method is that it usually takes an inordinate amount of time to compile the necessary information. In a large, complex, diversified, multi-level organization the time required to compute, assemble, and analyze this data may range from several months to the better part of a year. Thus in many cases by the time the final forecast is published it is already outdated. Another drawback in the use of this method is that it does not give an entire picture. While it may tell quite clearly the numbers of direct labor personnel and most of the indirect people, the estimate to complete does not impose itself into the general and administrative areas or other portions of the business entity that are vital to its life but not concerned with the work items covered by the estimate. Examples of these functions are housekeeping, security, employment, industrial relations, and planning!

In some companies the estimate to complete is compiled by the program management staff while in others it is done by the departments who will actually perform the work. Initially, all source information is obtained from the operating units. Charles H. Granger has argued that plans are properly made by these units and not by members of a higher planning staff but can be reviewed by the higher authority. He summarizes the argument as follows:
This situation is fraught with dangers. Planners can be caught in a political power play. In one sense, operating people may look at the planners as a super Gestapo that second-guesses the operating units. This view can give the planning concept a jolt from which it may never recover.

On the other hand one can logically argue that if the plans...are taken at face value, without some sort of headquarters review, there will be no system of checks and balances. The headquarters staff must have the "right to look". The problem in actual practice is that the headquarters planning staff has only the capability of examining form, not substance.¹

The question as to who will compile the estimate to complete is a political football in many companies and will probably depend upon who demonstrates the better capability and accuracy. The manpower forecasting methods survey showed that the estimate to complete is generally the most popularly utilized method of forecasting and that the departments doing the work, as opposed to the program management staff, assembled this information in a slight majority of the cases. It is logical that the organization with the best capability for assembling and analyzing the needed information be charged with the responsibility for performance of the task.

Extrapolation of Trend Lines
(Simple Regression)

Many types of forecasting can be accomplished by means of extrapolation of trend lines--prediction of personal needed in any one

department, in the entire plant, by number of direct labor employees as opposed to indirects, by number of managerial types needed, etc.

The illustration to be given here will be for the determination of the number of managers that will be needed in predetermined future points in time.

To begin with, in making this utilization, the numbers of managers employed during the past ten year period should be determined, a task that can be accomplished by perusal of personnel records initially, and then updated yearly to reflect latest statistics. This would enable the planner to determine the numbers of acquisitions and attritions made each year. A correlation must then be established between this statistic and some independent variable, in this case units of product. It is then quite probable that managerial manpower requirements can be predicted for as far into the future as sales for that product line can be estimated. The criterion must be, however, that a high correlation does exist between the number of units of product to be built (the independent variable) and the number of managers needed (the dependent variable) in order to build them. Regression analysis is the statistical tool to be utilized in making this determination.

The following terms apply to the example, which shows the number of computers produced and to be produced as the independent variable and the number of managers used and needed in the future as the dependent
variable that correlates with the independent. 1

1. **Year** - The period of time for which each statistic is applicable.

2. **Number of Managers** - The actual quantity of managers employed in each of the years indicated.

3. **Number of Computers** - The actual quantity of computers produced between 1954 and 1963, and the quantity of computers anticipated (by the sales forecast) to be produced through 1968.

4. **Y** - The mean number of computers per manager through 1963, obtained by dividing the quantity of managers into the quantity of computers.

5. **X** - The values which are applied to the time ordinate and whose sum equals zero. These values are utilized to eliminate yearly discrepancies or variances from the general trend and thus reduce the trend line to the most perfect fit.

6. **X²** - X multiplied by itself.

7. **XY** - The product of X and Y.

8. **A** - The total of years of actual experience divided into summation Y, which produces the height of the trend line.

9. **B** - Summation X² divided into summation XY, which produces the slope of the trend line.

10. **BX** - The product of B and X.

11. **YC** - The sum of A plus BX. This is the trend line (YC = A plus BX). Every year under consideration yields a point YC, and plotting these YC points yields an absolute mathematical progression which can be extrapolated through the years under consideration. YC in its extrapolated state

---

1 This example has been adapted from one used by Richard I. Hartman in *Managerial Manpower Planning in Selected Manufacturing Firms*, Indiana University Library, 1961, pp. 56-62.
determines the average quantity of computers per manager from 1964 through 1968. In order to obtain the probable number of managers required for that period, the number of computers to be produced (as determined by the sales forecast) is divided by the extrapolated quantity of computers per manager. The quotient is the actual number of managers needed.

The actual statistical calculations for this fictitious firm are illustrated in TABLE 2. The actual managerial manpower totals during the period 1964 to 1968 are based upon the 1968 estimated production of 12,745 computers, and projects that by 1968 this company will require an additional 79 managers for a total of 331.

Employment turnover must then be factored into this prognostication. Here again this analysis must begin with historical data and regression analysis must be utilized to extrapolate turnover for 1968. Obtaining the turnover percentage is accomplished by dividing the number of turnovers by the number of managers (TABLE 3). These percentages can then be factored into the extrapolated managerial manpower figures for 1964 to 1968 to yield a final determination of managerial manpower needs with allowance for turnover. Thus if 331 managers are predicted for 1968 and the turnover percentage is 16.3, the actual need is for 385 men, 54 having departed from the payroll.

In the following tables, \( YC = A + BX \),

\[
A = \frac{\text{Summation } Y}{N(\text{Years})}, \quad B = \frac{\text{Summation } XY}{\text{Summation } X^2}, \quad \text{and}
\]

\[
\text{No. of Predicted Computers} = \frac{\text{Extrapolated} \ YC}{\text{No. of Managers}}
\]
<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Managers</th>
<th>Number of Computers</th>
<th>Average Computers per Manager</th>
<th>X</th>
<th>X²</th>
<th>XY</th>
<th>A</th>
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**Table 2**

MANAGERIAL MANPOWER EXTRAPOLATION
<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Managers</th>
<th>Number of Turnovers</th>
<th>Turnover Percentage</th>
<th>X</th>
<th>X^2</th>
<th>XY</th>
<th>A</th>
<th>B</th>
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<th>YC</th>
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<td>1968</td>
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<td></td>
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<td></td>
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### TABLE 4

**EXTRAPOLATED FIGURES CORRECTED FOR TURNOVER**

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Managers (Extrapolated)</th>
<th>Turnover Percentage</th>
<th>Number of Managers (Corrected)</th>
</tr>
</thead>
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<td>1964</td>
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<td>305</td>
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<td>1965</td>
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<td>363</td>
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<tr>
<td>1968</td>
<td>331</td>
<td>16.3</td>
<td>385</td>
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</table>
Probably the chief advantage of forecasting by means of extrapolation of trend lines is that of time utility. The planner need go no further than the company's personnel records to obtain the necessary input for making this determination. This extraction of information can be accomplished by the planner with little outside assistance, thus he can perform his function without being hampered by inaction from outside parties when data is needed for them. Furthermore, once the data has been accumulated for the initial forecast employing this method, updating of the information simply involves dropping the first year and including the year just past. The computations can all be performed in the planner's own office, thus giving him the benefit of almost all the available time.

Another advantage is that information used in making this correlation analysis is historical and thus factual as opposed to estimated. A long period of time can be utilized as a base and, as John Howard says, "The longer the period (of observation), other things being equal, the more reliable will be the estimates of the relationships". 1 Also the straight line type of relationship is one of the simplest functions to fit and to explain, and lends itself very readily to graphic presentation. 2

There are many disadvantages to this type of forecasting. To begin with, a company that has a diversified product line will encounter difficulty in attempting to utilize physical units of product as the independent variable. It can be done, but separate analyses would have to be made for each type of product and then a symbiosis of the result could yield the true trend line. The difficulty in doing this (a process that could consume precious time that the planner hopes to save by utilizing the method) is compounded by the fact that some product lines have been added or dropped in the ensuing years, thus the validity of the statistics can be called into question. In addition, the prognostications are dependent upon the projections made of the independent variable and thus, as a secondary prediction, can be no more valid than the primary prediction.

Another disadvantage is expressed thusly by Ezekiel and Fox:

> By its very nature (simple regression) can represent only a situation where the change in the dependent variable for a unit change in the independent variable would be expected to be the same regardless of how large or how small the independent variable was; i.e., where the regression line has the same slope throughout. This is a very precise and narrow relation. In many cases, the line which theoretically would be expected would have a changing slope as the value of the independent variable changed. Unless there is a good logical reason to expect the linear equation to represent truly the situation present, fitting a straight line can be regarded only as an empirical exercise, with no meaning to the constants obtained beyond the purely formal one of specifying the straight line that most nearly represents the observed data.  

\[1\]

\[1\] Ibid.
Another drawback lies in the application of the old adage that "correlation does not imply causation". One might prove, for example, that the number of new trees planted each year on a tree farm in Oskwewgy, British Columbia has been identical to the number of children born in Ecuador each year for the past five years. This does not mean that increased tree planting on the farm will cause a jump in Ecuador's birth rate, nor does it imply that the relationship will remain constant in the future.

John A. Howard has listed the three major limitations of the regression method of forecasting as, (1) the method assumes that a relationship existing in the past will hold true in the future, (2) causality may not flow unilaterally from the independent to the dependent variable, and (3) if a lagged relationship does not exist it is necessary to predict the independent variable, and this may prove difficult.  

Finally, some correlations are spurious. As Heidingsfield and Blankenship indicate,

A high correlation does not always mean that fluctuations in one variable are related to fluctuations in another. Sometimes both variables increase or decrease as a third unmeasured variable changes. In such a case both variables studied are dependent on the third.  

---

1 John A. Howard, op. cit., p. 127.

Intuitive Judgment

Forecasting by means of intuitive judgments is easily the most simple and convenient method for formulating predictions. The method involves personal interviews with key executives and other personnel directly concerned with the customer and his requirements and those concerned with the general military market and probable future aerospace requirements. The planners gather these consensuses of opinion, factor in their own beliefs and judgments, and emerge with a prognostication of probable company position at stated future periods. When reduced to manpower requirements, these statements are usually expressed "We did X number of dollars worth of business with Y number of employees; if we do X + 5% next year, we will need Y + 5% number of employees next year". The increment in sales and employees need not necessarily be a straight line relationship--X + 5% in sales may be done with Y + 3% of employees. The relationship also might be expressed in units of product rather than in sales dollars, i.e. if X number of units were produced with Y number of employees then X + 125 units may be produced with Y + 30 employees. This type of forecast may be compounded on a department by department basis or on an overall company viewpoint.

While this type of forecasting may be completely unscientific and lacking in methodology and discipline, it can not be completely discredited on this contention. Business management is a science that is built upon intangibles and intuitive management decision-making has
guided many companies to success and profitability. All methods of
prognosticating, by virtue of their assumptions concerning the future,
involve a certain degree of judgment which must be made by the fore-
casters themselves and/or by the executives from whose jurisdiction
the information is derived and/or by the executives to whom it is
reported. Thus intuitive judgment can not be discounted—it is in
this area that the qualifications, abilities, experience, and maturity
of the planner are put to the acid test. Information-gathering is not
a particularly high-level function; it is the discriminative sorting,
analysis, refinement, and synthesis of this information based upon
subjective judgments by the planners that puts guts into the operation
and classifies it as a high-level pursuit. This approach has been
described by one practitioner as, "It rests on an unpatented blend
of statistical data, historical relationships, heroic assumptions, and
a sufficient mixture of past boners and good guesses usually referred
to as experience". 1 Thus intuitive judgment is and always will be
an integral part of any planning function, and its role must be
acknowledged. The danger lies in using this technique to the exclusion
of all others since input derived from more formalized techniques may
provide a basis for forming or altering intuitive decisions. As George
A Steiner has written,

1Murray L. Weidenbaum, "Trend of the Military Market", The
Making the forecast is a hard research project. All the available tools of analysis should be used where the cost is less than the value. Important, of course, is the collecting of available information. Various statistical techniques are helpful in analyzing and using this data. Individual experts are of outstanding importance as sources of information and value judgments. Throughout the research, interviews with experts constitute a continuous evaluation process of the highest importance. The various techniques used in building up data and information are, at best, aids to judgment. There is nothing quantitatively automatic that can produce an acceptable budget forecast. The resulting forecast, therefore, is a mass of judgments about future probabilities as they relate to the defense budget. The more expert knowledge is focused on the accumulated data, the more valid is the final judgment likely to be.

General Indicators

Forecasting, especially for the longer term, can not depend exclusively upon contract-by-contract or product-by-product analysis.

There are many other indicators which are of value to business when attempting to predict what their potential is in various areas and whether they are liable to increase or decrease in years to come. These can be classed as general military, political, or economic indicators.

Military indicators include such considerations as (1) what will the congressional appropriations for defense amount to in dollars and cents and in terms of hardware included in the submitted budget? (2) what will be the technology of modern warfare? (3) what is the nature

---

of the foreign military threat and how will we probably combat it?

(4) what are the possibilities of limited or total world disarmament?

(5) what is the anatomy of our strategy of peaceful-but-armed
deterrence? (6) what equipment will be required for limited or total
warfare? (7) what are the aims and capabilities of the space program?

(8) what is the composition of government spending for defense, offense,
and space exploration? (9) what is the pattern of allocation of funds
among military suppliers? and (10) what is the future for specific
types of hardware now purchased or contemplated by the military?

The list can go on and on. The following tables show some of these
factors.

**TABLE 5**

**COMPOSITION OF MILITARY PROCUREMENT**

*(FY 1960, in billions)*

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<th>Navy</th>
<th>Air Force</th>
<th>Total</th>
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<td>*</td>
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*Less than $50 million

% of Total  10.3%  31.5%  58.2%  100.0%

FIGURE 4

MILITARY PROCUREMENT EXPENDITURES
BY TYPE

Land Vehicles and Ships

Ground Electronics

Missiles

Aircraft

Source: Department of Defense Data
FIGURE 5:

DISTRIBUTION OF MILITARY PRIME CONTRACTS
BY TYPE OF PERFORMER

Source: Department of Defense Data for Fiscal Years 1951 - 1958
FIGURE 6

DISTRIBUTION OF MAJOR MILITARY PRIME CONTRACTS BY INDUSTRY

Source: Department of Defense Data for Fiscal Year 1959
### TABLE 6

**ALLOCATION OF THE MILITARY R & D DOLLAR - 1960**

<table>
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<td>Research Facilities</td>
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### TABLE 7

**ALLOCATION OF THE MILITARY RESEARCH DOLLAR - 1960**

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<td>Physical Sciences</td>
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<td>Social Sciences</td>
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<tr>
<td>Biological Sciences</td>
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</tr>
<tr>
<td>Mathematics</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>


### TABLE 8

**MILITARY PROCUREMENT EXPENDITURES BY TYPE**

*(Fiscal years, by percent)*

<table>
<thead>
<tr>
<th>Year</th>
<th>Aircraft</th>
<th>Missiles</th>
<th>Ground Electronics</th>
<th>Land Vehicles and Ships</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>60.7</td>
<td>0.5</td>
<td>4.9</td>
<td>33.9</td>
</tr>
<tr>
<td>1952</td>
<td>42.6</td>
<td>1.5</td>
<td>5.2</td>
<td>50.7</td>
</tr>
<tr>
<td>1953</td>
<td>43.3</td>
<td>1.7</td>
<td>3.8</td>
<td>49.2</td>
</tr>
<tr>
<td>1954</td>
<td>52.2</td>
<td>3.2</td>
<td>5.2</td>
<td>39.4</td>
</tr>
<tr>
<td>1955</td>
<td>61.8</td>
<td>5.5</td>
<td>4.9</td>
<td>27.8</td>
</tr>
<tr>
<td>1956</td>
<td>58.7</td>
<td>9.6</td>
<td>6.3</td>
<td>25.4</td>
</tr>
<tr>
<td>1957</td>
<td>58.4</td>
<td>15.3</td>
<td>6.5</td>
<td>19.8</td>
</tr>
<tr>
<td>1958</td>
<td>57.6</td>
<td>18.6</td>
<td>6.0</td>
<td>17.8</td>
</tr>
<tr>
<td>1959</td>
<td>50.0</td>
<td>23.6</td>
<td>5.2</td>
<td>21.3</td>
</tr>
<tr>
<td>1960</td>
<td>45.1</td>
<td>26.9</td>
<td>7.2</td>
<td>20.8</td>
</tr>
</tbody>
</table>
Political indicators would include such factors as the following:

What are the prospects for settling or easing of cold war tensions or, conversely what diplomatic policies are likely to be pursued that will add to cold war strains? Will the next administration pursue a liberal or penurious policy of defense spending? What is the likelihood of change in key decision-making posts in the administration with a consequent change of philosophy regarding defense and space projects?

Will our political prestige in the eyes of the rest of the world need to be suddenly enhanced such as it was after the Russians shot the first Sputnik into space? What moves have the Soviets or other potential adversaries made in recent months that will require defense or aerospace-oriented countermeasures? Is the political climate acclimated to aggressive or defensive warfare? What is the character of the foreign market? These and other questions could form an almost endless list of political considerations that the forecaster might take into account when formulating his predictions.

Economic indicators in the aerospace industry are unique insofar as the aerospace economy is not shaped by the laws of supply and demand that figure so heavily in the sale of commercial products. There is only one customer—the government—and this places different constraints upon aerospace firms than upon those engaged in public commerce. Economic indicators may take a reverse twist in the case of companies in this industry. Are there likely to be more government awards in one area due to economically depressed conditions there?
Will the need to retain defense facility capability result in contract awards to a firm whose prospects are declining due to reduced awards in the past? Will government spending in general be increased to provide impetus to the economy? These and other economic concepts are factored into the forecaster's considerations.

The role of general indicators in the theatre of planning is that of overview. The entire forecast is usually appraised in the light of these considerations and tempered accordingly. As J. A. Stockfisch has written,

The budgetary process is by no means a one-way street: the state of the economy, the threat, technological changes, and the subtle and sometimes unsubtle relationship between the military services, the Secretary of Defense, the President and the Budget Bureau, and the Congress—all interact to influence both the level and composition of defense spending.¹

Probability Forecasting

No one can be 100% sure about the future. Forecasting, then becomes the art of prediction in the face of uncertainty. Such predictions can only be expressed in terms of probability—a level of confidence expressed by the prognosticator concerning the likelihood that certain events will actually occur.

Any company participating in competitive bidding does not know two things: which bids will be successful and when contract coverage will be received. In order to forecast with reasonable accuracy in the face of these uncertainties, a theory of probability has been formulated which works in the following manner.

Expressed simply, the probable manpower requirements for future time periods are a function of the probability of getting contract coverage, the time from submission of bid to receipt of contract coverage, the possible manloading assignments per contract, and the number of proposals outstanding.

Assume, for instance, that there is an even chance that a specific contract will be received in any one of four months—September, October, November, or December. Thus there is a 25% probability of receipt in each month. If this contract called for the utilization of 100 men for a period of five months, the probable requirement for men for the month of September would be 100 (.25) or 25 men. In October the need would be for 25 men carried forward from a possible September go-ahead and an additional 25 men computed from possible contract coverage in October, or a total of 50 men. Extension of the logic provides the following table:
TABLE 9

<table>
<thead>
<tr>
<th>Month</th>
<th>Probable Manpower Need</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept.</td>
<td>25</td>
</tr>
<tr>
<td>Oct.</td>
<td>50</td>
</tr>
<tr>
<td>Nov.</td>
<td>75</td>
</tr>
<tr>
<td>Dec.</td>
<td>100</td>
</tr>
<tr>
<td>Jan.</td>
<td>100</td>
</tr>
<tr>
<td>Feb.</td>
<td>75</td>
</tr>
<tr>
<td>Mar.</td>
<td>50</td>
</tr>
<tr>
<td>Apr.</td>
<td>25</td>
</tr>
</tbody>
</table>

500 Man-Months

Under any set of possibilities, there will be contract coverage during December and January, therefore the manpower requirement is maximized during those months. The probable requirement in April, however, is only 25 men since work will be performed in April only if contract coverage is received in December. It should be noted that the total probable man-months in Table 9 is the same as the actual number of man-months needed—500 man-months is the same as 100 men for five months.

L. B. Wadel and C. M. Bush have reported a mathematical formulation of this procedure in the following manner.\(^1\) The expected manpower requirement for a specific contract is represented by the formula,

\[
\bar{M}(t) = \sum_{i=1}^{n} M_i(t)p(M_i)
\]

\(\bar{M}(t)\) = "expected" manpower required as a function of

---

\[ P = \text{overall probability of getting the contract } 0 \leq P \leq 1 \]

\[ M_i(t) = "i"^\text{'th possible manpower assignment function}, \quad i = 1, 2, \ldots , n \]

\[ p(M_i) = \text{probability of occurrence of } M_i(t) \text{ if contract is received at all} \]

\[ \sum_{i=1}^{n} p(M_i) = 1 \]

\( t \) represents an independent time variable while \( M_i(t) \) and \( M(t) \) are treated as constant during each time interval, such as one month. A manpower requirement function, \( M_i(t) \) is selected for each conceivable contract coverage date \( t_i \). In this event, \( p(M_i) \) and \( p(t_i) \) are identical, the probability of contract coverage occurring at \( t_i \).

Both \( P \) and \( p(t_i) \) may be surmised from consideration of interpretations of customer statements, appraisal of customer requirements, analysis of program potential, extrapolation from experience with the particular contract type or customer, judgment of bid stipulations, or any other intelligence that may be applicable.

If all possible manpower assignment functions are different only in the contract coverage date, \( M_i(t) \) can be expressed as \( M(t-t_i) \). In this case,

\[ \bar{M}(t) = \sum_{i=1}^{n} M_i(t)p(t_i) = \sum_{i=1}^{n} M(t-t_i)p(t_i) \]

Taken alone, this "probable" figure is rendered insignificant. A contract will be bestowed on one certain date or not at all. The technique's significance increases, though, in proportion to the quantity of submitted
bids still outstanding. It yields a total probable manpower need. It is recommended that this method be employed only when six or more bids are outstanding.

K. S. Packard has made the point that this analysis should include the consideration that the probability of bidding success is a function of the age of the proposal.\(^1\) As the time lengthens from time of bid submission, the probability of capture decreases. Packard's analysis yields the following table where the sum of any row is equal to \(P_{M_i}^n\) above.

**TABLE 10**

<table>
<thead>
<tr>
<th>(n)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.15</td>
<td>0.15</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>1</td>
<td>0.18</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>0.06</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>0.08</td>
<td></td>
</tr>
</tbody>
</table>

This method of probabilistic forecasting can yield, at best, an average number of people who will be required during future periods.


\(^{2}\)Ibid, p. 137.
The greater the number of bids included in this analysis, the greater the accuracy will be in estimating actual requirements. It is possible that a frequency distribution could be made of the results of these analyses and the standard deviations measured to arrive at a useful level of confidence.

The advantages of this method are fairly apparent. It is a very convenient method to use, just as in the sales per employee methods, because it merely involves fitting data to a predetermined formula. Secondly, it has time utility; a manpower forecast may be made in minimum time by application of the probability analysis. Although the emphasis has been upon its relation to outstanding proposals, this same technique could be applied to in-house business where \( P = 1 \) or 100% probability of capture. Another advantage is realism. When speaking of the future, the forecaster is actually speaking in terms of probabilities, not facts. This method takes this into account and expresses the forecast in terms of statistical probability.

A drawback, if not a disadvantage, of this technique is its sophistication. This is operations research type thinking and there are very few, if any, planners in the field who are qualified as operations research analysts or accustomed to thinking in operations research terms. A second disadvantage is that this method makes the formulation of qualitative manpower determinations almost impossible since the forecaster does not know which of the total quantity of men predicted are destined for jobs on which contracts. A third disadvantage is that this technique
is relatively difficult to sell to management because it is relatively difficult to understand. This is not to imply a general density on the part of executives; it simply means that a technique which embodies this degree of sophistication does not gain general acceptance because it is not readily grasped or employed. Finally, the initial subjective decisions regarding probability of getting the contract \( P \) and of manpower assignments \( M_1(t) \) and the timing of receipt of coverage \( t_1 \) require much experienced planner judgment and even then leave much latitude for error.

Other Methods

Several other methods of manpower forecasting were described by responding companies and deserve mention here. One firm reported using the sales per employee technique based upon the average number of employees for the year but modified it one step further. The sales figure was further analyzed to see when shipments of various items were to be accomplished. This was done on the theory that the sale is not necessarily incurred at the time the materials are delivered, yet the labor involved in creating the sale has already been utilized. Their formula, therefore, reads,

\[
\frac{\text{Total Shipments}}{\text{Average } D/L \times \text{Working Days}} = $ \text{per day per } D/L
\]

This technique, rather than being called sales per employee, could properly be termed shipments per employee.
Two firms reported techniques that leave much to be desired in the way of validity but will be mentioned here to give the reader an idea of the tremendous disparity of techniques utilized in the field. One of these companies attempts to set a manpower ceiling beyond which no more people will be hired. This is in an attempt to establish standard ratios of indirect to direct labor, salaried to hourly-paid employees, number of employees by department, etc. The second firm uses a facilities saturation approach on the theory that their facilities can accommodate just so many people and beyond that point they will stop hiring. In both these cases, manpower, not sales, seems to be the primary approach. One is prone to wonder what will happen if these companies obtain more sales than could be accommodated by the manpower under the present ceiling, in the former case, or by the present facilities in the latter situation. It is probable that the ceiling would have to be raised or the facilities expanded rather than allow the opportunity for additional profit to pass unheeded. As has been mentioned previously, the sales forecast must act as the springboard from which the manpower forecast is derived.

Another firm has reported the use of ogive curves developed from historical data and programmed into a computer to determine the final cost position, the expenditure in man-hours to date, and the estimated number of man-hours to be expanded. Ogive curves are extrapolations of trend lines based upon previous experience with the type of work in question but are factored down by the use of the learning curve. The
theory is that as the firm becomes more familiar with methods of performing the work, the trend line can be reduced by specific percentages each month to take into account added productivity per month. Thus the time interval for completion of the work is reduced and the length of time that people will be needed is reduced accordingly. In some cases the number of people, rather than the length of time in which they will be required, is reduced.

Finally, a variation on the estimate-to-complete method is reported which makes use of PERT (Program Evaluation Review Technique). This involves taking the entire program, as depicted on the PERT networks, and having the individual departments estimate requirements against each item in the networks. The requirements are then summarized by department, by contract item number, and then by program. When this is accomplished, the estimates are submitted to management and, if approved, become the basis for manpower requisitions.

CHAPTER VI

RESULTS OF THE MANPOWER FORECASTING METHODS SURVEY

The industry's response to the mailed questionnaire was excellent. Out of the first 323 questionnaires distributed, 108 responses were received. 102 of these were usable; the remainder of the respondents either declined to supply information or stated that it was unavailable.

On a size basis, with reference to numbers of employees, the respondents distributed themselves in this manner:

<table>
<thead>
<tr>
<th>No. of Employees</th>
<th>No. of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1,000</td>
<td>16</td>
</tr>
<tr>
<td>1,000 to 5,000</td>
<td>33</td>
</tr>
<tr>
<td>5,000 to 10,000</td>
<td>39</td>
</tr>
<tr>
<td>10,000 and over</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>102</td>
</tr>
</tbody>
</table>

1 The survey was undertaken in November and December 1962, and February, 1963. All data was tabulated by hand and the results were reviewed by another person to assure accuracy. Editing was done by the writer.
On the basis of sales volume, this grouping was made:

<table>
<thead>
<tr>
<th>Sales Volume</th>
<th>No. of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under $5,000,000</td>
<td>5</td>
</tr>
<tr>
<td>$5 million to $25 million</td>
<td>24</td>
</tr>
<tr>
<td>$25 million to $100 million</td>
<td>40</td>
</tr>
<tr>
<td>$100 million to $500 million</td>
<td>24</td>
</tr>
<tr>
<td>Over $500,000,000</td>
<td>6</td>
</tr>
<tr>
<td>Volume not given</td>
<td>3</td>
</tr>
</tbody>
</table>

According to the Aerospace Industries Association of America, there were only seven companies in the United States within which the net value of military prime contract awards exceeded $500,000,000 in fiscal year 1962.¹

Table 11 shows the various methods of manpower forecasting used by the different companies, segregated by employment size groups, and the number of times each particular method was cited as being in use. Probably one of the most striking observations that can be made concerning this study is that almost every company reported using two

### TABLE II

**NO. OF COMPANIES UTILIZING MANPOWER FORECASTING TECHNIQUES COMPARED BY NUMBER OF EMPLOYEES**

<table>
<thead>
<tr>
<th>Number of Employees</th>
<th>Sales Per Employee on Basis of Total Employees</th>
<th>Sales Per Employee on Basis of Avg. Employees Included</th>
<th>D/L % of Total Sales (w/G&amp;A Excluded)</th>
<th>D/L % of Total Sales (w/G&amp;A Excluded)</th>
<th>Estimate to Complete By Dept.</th>
<th>Doing Work</th>
<th>By Program Mgmt, Staff</th>
<th>Extrapolation of Trend Lines</th>
<th>History of Company</th>
<th>General Indicators</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1,000 (16)</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>12</td>
<td>8</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>1,000 to 5,000 (33)</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>22</td>
<td>18</td>
<td>15</td>
<td>21</td>
<td>14</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>5,000 to 10,000 (39)</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>9</td>
<td>25</td>
<td>21</td>
<td>17</td>
<td>7</td>
<td>16</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Over 10,000 (14)</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>7</td>
<td>11</td>
<td>8</td>
<td>11</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
or more manpower forecasting techniques. The techniques shown in Table 12 are in the same order as in the original questionnaire.

Another fact that emerged from the research was that most companies used different forecasting methods for varying forecast purposes. For instance, general military, political, and/or economic indicators were used with increasing frequency as the span of time covered by the forecast was increased, while the estimate-to-complete, used most frequently for short term forecasts, had a declining rate of recurrences as the length of time covered by the forecast increased. Table 12 illustrates how the types of forecasting techniques utilized varied according to the application of the forecast. It is interesting to note that while most companies made short term (one year or less), forecasts and intermediate term (eighteen month to three year), forecasts, the number making longer term forecasts drops considerably. Another salient observation is that the estimate-to-complete method, both by the department doing the work and by a program management staff, is utilized with far more frequency than any other forecasting method for any purpose. The only exceptions to this are extrapolations of trend lines for the purpose of long term forecasting and growth propagation and general military, political and/or economic indicators for the purpose of long term forecasting.

Table 13 is an indicator of forecasting accuracy among the firms included in the survey. These figures, however, must be accepted with caution--it is here that bias of the responders might enter the
### Table 12

**No. of Companies Utilizing Given Manpower Forecasting Techniques Expressed by Forecast Purpose**

<table>
<thead>
<tr>
<th></th>
<th>Short Term Est. (1-1/2 yrs.)</th>
<th>Intermediate Term Est. (1-3 yrs.)</th>
<th>Long Term Est. (13-16 yrs.)</th>
<th>Facilities Planning</th>
<th>Manpower Planning</th>
<th>Propagation Planning</th>
<th>Growth Planning</th>
<th>Departmental Planning</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales/Emp. Based on Total Employees</td>
<td>14</td>
<td>11</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td>13</td>
<td>7</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Sales/Emp. Based on Avg. Employees</td>
<td>12</td>
<td>17</td>
<td>18</td>
<td>20</td>
<td>11</td>
<td>14</td>
<td>13</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>D/L% of Total Sales w/G&amp;A Included</td>
<td>14</td>
<td>11</td>
<td>10</td>
<td>13</td>
<td>11</td>
<td>11</td>
<td>9</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>D/L% of Total Sales w/G&amp;A Excluded</td>
<td>22</td>
<td>13</td>
<td>9</td>
<td>12</td>
<td>14</td>
<td>15</td>
<td>5</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Est. to Comp. by Dept. Doing Work</td>
<td>60</td>
<td>38</td>
<td>21</td>
<td>28</td>
<td>43</td>
<td>36</td>
<td>14</td>
<td>41</td>
<td>5</td>
</tr>
<tr>
<td>Est. to Comp. by Prog. Mgmt. Staff</td>
<td>50</td>
<td>38</td>
<td>20</td>
<td>25</td>
<td>36</td>
<td>28</td>
<td>11</td>
<td>36</td>
<td>4</td>
</tr>
<tr>
<td>Extrapolation of Trend Lines</td>
<td>22</td>
<td>25</td>
<td>25</td>
<td>21</td>
<td>18</td>
<td>20</td>
<td>15</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>Past History of Company</td>
<td>31</td>
<td>21</td>
<td>17</td>
<td>18</td>
<td>12</td>
<td>12</td>
<td>7</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>General Military, Pol. and/or Econ. Indic.</td>
<td>20</td>
<td>24</td>
<td>31</td>
<td>15</td>
<td>10</td>
<td>14</td>
<td>11</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>252</strong></td>
<td><strong>202</strong></td>
<td><strong>162</strong></td>
<td><strong>169</strong></td>
<td><strong>174</strong></td>
<td><strong>168</strong></td>
<td><strong>94</strong></td>
<td><strong>169</strong></td>
<td><strong>30</strong></td>
</tr>
</tbody>
</table>
### TABLE 13

**FORECASTING ACCURACY***

<table>
<thead>
<tr>
<th>Number of Employees</th>
<th>95 to 100%</th>
<th>85 to 95%</th>
<th>75 to 85%</th>
<th>65 to 75%</th>
<th>50 to 65%</th>
<th>Less Than 50%</th>
<th>No Report</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Under 1,000</strong></td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>1,000 to 5,000</strong></td>
<td>1</td>
<td>17</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td><strong>5,000 to 10,000</strong></td>
<td>9</td>
<td>14</td>
<td>11</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Over 10,000</strong></td>
<td>3</td>
<td>9</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>15</td>
<td>43</td>
<td>24</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

*Since almost all responding companies cited more than one method of forecasting, it is not possible to draw conclusions as to the accuracy of any one method. The figures above, however, reveal the general degree of forecasting precision by size of company.*
statistics. A planner who reports low accuracy is admitting his own inefficiency, and it is suspected that there are some cases where the numbers were influenced by this conscious or subconscious consideration. Nevertheless, it is interesting to note that four firms reported less than 50% accuracy, two firms reported 50 to 65% accuracy, and four firms reported 65 to 75% accuracy. With a reliability factor this low, the forecasting function loses its usefulness to the company. It is suggested that 85% accuracy is minimal and that 95 to 100% should be the goal of any forecasting function. In some cases, however, due to the dynamic nature of the business, forecasting accuracy may be influenced by sudden changes in the sales picture occasioned by contract cancellations, sudden changes in scope of contracts, or unexpected contract awards. This can happen to even the most sophisticated forecasting group and does not necessarily demean the methodology employed.

A final pertinent point is that of the ten firms that did not respond to the request for degree of accuracy, five indicated that their manpower planning function was in its infancy and that not enough time had elapsed for them to evaluate their forecasting precision in the light of actual experience.

An attempt was made to correlate the size of the firm with the type of forecasting method utilized in order to see if the technique selected was influenced or dictated by the number of employees in the company. It was not possible to make this correlation. In all cases
<table>
<thead>
<tr>
<th>Number of Employees</th>
<th>95 to 100%</th>
<th>85 to 95%</th>
<th>75 to 85%</th>
<th>65 to 75%</th>
<th>50 to 65%</th>
<th>Less Than 50%</th>
<th>No Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1,000</td>
<td>13%</td>
<td>18%</td>
<td>44%</td>
<td>0</td>
<td>0</td>
<td>13%</td>
<td>13%</td>
</tr>
<tr>
<td>1,000 to 5,000</td>
<td>3%</td>
<td>52%</td>
<td>15%</td>
<td>6%</td>
<td>2%</td>
<td>0</td>
<td>21%</td>
</tr>
<tr>
<td>5,000 to 10,000</td>
<td>23%</td>
<td>36%</td>
<td>28%</td>
<td>5%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Over 10,000</td>
<td>21%</td>
<td>64%</td>
<td>7%</td>
<td>0</td>
<td>0</td>
<td>7%</td>
<td>0</td>
</tr>
</tbody>
</table>

*When the number of firms reporting various degrees of accuracy are analyzed by percentages, the above picture emerges.*
the estimate to complete (both by the departments doing the work and the program management staff), extrapolation of trend lines, and past history of the company were used by the majority of the firms in all categories, and like proportions of other methods such as sales per employee and direct labor percentage of total sales were employed on a less extensive scale. It can therefore reasonably be concluded that the size of the company is not a factor in determining the method of manpower forecasting utilized, although forecasting accuracy does improve as company size increases (Table 14).
CHAPTER VII

A SUGGESTED METHOD FOR QUANTITATIVE MANPOWER FORECASTING

There are many techniques for forecasting manpower requirements and it is likely that satisfactory results can be obtained with the use of any one of several of them. This is to say that the suggested method to be expounded in this chapter is not the only one that might be utilized. The technique to be explained here is simply one that should, if used with prudence and attention to detail, produce figures that will be consistently useful to the company. The technique will not be described in minute detail since the attempt here is to formulate a technique that will be universally applicable under many varying sets of circumstances.

The many techniques described in Chapter V can be briefly summarized into two categories: those that begin with the total sales picture and attempt to extract manpower requirements (e.g. the sales per employee methods) and those that start with individual elements of sales or product and build the total requirements from the bottom up (e.g. the estimate-to-complete method). In general it would appear that manpower requirements that are determined by the summation of
identifiable discrete quantities in an orderly and standardized procedure would be superior to those methods which are extractive in nature and within which many of the unusual cases or influencing variables tend to be discounted.

When formulating a forecast by identification of individual quantities and building from the bottom up, the input must be the responsibility of the departments doing the work. The items upon which the forecast is based are obtained from the sales forecast. Each item of sales--each contract and the individual items in the scope-of-work statement of each contract--must be analyzed and the following determination made:

1. A definition of all basic or significant tasks that must be performed within the allotted period of time.
2. The location of performance of each task.
3. The major contract operation of which each task is a part.
4. The sequence in which the tasks are to be accomplished.
5. The time required for each task (in terms of man/hours).
6. The type of labor required for each task.
7. The frequency with which each task is to be repeated (number of times the task will recur).

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1 Charles H. Granger, op. cit., page 373
8. Extension of the number of man/hours for each task
multiplied by the number of times (frequency) the task
must be performed in order to obtain the total number of
man/hours required for each task and the total task. This
will also provide the total number of man/hours required
from each type of labor.

Thus it can be seen that the estimation of need manpower is
implicitly dependent upon the result of two computations—tha that of the
number of times (or frequency) that the task will be repeated and that
of the amount of time required by each type of labor to perform each
task. The computation for the total number of men required for a
specific period of time is then performed in this manner:

A—Total number of men of a specific type of labor needed to
execute a certain task over a given period of time.

B—Time required to perform the task.

C—Frequency with which the task occurs in the given period of
time.

D—The number of hours obtainable from one man of the labor
type in question for the given period of time.

\[ A = \frac{BC}{D} \]

This computation must be performed for each task to be performed
by each type of labor. When the calculations are completed, the result
will be a definitized figure for the total number of men of each position.
type required and a summation of these totals to arrive at a total manpower requirement. This calculation will usually produce fractions which, of course, must be corrected to reflect whole men.

Brief mention was given in (2) above to the location of each task. This becomes meaningful if the work is to be performed in more than one place. If this is the case, manpower requirements must be computed in light of location as well as in terms of total requirements. It is quite possible that half of a man's time may be required at two locations simultaneously. In this instance, the formula would indicate that only one man was required. It is only through further analysis, by location, that the need for two men will become apparent.

The method outlined above is not applicable to all cases but covers most average or reasonable cases during a normal forecasting period. What is provided here is a number descriptive of the average workload per labor type. Certain other considerations may also assume importance for a particular forecast. For example, if there is interaction between various operators or products upon which work is being performed it may be necessary to have personnel on hand even though they are not working to capacity or are working only in short spurts. Also, this calculation of average manpower required may not cover periods of time when the workload hits a peak or a slump for a temporary period of time. Manpower for the peak periods will depend upon a minimum figure requirement which may be
higher, for that relatively short time period, than the average required for the entire time period of the task. These needs should be spotted in advance and the calculations made separately or else the average will be distorted.

The above procedure will work well for all personnel who are charged to the contract as direct labor. When the manpower forecast progresses to the area of indirect personnel, however, a different predictive technique must be employed.

Each company differs in the amount of indirect people employed in proportion to the number identifiable as direct labor. It is incumbent upon each practitioner in the field of future planning, therefore, to develop indirect-to-direct personnel ratios for each category of indirect labor in the company. This comparison, however, must be made on the basis of the number of indirect people in proportion to the number of direct people, not on the basis of the direct and indirect labor percentages of total sales. The latter is a dollar figure; what is needed in manpower forecasting is a head-count figure. By calculating the indirect personnel in this manner the disproportionate distortion caused by including general and administrative personnel in the indirect: direct ratio\(^1\) is automatically negated. Each category of indirect labor

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\(^1\)See Chapter V, Page 60.
is accorded its distinct ratio and the numbers and proportions of general and administrative personnel can readily be seen.

The manpower forecast must be built from the sales forecast as it describes each contract and (hopefully) each task item within each contract. It must be the responsibility of each operating department to prepare the forecast and manning table for each item of work it is to perform. These figures are assembled and coordinated by the central planning group where the summation is to be made. If there are indirect people within the operating departments they should be included in those forecasts, although delineated separately. Indirect personnel applicable to company-wide operations, though, should be added to the manpower forecast at the central planning group level. These would include such people as those in the personnel department, plant protection, maintenance, and the central planning group itself.

The role of the manpower planner in the process described here is generally that of guidance and surveillance rather than that of actually developing numbers. Those charged with the responsibility for developing the entire company manpower forecast do not become actively involved until the direct manpower numbers have been generated by the responsible departments and the indirect people must be factored into the total. They may contribute format and techniques and in other ways assist the operating departments in the development of figures but cannot and should not attempt to second guess those at the operating level. As Charles H. Granger has
(The headquarters planning function) coordinates the plans of the present operating units. It assures the use of compatible formats, the presentation of data on comparable basis, the presentation of key data for corporate consolidation purposes and that the data are presented on the appointed date. This is not really a planning function (in a decentralized company) because the planning is being done by the operating units.

The central planning group, though, must have some way in which to check the forecasts received from the operating departments. They must act as the "check and balance" for all other planning effort performed in the company. It would, however, be virtually impossible for these manpower planners to review each contract item to determine if manpower has been properly provisioned. They can examine form but not substance.

In order to gain confidence in the forecast, the responsible planners must apply a different test that can be accomplished at their level without reference to the operating departments. This can be done by utilizing a technique such as described earlier in this work as the "Sales Per Employee" method.

The agency responsible for the total manpower forecast should keep records of the equation between total sales for the year and the number of employees that were utilized in order to produce that many sales. Reduction of this equation will indicate the sales anticipated per employee. These records should produce a sales-per-employee figure that is relatively constant over a period of at least five years before it can be considered valid.

1 Charles H. Granger, op. cit., p. 374.
If the company is performing production work that is of a relatively stable nature throughout the year, the sales-per-employee figure can be computed on the basis of total employees required. If there will be peaks and valleys in the employment cycle better results would be obtained by computing the sales-per-employee figure on the basis of average employees.

The total forecasted sales are then divided by the sales-per-employee figure to determine either the total number of employees required or the average number required, depending upon which sales-per-employee technique is selected. This number is then compared with the number obtained from the summation of the operating departments' forecasts and the application of the indirect:direct ratio. (This latter figure will have to be divided by twelve if the method of sales-per-employee based upon average employees is utilized.) The two totals should closely approximate each other. If they do not, the manpower planner must look for special instances not applicable to the other years included in the sales-per-employee analysis, must re-investigate his figures, or must re-evaluate the input of the departments who made the forecast. If they do agree, though, then the manpower forecaster has established his double-check and can utilize the forecast with a high degree of confidence.

It should be noted here that the method advanced in this chapter can be quite time-consuming and hence distasteful to those adopting
its use. Its saving grace is the factor that makes it uniquely applicable to the aerospace industry or to any firm contracting or subcontracting for government business. Most requirements will have been calculated beforehand during the proposal effort and will be a matter of record. The sales forecast will simply tell the operating departments which proposals are likely to be received and which will probably be rejected. There will always be a certain number of sales which will be forecasted for contracts upon which work has already started. The effort for these contracts will consist of subtracting the man/hours already expended, by type of labor and by location where necessary, from the total number of man/hours required. The only new effort occasioned by the use of this method will be for those items that have not yet been proposed but which the sales forecast shows that there is an expectation of receipt and sale.

Probably the biggest advantage in the use of this method is that it identifies the manpower needed not only quantitatively but qualitatively as well. The original breakdown of man/hours by type of labor builds a qualitative requirement right into the structure of the methodology. The application of the indirect/direct ratio for each category of indirect labor in the company allows a qualitative assessment of indirect personnel requirements to be made simultaneously with the total numerical indirect personnel calculation.

The fact that this type of forecasting is oriented toward manpower
from start to finish also makes this an excellent method to use for the purpose of manpower forecasting. There is no need for any correlative factors as in the extrapolative methods or for the use of any formulae, except those used in the sales-per-employee method of checking the validity of the derived numbers.

In summary, the methodology to be employed in forecasting manpower is one that combines aspects of several techniques explained in Chapter V. Accuracy will best be obtained by building the forecast from the bottom up by use of a task-by-task analysis of each contract or statement of work presently in-house, proposed, or otherwise anticipated. Indirect labor should be added to this direct labor total through use of the indirect:direct ratio. When the final summation is made, the figures obtained can be verified by the manpower forecasting group or person by application of the sales-per-employee formula to the sales forecast.
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"100 Prime Contract Awards - Fiscal Year 1962), Memorandum from Ruth Frazier, Aerospace Industries Association of America, Inc., 610 Shoreham Bldg., Washington 5, D. C., Nov. 30, 1962, Table, 1, Pg. 1
I am currently enrolled at San Fernando Valley State College in the pursuit of a Master of Science Degree in Business Administration. My field of endeavor is Short and Long-Range Planning, with particular emphasis on manpower forecasting. The scarcity of published material indicates the need for research in this area, a project that can be undertaken only with the assistance of men currently engaged in this work.

Outlined below is the approach I have tentatively established.

Statement of the Problem
Hypothesis
Advantages and Disadvantages of Manpower Forecasting
Current Manpower Forecasting Methods
Analysis of the Existing Methods
The Test of the Hypothesis
Conclusions

The area in which I need your assistance is, "Current Manpower Forecasting Methods". I would greatly appreciate having you fill out the enclosed form and returning it to me in the self-addressed, stamped envelope. Please use the reverse side of the form for any additional information you deem pertinent.

Recognising that this study will be published, you may be unwilling to submit information you may consider proprietary. Please be assured that your name and your company name will be withheld—in fact, you need not sign the form. For my purposes, a general size and description of your company will suffice. The advantages implicit in this study, however, will obviously benefit the profession and your contribution coupled with others will be a valuable addition to the available information in this field.

If this information can better be supplied by someone else in your organization will you please forward this request to them?

In advance of your reply, I wish to sincerely thank you for your response.

Yours truly,

Martin Levy

Martin Levy
## APPENDIX B

### any □ or DIVISION □

<table>
<thead>
<tr>
<th>N. of Employees</th>
<th>% of Total</th>
<th>N. of Projects</th>
<th>% of Total</th>
<th>Prime</th>
<th>% of Total</th>
<th>Sub</th>
<th>% of Total</th>
<th>Other</th>
<th>% of Total</th>
</tr>
</thead>
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<tr>
<td>Under 5,000,000</td>
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<td></td>
<td>0%</td>
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<tr>
<td>5,000,000-25,000,000</td>
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<td>Over 500,000,000</td>
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<td>5%</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### POWER FORECASTING METHODS

Please assume that a forecast of anticipated sales is prepared and available for use. If you use any of the following methods, check the appropriate box. Indicate the method(s) you employ and the purpose of each.

- **A. DOLLAR VOLUME PER EMPLOYEE**
  - Computed on the basis of total employees required at the end of the year.
  - Number of employees per total sales.

- **B. LABOR % OF TOTAL SALES**
  - D/L = \( \text{D/L \times Annual D/L Wage Rate} \) / \( \text{Ratio of I:D/L} \)
  - With G&A people included in I:D/L ratio with G&A people factored in subsequently

- **MATE TO COMPLETE**
  - By Department doing work
  - By Program Mgmt. Staff

- **APPLICATION OF TREND LINES**
  - History of Company (Intuitive judgment)
  - General Military, Political and/or Economic Indicators: Share of R, Type of Effort, etc.

### NOTE ON SUBSEQUENT USE

- Use the following column:
  - Add and/or
  - Subsequent
  - Sierra
  - Intermediate Term Forecast (1 - 3 years)
  - Long Term Forecast (3 - 5 years)
  - Facilities Planning
  - Manpower Planning
  - Product Planning
  - Departmental Planning
  - Other (define)

### NOTE ON LITE LIGHT OF ACTUAL EXPERIENCE

- Your Forecasting Method(s)
  - Rate Proven in Past
  - 75 - 100% Acc. 95% - 99%
  - 75 - 95%
  - 65 - 75%
  - 50 - 65%
  - Less than 50%