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INSTRUMENTS FOR CORPORATE MANPOWER PLANNING

APPLICABILITY AND APPLICATIONS

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GEBOREN TE GEERTRUIDENBERG

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Voor mijn ouders
Voor Mariëtte

PREFACE

The title of this book is "instruments for corporate manpower planning, applicability and applications". Manpower planning, also called personnel planning, implies the analysis of possible discrepancies in the future between personnel demand and supply. Personnel demand will also be called personnel requirement and personnel supply is also called personnel availability. The notion "corporate manpower planning" refers to the planning of personnel on the level of an industrial or governmental organization and as such it does not stand for the manpower planning for branches of industries or the labour market studies of countries or international communities.

One type of manpower planning is the planning of the successions of managers on short term or the assignment planning of the positions to the induvidual employees for next year. In fact, this type of short term manpower planning is always executed, whether formally or informally, centrally or otherwise. Another type of manpower planning, however, may be executed in order to match the requirement for and availability of personnel on medium and long term. This type of manpower planning considers groups of employees rather than individuals. Our goal is to consider the medium and long term manpower planning for groups of employees. We call this the multi-category approach to manpower planning. In our view, this medium and long term personnel planning provides the conditions for the individual manpower planning or for personnel development.

The above-mentioned discrepancies between manpower requirement and availability are, for instance, a shortage of highly qualified personnel, a surplus of employees in lower grades and so on. Such possible discrepancies can be forecasted by the estimation of the future requirement for and availability of personnel. Then, one may assess the impact of alternative policies, e.g. changes in the degree of automation, recruitment of different numbers or types of personnel, changes in career opportunities, etc., on the evolution of manpower requirement and availability. Alternative policies may lead to management decisions. Since employees often stay with an organization for a long time, management decisions concerning manpower produce a long term impact on it. Moreover, some time may pass before the decisions with

respect to the personnel become effective. If, for instance, the organization needs employees with much experience, then it has to recruit them many years in advance. However, the decisions with respect to the manpower flows, such as changes in recruitment, increase or decrease of the average time until promotion, do not have consequences only for the organization, but also for the employees. In our view, medium and long term manpower planning is important to dissolve discrepancies between manpower requirement and availability, but the impact of alternative policies on the interests of the employees has also to be considered.

In this book we will consider instruments for medium and long term corporate manpower planning and, in particular, instruments which demonstrate the impact of managerial policies on the evolution of the manpower requirement and availability. Such instruments are needed in order to forecast the quantitative and qualitative manpower requirement and availability. Also, they must offer the possibility of considering the impact of alternative policies on demand and supply of personnel, career opportunities, salary costs, etc.. Management needs a decision support system which facilitates the application of such instruments. Again, these instruments must offer the opportunity to analyse possible discrepancies with respect to manpower and to evaluate the impact of alternative policies. To this effect, we developed the manpower planning system FORMASY which will also be described in this book. By application of FORMASY in some large Dutch organizations, much insight in the applicability of manpower planning instruments has already been gained.

We will now describe our view of manpower planning. Firstly, one has to estimate both future manpower requirement and future manpower availability. In the following matching process, these forecasts are compared and analysed for possible discrepancies. In this phase, the impact of alternative policies on the manpower requirement and availability forecasts must be assessed in order to solve the discrepancies. The instruments to execute this manpower planning process are the subject of this book. The chapters correspond with the different phases of our manpower planning approach. Each chapter begins with an introductory section describing the contents of the chapter.

In chapter 1 we introduce medium and long term corporate manpower planning, the importance of this type of personnel planning is discussed and the different manpower planning activities which are part of it. Besides, we consider the type of organization and the type of personnel for which these manpower planning activities are important. We will also discuss why groups of employees are considered and not the individual employees. In this chapter we also explain in some more detail the goals and restrictions imposed on this book.

In the second chapter we investigate manpower requirement forecasting. Statistical and subjective methods are described. Moreover, an analysis is given of the way some Dutch organizations try to forecast their manpower requirement. Finally, we will present an outline of a manpower requirement forecasting procedure.

Chapter three is devoted to some mathematical models for manpower availability forecasting as found in literature (see e.g. Bartholomew [3], Bartholomew /Forbes [6] , Grinold/Marshall[40]). It has been shown that instruments based upon such models can be used to describe the evolution of the personnel size, to analyse career prospects and so on. However, these methods are not extensively used or, in any case, not many reports concerning applications do exist.

In chapter four we introduce our manpower planning system, called FORMASY, which is based upon Markov models. This manpower planning instrument is an approach to manpower availability forecasting and the matching process, in which an interactive computer program system is used. FORMASY can be used by members of a personnel or planning department. The fact that FORMASY can be used by the experts on manpower planning adds to the applicability of this system.

In chapter five we consider the use of FORMASY for the matching of manpower requirement and availability. We will explain how it can be used for the evaluation of alternative policies concerning recruitment, career opportunities, etc. with respect to their impact on the evolution of manpower availability.
We also discuss the level of aggregation (the categories of personnel) which can be chosen and the length of the planning horizon which is useful. Moreover, some remarks on the requirements of the introduction of such manpower planning systems for the registration of personnel

and for the organization of the personnel department are considered.

In the sixth chapter we illustrate the applicability of FORMASY by the presentation of a case-study within a large Dutch organization.

Finally, in the appendix we will give part of the processing list of an application of FORMASY on a general purpose computer.

CONTENTS

CHAPTER 1

CORPORATE MANPOWER PLANNING

1.1. Introduction

Corporate manpower planning is the planning of personnel for large or-
ganizations such as industrial firms, public services, hospitals, etc.
Manpower planning is the process of forecasting manpower requirement,
forecasting manpower availability and the matching of manpower require-
ment and availability. Instruments based on mathematical models can be
useful for this forecasting as well as for the analysis of discrepan-
cies between personnel demand and supply.

Mathematical models for manpower planning have been used first to fore-
cast the evolution of the personnel distribution (Seal [71], Vajda[79]).
The personnel distribution indicates the number of employees on diffe-
rent levels of the organization corresponding to grade, rank, salary,
etc. Computer-aided systems, based on mathematical models, have been
developed to describe this evolution. Many publications on this sub-
ject appeared in the seventies (see, for instance, Bartholomew/Forbes
[6] , Bryant/Niehaus [20], Grinold/Marshall [40]). The publications
mainly considered the mathematical aspects of manpower planning instru-
ments.

In this chapter we will explain our view on medium term and long term
corporate manpower planning. In section 1.2 some interpretations of
the notion "corporate manpower planning" are discussed. In section 1.3
the importance of medium and long term personnel planning for large
organizations is considered. The relation of manpower planning with
financial planning and with the planning of other resources is described
in section 1.4. In that section we will also discuss specific manpower
planning activities: career planning, recruitment planning, training
and development planning and allocation planning. In section 1.5 we
explain the importance of the manpower planning approach in which
groups or categories of employees are considered, whereas in approaches
like personnel development the careers of individuals are considered.
In section 1.6 we provide a rough typology of organizations for manpo-
wer planning, which indicates the importance of different manpower plan-

ning activities depending on the type of organization and the type of personnel. Finally, in section 1.7 we explain the goals and restrictions of this book in some more detail.

Our view on manpower planning has proceeded from our research in Dutch organizations. Of course, social and legal circumstances influence the goals and restrictions of manpower planning. Examples of such circumstances are labour laws, the impossibility of involuntary dismissal or transfer of employees, equal employment opportunities and so on. We believe, however, that the instruments described in this book are also suitable in other countries.

1.2. Interpretations of corporate manpower planning

1.2.1. *Introduction*

In this section we introduce some views on (corporate) manpower planning as found in previous publications. In most interpretations only the interests of the organization are considered, namely the matching of personnel supply and demand. In subsection 1.2.2 we give some of these definitions of manpower planning. Only a few interpretations consider – besides the interests of the organization – the interests of the employees. These interests may be the ambition to do a specific type of work, to earn a certain salary, etc. Such an interpretation of the tasks of manpower planning is presented in subsection 1.2.3. In subsection 1.2.4 we will compare the definitions of manpower planning in some detail. Our own view of manpower planning is given in subsection 1.2.5.

1.2.2. *Interpretations considering only organization interests*

In the view of Vajda [81]"manpower planning is concerned with arranging for the necessary number of suitable people to be allocated to various jobs, usually in a hierarchical structure".

An analogous interpretation has been proposed by Geisler [34]. He states that manpower planning is the process by which a firm ensures the availability of the right number of people and the right kind of people, at the right place and the right time, doing things for which they are economically most useful. This process does not only include –

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forecasting and controlling but also the development implementation of instruments in order to provide top-management with the necessary information.

Bowey [17] considers manpower planning as "a strategy for matching future manpower numbers and skills with organizational activities".

Küching [52] regards manpower planning as the set of activities to be executed by the company in order to make available the necessary number of personnel with respect to the profitability or the cost-minimizing principle.

Casson [22] mentions two kinds of activities under the heading "manpower planning":

- firstly, a regular monitoring activity, through which manpower and the relationship of manpower to the business can be better understood, assessed and controlled, problems can be highlighted and a base can be established from which one can respond to unforeseen events;
- secondly, an investigative activity, by which the manpower implications of particular problems and changing situations - e.g. the restructuring of the business - can be explored and the effects of alternative policies and actions can be investigated.

1.2.3. *An interpretation considering the interests of employees as well*

We will consider in this subsection an interpretation of the tasks of manpower planning that pay attention to the interests and ambitions of the individual employees.

Wächter [88] points out that manpower planning is only useful if the employees can take part in the process of goal-setting.

Based upon this consideration the following formulation of the tasks of manpower planning has been developed by Gohl/Opelland [36] (cf. Schmidt [70]): "manpower planning is an integrated part of corporate planning in order to keep available a necessary number of employees with qualifications and dispositions - well fitting to the work tasks - under the assumption of an equivalent handling of the corporate goal to achieve an economic design of work and realization of individual goals".

1.2.4. *Discussion*

In our opinion, the realization of individual interests should be
an essential consideration for manpower planning. Such individual
interests may concern the salary level, career opportunities, work
circumstances, protection from dismissal or involuntary transfer and
so on. If one - while doing manpower planning - does not consider
whether such goals can be achieved, now or in the future, this
may have negative consequences both for the organization and for the
individual employees. A consequence for the organization may be
that the best employees leave the organization or that the performance
of the employees deteriorates. The consequence for the employees may
be that their goals are not achieved. Of course, such considerations
apply in a different degree for different countries or organizations.
In some countries, for instance in the Netherlands, the commitment
of many organizations towards their personnel is high, which means
that protection from dismissal exists and also good career opportunities,
good work circumstances, etc. This is partly in contrast to the United
States, where people can be fired on short notice in many organizations.

We will discuss the commitment of organizations towards their person-
nel in some more detail in section 1.6. Here we want to emphasize the
necessity of considering individual prospects and interests when
developing manpower policies. Therefore, in our opinion, the definitions
of manpower planning given in subsection 1.2.2 are insufficient. We
are in sympathy with the interpretation of subsection 1.2.3 which in-
corporates the individual interests in manpower planning.
Notice, moreover, the correspondence between the interpretations of
subsection 1.2.2, except the one of Casson. These definitions emphasize
the search for manpower policies such that the organization's demand
for personnel (qualitatively and quantitatively) will be answered.
So, these interpretations emphasize the organization interests but do
not discern the importance of including individual expectations and
interests. Casson describes the activities belonging to manpower plan-
ning, particularly, a regular monitoring activity and an investigative
activity for particular problems. His interpretation stresses the im-
portance of the development of manpower policies and, implicitly, of
the development of instruments for the analysis of manpower policies.
In fact, this is a start to consider the individual interests.

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1.2.5. *Our own view on manpower planning*

In our view, manpower planning is a set of activities in order to keep available the necessary numbers of employees with the necessary qualifications in order to realize the organization's goals while taking into consideration the interests of the individual employees.

This definition of manpower planning is in fact a reformulation of the interpretation of Gohl and Opelland (subsection 1.2.3).

Consider our definition somewhat further. The necessary qualifications indicate the required abilities of the employees such that they can perform the different tasks within the organization. Such abilities may be expressed, for instance, in the training, experience or age of the employee. We will discuss the characteristics of employees which are important for manpower planning somwewhat further in subsection 3.3.1.

The implication of this definition of manpower planning is that several manpower planning activities have to be executed, which may have a regular monitoring nature or an investigative nature (cf. Casson, subsection 1.2.2). These manpower planning activities (career planning, recruitment planning, training and development planning and allocation planning) will be described in subsection 1.4.4.

This definition brings us to the distinction of the following phases in the manpower planning process:
- the forecasting of manpower requirement (both qualitatively and quantitatively)
- the forecasting of manpower availability (both qualitatively and quantitatively)
- the matching of manpower requirement and availability.

The distinction - which will be sustained throughout the book - follows particularly from the importance of the consideration of the organization's commitment to its personnel. The distinction enables the organization to analyse possible discrepancies between manpower requirement and availability forecasts and to develop alternative manpower policies. Thus, both the organization's interests and the goals and interests of the employees can be considered.

If one interprets the word "planning" in a narrow sense, then only the third phase would deserve the name "manpower planning". However, we

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will use the notion "manpower planning" in a broader sense and include both forecasting and matching of personnel requirement and availability.

We will restrict ourselves to medium and long term manpower planning. In this book we will interpret the time indications short, medium and long in the following sense: in short term planning one considers a horizon of less than one year, in medium term planning one considers roughly one to ten years ahead and in long term planning more than ten years ahead are considered.

1.3. Importance of manpower planning

1.3.1. *Introduction*

In this section we will describe some circumstances which emphasize the importance of medium and long term manpower planning.

Let us discuss first a very simple case. Consider an organization in which the manpower requirement will remain constant over a very long time (both qualitatively and quantitatively). Moreover, the manpower availability has been constant over a very long time. We will call such an organization a stable organization. In that case, medium and long term manpower planning for groups of personnel (multi-category manpower planning) is not necessary since the matching of manpower requirement and availability can be executed easily. In fact, the only manpower planning activities to be considered are the allocation of jobs to the individual employees, personnel development in as far as the succession of management is concerned and possibly job rotation for staff functions. However, these subjects fall out of the scope of this book.

Consider, on the other hand, an unstable organization in which, for instance, the manpower requirement is strongly varying. In that case, there will not automatically exist a match of manpower requirement and availability. Thus, future manpower requirement and availability has to be estimated and policies must be analysed in order to prevent possible discrepancies.

Usually, the ideal situation of stability does not occur, which implies that always some medium and long term manpower planning activi-

ties are needed. In subsection 1.3.2 we will discuss some circumstances which call for manpower planning.

1.3.2. *Circumstances which call for manpower planning*

1. Decreasing growth of organizations

Some organizations have known several years of growth, which led to the engagement of many - usually young - recruits in this period. These recruits could be offered a decent career since the growth led to a sufficient number of functions on a higher organizational level. Of course, this does not imply that all recruits would reach the highest organizational level (expressed, for instance, by salary, responsibility or required qualifications), but the probability of achieving a high position for people with high potentials has increased compared with the situation of no growth or even decreasing size. If such an organization is not growing any longer, then the average career prospects - in the sense of the positions which can be attained and the time in which this may happen - will diminish, at least if the wastage fractions remain constant. Wastage refers to the employees who leave the organization because of retirement, dismissal, death, etc.

Fig. 1.1 illustrates the above-mentioned effect by showing an example of the age distribution of employees in the actual situation after several years of growth (a), then the forecasted age distribution, about ten years later, if the growth would continue (b) and if the growth would stop (c). Recruitment occurs in the younger age groups and the retirement age is 65.
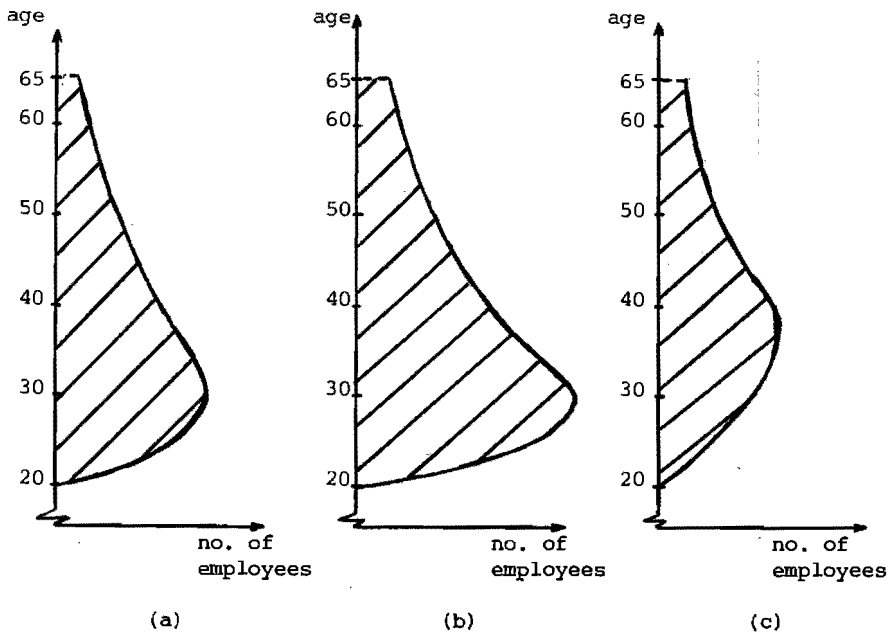
Figure 1.1. Actual age distribution after several years of growth (a);
the forecasted distribution about ten years later if the
growth continues (b); the forecasted age distributions
about ten years later if the growth stops (c).
It is assumed that the retirement age is 65 and recruit-
ment occurs in the younger age groups.

Figure 1.1. (c) shows how the age distribution will be disturbed if
growth of an organization suddenly   stops. Since recruitment will
decrease, the fraction of experienced employees will increase which
– paradoxically – may not be a desirable development (for instance,
for a research lab requiring many young engineers). The worse
career prospects may imply that employees cannot be promoted, though
they are qualified. So there are unequal opportunities for the em-
ployees who entered the organization at different times. These

effects affect the individual employees. However, worse
career prospects will also affect the organization, since some
employees may become frustrated, the better people may leave, dif-
ferent requirements arise for training and for the type of people
which is recruited, the qualitative structure of the organization
(i.e., the employees with their experience, training, etc.) may
change in an undesirable direction, etc. Moreover, some organiza-
tions have a high commitment with respect to their personnel, as
is the case for some Dutch public services, where sudden changes
of career opportunities are not allowed. Examples of the effects
of decreasing growth are given in section 5.3 and in Van der Beek/
Verhoeven/Wessels [11].

Another example of decreasing growth of an organization is encoun-
tered if an organization plans to transfer its activities to a dif-
ferent location. This may not cause a problem if the geographical
mobility of the employees is high. In the opposite case, however,
the matching becomes difficult: overstaffing may occur in the old
location and understaffing in the new location. Moreover, if the
employees who will not be transferred are highly qualified (expe-
rienced), then there will also be development and training problems
in the new location.

2. Irregular age structure

In some organizations the actual age distribution of the employees
is irregular because of manpower policies in the past. Such an ir-
regular age distribution may occur if the total organization size
has been changing much in the past and if recruitments take place
in only a few age classes (as is the case with many organizations,
for instance with defense organizations and police forces). If an
organization has had a period of growth followed by several years
of roughly constant size and has grown again recently, this may
have resulted in an age distribution with relatively many older
employees and many younger employees and only a relatively small
number of employees in the intermediate age groups (see fig. 1.2).
Examples of irregular age distributions are given in section 6.4,
Van Meeteren [57], Verhoeven [83].

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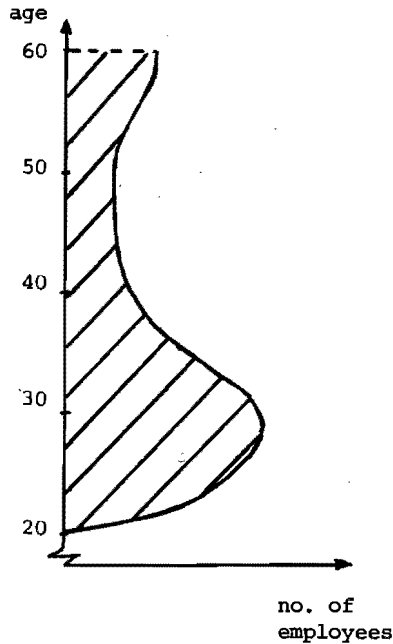
Figure 1.2. Actual age distribution for an organization after several
years of growth, followed by several years of about con-
stant size and again several years of growth. Recruitment
occurs in only a few (young) age classes.

Particularly in organizations with recruitment only in the lower age
classes, the age of an employee can be seen as an indication for his
qualification or experience (e.g. in the police forces). An irregu-
lar age distribution as in fig. 1.2 then implies that:

a the distribution of the qualifications of the employees is irre-
   gular;

b the numbers of recruits in the future will vary heavily.

ad a. Fig. 1.2 shows that in the actual situation many employees are
highly qualified and many employees do have little experience, where-
as only a few people belong to the intermediate class. In the near

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future, many employees will retire, which means that a shortage of
highly qualified personnel will arise. If recruitment only takes
place in the young age classes, then the career prospects of the
employees should correspond with age. This may lead to difficulties
if the situation of fig. 1.2 occurs. On one hand, the employees in
the intermediate classes have good career prospects. These employ-
ees may be promoted because of many retirements, though these em-
ployees may not have already the required qualifications. On the
other hand, the younger employees have only poor career prospects,
at least, if the total number of employees remains constant from
now on.

ad b. The high number of retirements in subsequent years will lead
to the recruitment of many young people if the number of employees
remains constant. Then, after several years, the recruitments will
decrease if the retirements decrease. If this process continues,
there will – for an extremely long time – remain an irregular age
distribution, since the wave in the age distribution propagates it-
self in the manpower system.
In a situation of an irregular age distribution, where age is rela-
ted so closely to the qualifications of the employees, one has to
forecast future manpower requirement as well as availability, both
qualitatively and quantitatively. Alternative policies have to be
developed in order to obtain a better age distribution, for instance
by recruitment in different age groups, flexible retirement ages,
training and development together with changes in career prospects
for the lower level employees, etc.
Investigations of the age distribution also help in studying the
impact of previous recruitment policies.

3. Salary structures

The salary costs for the organization depend heavily on the evolu-
tion of the personnel distribution, particularly on the number of
employees in the different grades and ranks, but they may also de-
pend on the evolution of the age distribution. Medium and long term
forecasts of the salary costs are useful in the case of an irregu-
lar age distribution or an irregular distribution of any other
salary-determining factor. We will consider here the impact of an

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irregular age distribution on the medium and long term salary costs.
If the actual age distribution is characterized by many young employ-
ees and a relatively small number of elder people (see fig. 1.3.(a))
and if the organization will be of constant size in the future, the
age distribution - several years later - may have the shape of fig.
1.3.(b).
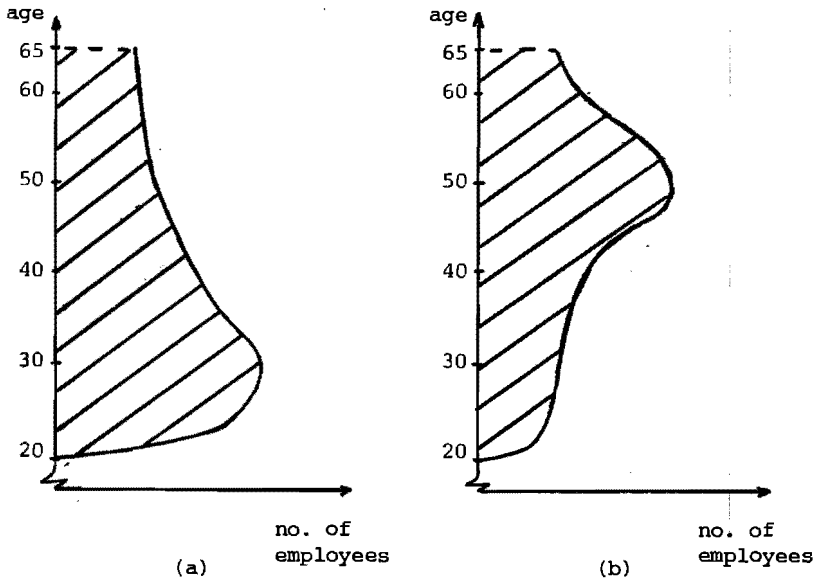
Figure 1.3. Actual age distribution (a) and the forecasted age distri-
bution after about 20 years if the organization remains at
about constant size (b).

In the case of fig. 1.3.(a) the salary costs will be relatively low,
since most employees are in the younger age groups, compared to the
situation of fig. 1.3.(b) which will result about twenty years later.
Because of the relevance of this uncontrollable evolution for the
financial planning, it is important to estimate future manpower
availability such that future salary costs can be determined.

Medium and long term manpower planning is particularly important
for the financial planning of labour-intensive organizations, such
as public services, banks and insurance companies.

The forecasting of salary costs will be discussed in some more detail in subsection 4.4.5. An example is given in Verhoeven/Wessels/Wijngaard [86].

4. Increasing complexity of organizations

Organizations have become more complex in time. The importance of planning in large and complex organizations has been described by, for instance, Koontz/O'Donnell [51]. Manpower planning, in particular, becomes also more important. In some cases, the contents of the personnel tasks has changed (specialization), in others the number of hierarchical levels has been increased, technology has become more complex, etc. The increasing complexity of organizations leads to the employment of differently skilled and trained personnel.

On the other hand, functional and geographical mobility of employees is often low. Therefore, the qualitative as well as the quantitative requirement and availability of personnel have to be estimated in order to determine necessary recruitment, development and training, reformulation of tasks, etc.

Top-management of large and complex organizations is interested in roughly controlling the manpower distribution and manpower policies, since one is not able to influence the manpower distribution or policies in a very detailed way. As has been mentioned in section 1.1, the manpower distribution indicates the numbers of employees at the different levels of the organization (corresponding to salary, grade, age, etc.). Manpower policies are particularly useful here with respect to recruitment and training, but also with respect to the career opportunities in order to avoid unequal career prospects for the employees in different locations and/or divisions of the organization. Avoiding unequal career prospects is important, among other reasons, since it helps to ensure that the abilities of the employees are used in the best way and will be used so in the future. On a lower level of the organization, management will be interested more in the impact of the manpower policies for their part of the organization (a more detailed approach).

5. Length of the feedback cycle of manpower policies

Another reason for the importance of medium and long term manpower planning is the length of the feedback cycle of manpower policies. If one notices, for instance, a lack of experienced employees in the organization, this cannot always be remedied on a short term. In the case of a shortage of experienced employees one may hire people from other organizations who do have the required experience, but the hiring and working-in of these people may take e.g. about two years. Another possibility to remedy the discrepancy would be the development and training of employees, (see Barber [2]), but this may take e.g. about five until ten years. This example illustrates the importance of monitoring the evolution of manpower requirement and availability (both qualitatively and quantitatively) and the signaling and analysing of possible discrepancies in time.

6. The manpower decision making process

Decisions with respect to manpower policies have a great impact on the organization and on the individual employees. Therefore, in large and complex organizations, such impacts have to be studied in detail. Moreover, many deliberations on various levels of the organization will precede a decision (see e.g. Likert [55]). Deliberations within top-management, middle-management, works council, etc. increase the demand for information about the consequences of alternative manpower policies on the career opportunities of the personnel, necessary capacity of training institutions, finance and so on. This information can be obtained by forecasting the requirement and availability of personnel, both qualitatively and quantitatively. Then, possible discrepancies have to be determined and alternative policies have to be designed in order to solve these discrepancies. Examples of manpower forecasting and the design of alternative policies are given in Verhoeven/Wessels/Wijngaard [86] and in chapter 5. The importance of making carefully considered decisions and the long time required for deliberations, imply the necessity of taking relatively long views.

1.4. Manpower planning and its relations with corporate planning

1.4.1. *Introduction*

In this section we will consider the relations between manpower planning and the planning of other organization's resources and we will describe the manpower planning process itself in some more detail.

In subsection 1.4.2 the relations between manpower planning and organizational planning are described. In subsection 1.4.3 we consider the factors which bear influence on manpower requirement and availability. In subsection 1.4.4 and 1.4.5 we describe the manpower planning process itself and, particularly, the manpower planning activities which can be executed for the matching: career planning, recruitment planning, training and development planning and allocation planning. In subsection 1.4.4 these activities are explained whereas in subsection 1.4.5 their nature is discussed in some more detail.

1.4.2. *Manpower planning and organizational planning*

The goal of organizational or corporate planning is the matching of required and available resources (finance, raw materials, equipment and personnel). This resource planning covers the following aspects: the determination of necessary requirements, plans for the acquisition or generation (supply) and, finally, the allocation of the resources (cf. Ackoff [1]). If the level of one of the resources changes, this has consequences for the level of the other resources. Therefore, for the planning of each of the resources one needs information about the other resources (fig. 1.4).
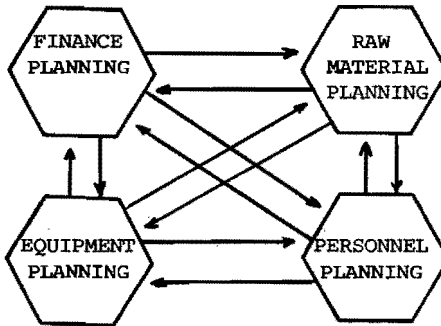
Figure 1.4. Information flows for the planning of the organization's resources.

The purchase of equipment in the form of new types of machines, for instance, enables the processing of more raw materials, but it has also financial consequences and may lead to the requirement of different numbers and types of personnel. If, in the past, people with certain qualifications were needed and were recruited, then this may give restrictions on the investment in equipment and it also has financial consequences. Similar considerations hold for the impact of changes in career policies, training and development programs and allocation patterns on the organization's resources and conversely. Notice, however, that the importance of such impacts depends on the type of organization: for process industries, the consequences for the planning of raw materials will be important whereas these resources do not exist for banks, etc.

1.4.3. *Factors which bear influence on manpower requirement and availability*

Particularly the manpower requirement depends on the levels of other resources. The organization plan provides future organization's activities in the sense of levels and types of production or services. Moreover, this plan indicates (or can be translated into) the necessary numbers and types of resources to execute these activities. Thus, also the relationship of manpower requirement (qualitatively and quantitatively) with the levels of other resources is included in this plan. But, as we mentioned in subsection 1.4.2, the level of every resource depends on the level of any of the other resources. Therefore, when laying an organization plan, there has to be feedback with respect to all resources. The starting-point for the organization plan, which is therefore the basis for the manpower requirement, is the forecasted demand for the products or services of the organization which in turn depends on the market share, the economic situation, etc. One further variable influencing the manpower demand is the innovation with respect to products or services and with respect to the way of production (e.g. automation). Notice that some variables cannot be controlled by the organization, such as the economic situation, whereas others can be (partly) influenced such as the market share, the level of automation and the market on which the organization operates. We will define external variables as those variables which are out of control of the organization.

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The manpower availability in subsequent years depends on the actual manpower distribution, the existing manpower policies (concerning careers, training, etc.), which may be explicitly formulated or which may exist implicitly. Furthermore, it depends on external variables such as the situation on the labour market, the attitude of trade-unions, social influences and so on. The values of these variables determine the evolution of the internal manpower availability, i.e. the numbers and qualifications of available employees within the organization.

Fig. 1.5 expresses the influences of the various variables on the manpower availability and requirement.
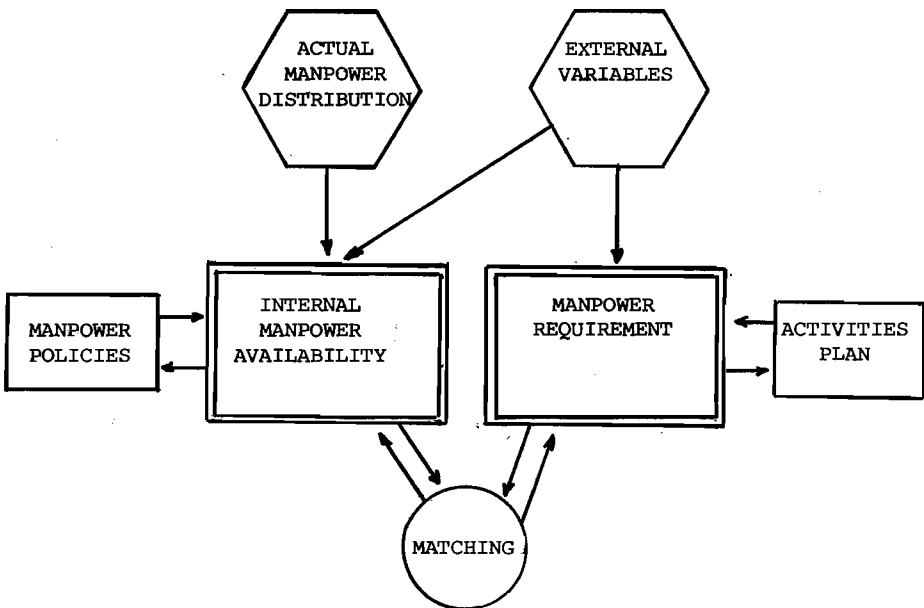
Figure 1.5. Influences of the various variables on the manpower availability and the manpower requirement and the feedbacks.

The activities plan indicates the future production level or amount of services to be delivered by the organization. This plan thus incorporates the necessary levels and types of the resources finance, raw materials and equipment.

The manpower planning process, now, is the forecasting of manpower requirement and availability as well as the development of alternative policies in order to dissolve remaining discrepancies. This may imply changes in manpower requirement, in manpower availability, or in both. In subsection 1.4.4 we will consider manpower planning activities which can help to obtain a match of manpower requirement and availability.

1.4.4. *Manpower planning activities*

Consider the above-mentioned discrepancies between manpower supply and demand somewhat further here. In principle, a match of manpower requirement and availability can be obtained by adapting the requirement or by adapting the availability, but also by adapting both. Whether manpower requirement will be adapted primarily, or manpower availability, depends on the type of organization. In a capital-intensive industry, such as process-industry, the manpower requirement will be less adaptable than e.g. in labour-intensive organizations such as public services.

The matching process results in a manpower plan which contains a career plan, a recruitment plan, a development and training plan and an allocation plan. We will call manpower planning activities the development of such plans and also the development of alternative policies resulting in adaptations of these plans.

So, we distinguish the following manpower planning activities:

A   career planning;
B   recruitment planning;
C   development and training planning;
D   allocation planning.

ad A. Career planning.

Career planning is the development of career policies. The goal of these policies is to have available for the organization at the right time the rightly qualified employees, while the employees have the opportunity to perform the tasks which correspond best with their abilities and expectations. It should be remarked here that we will consider career planning for groups of employees and not for individual employees.

The career of a group of employees can be expressed by several measures, such as the average time until promotion, the fraction of employ-

ees that is promoted, etc. The combination of function level and func-
tion seniority is often a good measure for the experience of employees.
Here, function seniority (or grade seniority) is defined as the number
of years which is spent on a certain function level (or grade, rank,
etc.) Engineers, for instance, with a high function seniority on
a high function level, will be better qualified – on the average – than
recently graduated engineers. Since there may be many differences
between employees with the same function seniority - with respect to
qualification or experience -, such measures for the experience
are only valid for groups of employees (average numbers) and not for
individuals.

In some organizations explicitly formulated career plans exist, e.g.
in a defense organization where the percentage of employees which will
be promoted is given for every grade seniority (see fig. 1.6; in
chapter 6 we will consider the role of manpower planning for such an
organization in more detail).

→ grade seniority

1	2	3	4	5	6	7	8	9	10	11	≥12
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

percentages: 0   0   0   0   0   0   0   35   56   65   0   0
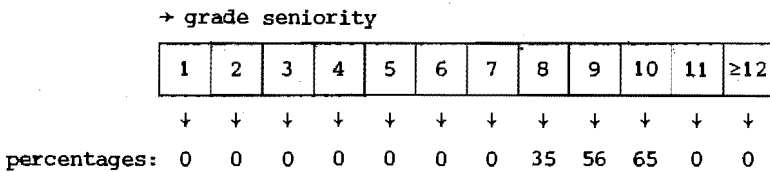
Figure 1.6. Example of a part of a career scheme, indicating the pro-
            motion percentages for every grade seniority (in years),
            concerning promotion opportunities from the grade "major"
            to the grade "lieutenant colonel" in a defense organiza-
            tion. Thus, for instance, 56 percent of the employees who
            have now grade seniority 9 will be promoted in this year.

In other organizations less strictly formalized career schemes exist,
while in some organizations the career policies are not formulated at
all. In a central research laboratory of a large industry, for instance,
the promotion possibilities are not formulated explicitly in terms of
grade seniority. However, one feels that the recruited young engineers
should be offered the opportunity to continue their career in a manu-
facturing division after a number of years in the research laboratory.
By the career policies for these engineers one tries to achieve this

goal, but these policies are not explicitly formulated. We will illustrate this example in some more detail in subsection 5.3.2.

As has been said, we are interested in career planning for groups of employees, however, the overall planning career prospects may have consequences for the induvidual employee . If the average time until promotion from a given function level to the next higher level is lengthened, this may imply that all employees would have to spend more time on the function level, but it may also imply that the better employees would be promoted according to the historical career prospects, whereas some employees may not be promoted at all. One goal of career planning is to make such choices. This example illustrates that career planning for groups of employees provides the conditions for personnel development which, in fact, arranges the functions the individual emplpyee will occupy in the future.

ad B. Recruitment planning.

Recruitment planning is the development of recruitment policies. The goal of these policies is to obtain a reasonable filling of vacancies (both qualitatively and quantitatively) on medium and long term.

Recruitment policies can be expressed in the numbers of employees to be recruited of relevant types. The type of personnel indicates – for instance – the qualifications (experience), training or ages of the employees.

Some circumstances which can make recruitment planning important, are the situation on the labour market (overemployment), restricted absorption capacity of the organization and the restricted possibility of involuntary dismissal of employees (which is the case in most West European countries).

Notice that there exists a link of recruitment planning and career planning. In the case of vacancies one may also decide to recruit (promote) employees from a lower level in the organization, which is sometimes called internal recruitment. Such policies have, of course, a great impact on the career opportunities of both the lower level and the higher level employees. Similar considerations hold for the relation of recruitment planning and training and development planning as well as allocation planning. We will discuss these relations in some more detail in chapter 5.

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ad C. Development and training planning.

Development and training planning is the design of policies in order
to prepare the employees for the positions they will occupy in the or-
ganization on medium and long term.

Development and training policies can be expressed in the number and
types of employees who should have the opportunity for additional trai-
ning and in the required scope of this training. These policies in par-
ticular emphasize the importance of the matching of the qualitative
manpower requirement and availability. Development and training are im-
portant, for instance, if the organization decides to automize, but also
for the succession of management. Management training is important for
qualified employees who will occupy management positions in the future.
In section 4.3 we will give some examples of groups of employees for
which development and training plays an important role.

Circumstances which call for development and training planning are
limited capacities of training institutions, high required qualifi-
cations and lack of willingness of the employees to be trained, etc.
Notice the relationship with the career planning, where development
and training can be necessary to make promotion.

ad D. Allocation planning.

Allocation planning is the design of allocation policies for the medium
and long term. Such policies indicate which type of functions will be
assigned to the different groups of employees (rotation schemes). These
functions exist on the same organizational level. Thus, for allocation
planning we consider the horizontal movements of employees.

Allocation planning can be important for those functions which require
highly qualified personnel, since rotation schemes may offer the oppor-
tunity for employees to obtain the required qualifications during their
employment in different functions on the same hierarchical level (see
fig. 1.7).

level 2

level 1 | A | B | C |
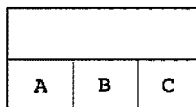
Figure 1.7. Example of an allocation policy. Employees who will obtain
functions on the second level, first have to spend 2 years
in A-type functions, 3 years in B-type functions and 5
years in C-type functions on the first level.

Circumstances which call for allocation planning are high required qua-
lifications, low functional mobility and restricted numbers of suitable
functions for allocation to employees who will occupy these positions
for only a short time. In section 5.2 we will consider allocation plan-
ning in some more detail. The importance of allocation planning will
also be demonstrated in the case-study (section 6.2).

Here again, we notice the relation of allocation planning to career
planning. The career opportunities may depend on the willingness of
employees to participate in the rotation schemes. A similar relation
exists between allocation planning and training and development plan-
ning. Training and development may depend on the willingness of parti-
cipating in allocation patterns.

1.4.5. *Discussion*

As mentioned in subsection 1.4.4 all manpower planning activities
are interrelated. All activities may be useful in order to obtain a
match of manpower requirement and availability, but sometimes one acti-
vity will be more relevant than others. The importance of an activity
is determined by the corresponding restrictions with respect to the
matching. If, for instance, discrepancies with respect to training and
development of employees are forecasted, then it is important to de-
velop (or change) training and development policies.

In subsection 1.4.3 we argued that policies have to be developed for
the matching of manpower requirement and availability. In subsection
1.4.4 we described the manpower planning activities which will result
in the design of such policies. Actions which may follow from these
policies are, for instance:

* in the case of an expected shortage of personnel:

    - (external) recruitment;
    - changes in career policies;
    - initiatives with respect to training and development;
    - changes in allocation patterns (job rotation);
    - subcontracting of work (changes in organization plans);
    - changes in manpower requirement (accelerating automation).

* in the case of an expected surplus of personnel:

    - dismissal (or stimulating turnover in various ways);
    - contracting additional work;
    - changes in allocation patterns in order to decrease the number
      of overoccupied functions;
    - changes in career policies.

Such actions will be discussed extensively in chapter 5.

1.5. The multi-category approach to manpower planning

In this section we will discuss why groups of employees are considered
in medium and long term manpower planning (multi-category planning)
and we will explain the relationship between this type of planning and
manpower planning for individual employees.

Different aggregation levels can be chosen in planning. In financial
planning, for instance, the investment level for the next ten years
may be expressed in investment amounts for periods of two years (strong
aggregation). The investment level for the next four years may be ex-
pressed in amounts of investment for each year per operation area
(some aggregation), while the investments for next year may be indi-
cated for each project explicitly (no aggregation).
In manpower planning, the level of aggregation corresponds with the
degree of heterogeneity of the considered personnel group. If manpower
planning is executed for the total number of employees, a heterogeneous
group, one has the strongest degree of aggregation. Some aggregation
exists if manpower plans for groups of employees are considered such
as top-level engineers, middle-level engineers, lower-level engineers,
etc. Manpower planning for individual employees, thus for homogeneous

"groups", is an example of no aggregation.

The choice for a degree of aggregation depends on the following factors:

a) the desired degree of detailedness of the planning;
b) the practicability of the detailedness of the planning.

We will consider these factors in some more detail now.

ad a) The desired degree of detailedness is determined by:
a1. the planning horizon;
a2. the organizational level on which the planning is executed.

ad a1. For a long planning horizon one is not interested in a high degree of detailedness. For short planning horizons a higher degree of detailedness is desired. In section 5.5 we will consider the planning horizon in some more detail. Examples of the relation between the planning horizon and the desired degree of detailedness are given in chapter 6.

ad a2. If the organizational level on which the planning is executed, is such that a great distance exists between that level and the level of the considered personnel, there will be a low desired degree of detailedness. In many organizations top-management is not interested in executing detailed manpower planning for all employees. On top-level only manpower planning with some degree of aggregation will be relevant (see, for instance, Crichton [26] and Sayles/Strauss [69]). Thus, in large organizations manpower planning may be relevant on several organizational levels and the degree of aggregation increases by increasing organizational level. In section 4.3 we will give some examples of the level of aggregation for different organizational levels of the planners.
The desired degree of detailedness may also depend on the considered personnel group. On top-level of the organization, management development will often be executed, which means that for a particular group of employees individual manpower planning is executed (i.e. forecasting of medium and long term requirement for management, the potentials of successors, the selection of managers, necessary training and development and so on). Management development has been described, for instance, in Taylor/Lippitt [76]. Further references can be found in Margerison/Hunter [56].

ad b) The practicability of the detailedness of the planning depends
on the available information. The available information is determined
by the organizational level on which the planning is executed. If a
great distance exists between that level and the level of the consid-
ered personnel, then there will probably be insufficient information to
make a detailed planning possible. On top-level of large organizations,
for instance, it will be impossible to forecast on medium and long
term which individual employees will be promoted or will leave the or-
ganization, which functions will arise and so on.

The level of aggregation will be discussed in some more detail in sec-
tion 5.4. Thus, if some aggregation is used in manpower planning, then
the personnel is classified in groups and the planning is based on
this classification. From the above it follows, that in medium and long
term manpower planning some degree of aggregation will always be de-
sired and/or necessary. This illustrates the relevance of the develop-
ment of instruments for manpower planning based upon groups of employ-
ees. The multi-category models for manpower planning discussed in this
book are applicable, in principle, for all aggregation levels except,
of course, for the individual level.

1.6. Typologies of organizations with respect to manpower planning

1.6.1. *Introduction*

In this section a typology of organizations with respect to manpower
planning problems is presented. The terms typology and classification
are interchangeable. This typology has been designed to give some idea
about the problems for which type of organization and which type of
personnel, which manpower planning activities (cf. subsection 1.4.4)
are important. We will call this a manpower planning typology of orga-
nizations. If we use in the remainder the term "organization", this
may refer to the organization or sub-organization (division), but also
to the considered personnel group of the organization. Which manpower
planning activities are relevant, depends on the type of organization
and on the considered personnel group of the organization.

In subsection 1.6.2 we will investigate which circumstances in the or-
ganization and its environment, influence the relevance of manpower

planning and, in particular, of the different manpower planning acti-
vities. In subsection 1.6.3 some existing classifications of organiza-
tions are given. We will examine in subsection 1.6.4 the relevance of
these classifications with respect to manpower planning. Since these
classifications have been developed mainly in order to gather infor-
mation about the organization structure (span of control, levels of
authority, etc.), these may not give the appropriate characteristics
for the relevance of manpower planning activities. Therefore, we at-
tempted to develop a manpower planning classification of organizations
which is described in 1.6.5. In subsection 1.6.6 we give some examples
of organizations and their place within this typology. In subsection
1.6.7 we will describe some indicators which can be used to determine
roughly the place of an organization within this typology. Finally,
in subsection 1.6.8 the examples of the places of organizations within
the typology are discussed in some more detail.

We only consider (relatively) large and structured organizations - as
was stated in section 1.1 - such as, for instance, large industrial
firms, public services, hospitals, etc. and as such we will not con-
sider e.g. a small workshop enterprise.

1.6.2. *Circumstances which indicate the relevance of the manpower*
       planning activities

Obviously, a certain amount of manpower planning is always executed,
in particular concerning the decisions of which functions have to be
allocated to which employees in short term. However, as has been sta-
ted before, organizations are also interested in the medium term and
long term personnel planning. The main reasons to do medium and long
term manpower planning, are:

1. high rigidity and high variability of manpower requirement;
2. high rigidity and high variability of manpower availability.

Rigidity means that manpower requirement or availability cannot be
influenced easily. High rigidity of manpower requirement occurs, for
instance, if the organization wants to accelerate automation but this
is not possible with the actual manpower distribution. In the case of
high rigidity of manpower requirement and/or availability, it is im-
portant to execute manpower planning activities.

Variability means that manpower requirement or availability change over time. If we use the term "variability", then we mean predictable variability (i.e., there are fluctuations, but these fluctuatins can be forecasted). High variability may also have ocurred in the past. In the case of high variability of manpower availability and/or requirement, it is useful to execute manpower planning activities. If, however, there are many fluctuations with a high degree of uncertainty, then manpower planning is less useful. In section 5.4 (aggregation level) and in section 5.5 (planning horizon) we will consider this in some more detail.

The terms "rigidity" and "variability" may refer to qualitative and/or quantitative rigidity and variability.

The manpower planning activities we will consider in this section have already been described in subsection 1.4.4. A summary follows here:

A. career planning (vertical movements);

B. recruitment planning;

C. training and development planning;

D. allocation planning (horizontal movements).

We will discuss the relevance of these activities for groups of personnel (cf. section 1.5) and for the medium and long term.

In order to answer the question for which organizations and which type of personnel the manpower planning activities are necessary, one has to investigate by which circumstances the rigidity and variability of manpower requirement and availability are caused.

1. A high degree of rigidity of manpower requirement is caused by:

a) a low degree of controllability of the market by the organization;

b) a low degree of freedom with respect to technology and/or organization structure.

ad a) A low degree of controllability of the market by the organization means that the organization can hardly influence the consuming market - on which it operates - in quality and/or in quantity. In this case, the organization would hardly be able to change its market share or it would be difficult to start with other products or services.

Manpower planning is particularly important in the case of a low degree

of controllability of the market, and at the same time, a high degree
of variability of the manpower requirement. Market is used here in a
very broad sense, such that also the outlet of services is included.
Some aspects of the controllability of the market by the organization
are described, for instance, in Needham [61] and in Sayles/Strauss
[69] , p. 157.

ad b) A low degree of freedom with respect to technology and organi-
zation structure means that the organization is hardly able to change
the technology or the organization structure. The technology is defined
as the techniques and technical processes the organization applies
to change imputs into outputs. A change of technology may lead to the
requirement of different numbers and/or types of employees. The orga-
nization structure indicates the numbers and types of functions and
the corresponding hierarchical levels in the organization. If the
technology and/or the organization structure can hardly be changed,
then manpower planning is particularly important and that is certainly
so, if - at the same time - a high degree of variability of the man-
power requirement exists.

2. A high degree of variability of manpower requirement is caused by:

a) a high degree of market variability;
b) a high degree of variability of technology and/or organization
   structure.

ad a) A high degree of market variability means that the consuming
market - on which the organization operates - changes over time, in
quantity and/or quality. The quantitative changes indicate the changes
in the demanded numbers of products or services. The qualitative chan-
ges indicate the demand - by customers - for other types of products
or services in the same product class or service class. The impact of
market fluctuations on manpower requirement has been described - for
instance - in   Sayles/Strauss [69].

ad b) A high degree of variability of technology and organization
structure means that technology and organization structure change over
time. Aspects of changes in technology and organization structure are
discussed, for instance, in Crichton [26] and in Sayles/Strauss [69].

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3. A high degree of rigidity of manpower availability is caused by:

a) a high degree of uncontrollability of the characteristics of employees;

b) a situation of overemployment on (relevant segments of) the labour market;

c) high commitment of the organization towards its personnel.

ad a) A high degree of uncontrollability of the characteristics of employees is caused by the fact that some characteristics cannot be changed, such as age or potential of the employees. An exception to this rule exists if, for instance, elder employees can be dismissed and, at the same time, younger people can be recruited. Other characteristics, such as experience or mobility (functionally and/or geographically), can be influenced partly (sometimes). A lack of mobility implies a high degree of rigidity.

ad b) In a situation of overemployment on relevant segments of the labour market, it will be hard to recruit the employees with the required qualifications (see e.g. Sayles/Strauss [69], pp. 169-170).

ad c) The commitment with respect to the personnel is the level of responsibility the organization accepts for its employees' welfare. High commitment is expressed by, for instance, the obligation of offering careers to the personnel, protection from dismissal or involuntary transfer, etc. A high level of commitment may arise from the type of organization (if, for instance, highly qualified personnel is employed), external social control, or voluntarily.

4. A high degree of variability of manpower availability is caused by:

a) an irregular distribution of employees with respect to the age or the type of personnel;

b) fluctuations in the situation on the labour market in the past and in the future.

ad a) If, for instance, the organization employs many older employees, then there will be many retirements in subsequent years. If the age distribution is irregular (as in fig. 1.2), then the number of retirements will change heavily over time. An example of an irregular age distribution will be given in section 6.4.
An irregular distrubution of employees with respect to the type of

personnel exists, for instance, if recruitment has been constant over time, but the fraction of highly trained recruits has been fluctuating.

ad b) Fluctuations in the situation on the labour market, in the past and in the future, may cause fluctuations in turnover. In the case of overemployment, turnover may be high, whereas turnover will be low in a situation of unemployment (see, for instance, Sayles/Strauss [69], pp. 52-53).

In summary, high levels of rigidity and variability of manpower requirement and availability indicate, in our view, the relevance of manpower planning activities. Particularly, in the case of both high rigidity and high variability, the importance of manpower planning exists.

In subsection 1.6.4 we will use these rigidity and variability concepts for our manpower planning typology.

1.6.3. *Existing typologies of organizations*

Since in previous works many classifications (or typologies) of organizations have been developed, we will present here some of these classifications in order to investigate whether these are useful as a manpower planning typology of organizations.

Woodward [91] investigated the organization structure in manufacturing firms. She developed a classification of technologies, from which a typology of organizations can be deduced based upon "technical complexity". The degree of technical complexity is "the extent to which the production process is controllable and its result predictable". A high degree of technical complexity occurs, for instance, in process industry. In organizations based upon small batch and unit production the degree of technical complexity is low.

Another well-known classification was made by Etzioni [31]. His typology is based upon two elements, the "power applied by the organization to lower participants" and the "degree of involvement in the organization by lower participants."

The typology of Blau and Scott [13] is based upon the "cui bono" principle. This means that the organization is typified by the category of

persons which is the prime benificiary of the organization's opera-
tions. The categories of persons are: (1) the members of the organiza-
tion; (2) the owners or managers; (3) the clients; and (4) the public-
at-large. Four types of organizations then result: (1) mutual-benefit
organizations; (2) business concerns; (3) service organizations and
(4) commonweal organizations respectively. The police organization is
an example of the last mentioned type of organization in the ideal si-
tuation (but not in a police state).

Harvey [42] classifies the industrial organizations according to "tech-
nical specificity". The degree of technical specificity is indicated
by the number of product changes in the last ten years. Harvey dis-
tinguishes three classes:

1. technically specific organizations using sophisticated technolo-
   gies (e.g. the oil industry);
2. technically diffuse organizations with a wide variety of products,
   many new products on the market or manufacturing according to cus-
   tomer specifications (e.g. the electronics industry);
3. technically intermediate industries.

Botter [15] classifies the industrial organizations according to:

a. their place in the industry column corresponding with the flow of
   goods;
b. the specificity of the assortment. The assortment is specific if
   no standardizations have been achieved (unit and small series pro-
   duction).

Notice that some organizations (for instance, organizations buying
raw materials on one hand and selling machineries on the other hand)
fill several elements of the industry column.

Katz and Kahn [47] distinguish first-order factors that describe the
genotypic function of the organization and second-order factors which
are generally related to these basic functions. Genotypic functions
refer to the type of activity the organization is engaged in: (1)
productive or economic functions; (2) maintenance functions; (3) adop-
tive functions (4) managerial or political functions, concerned with co-
ordination and control of resources and people. The second-order cha-
racteristics are: (1) the nature of the through-put; (2) the processes
for ensuring the continuous input of human personnel; (3) the nature

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of the bureaucratic structure and (4) the type of equilibrium of the system.

Pugh, Hickson and Hinings [66] used the following empirical factors as a basis for a classification of organization structures:

a. the degree to which the activities are structured;
b. concentration of authority;
c. the degree of line control of workflow.

The organizations have been classified according to the extent to which these factors occurred in the organizations they considered. The following types of organizations result then, corresponding to their characteristics: "full bureaucracies, nascent full bureaucracies, workflow bureaucracies, personnel bureaucracies, implicitly structured bureaucracies".

Other classifications of organizations are given in Blau/Scott [13], Jackson/Morgan [45], Parsons [64].

1.6.4. *Discussion of existing typologies of organizations*

In this subsection we will investigate whether the essential factors for manpower planning, rigidigy and variability, can be found in the classifications given in subsection 1.6.3.

The rigidity of manpower requirement recurs more or less in the technical complexity (Woodward), the specificity of the assortment (Botter) and some characteristics of Katz and Kahn. The variability of the manpower requirement can be found in the technical specificity (Harvey). In particular the factors concerning the manpower availability do not occur explicitly in the existing classifications (except, possibly, the commitment of the organization, which may be expressed in the cui bono principle of Blau and Scott).

In fact, the existing classifications have not been developed for manpower planning. Therefore, it is not surprising that essential factors for manpower planning do not recur explicitly in these classifications. For this reason we will describe in subsection 1.6.5 a typology of organizations with respect to manpower planning.

1.6.5. *A manpower planning typology of organizations*

The characterics, according to which the organizations can be classi-
fied in order to determine which manpower planning activities are im-
portant, will be called "dimensions".

The dimensions we will use here are rather broad. If the typology is
applied to an organization, in order to investigate which manpower
planning activities are important, then an operationalization of the
dimensions is necessary. We will give in subsection 1.6.7 some indi-
cators which can be used to determine roughly the place of an organi-
zation within our typology.

In our typology, the organizations are classified according to the
following dimensions:

1. the commitment of the organization with respect to its personnel
   (called commitment);
2. the inflexibility of the organization with respect to the market
   (called inflexibility);
3. the specificity of the personnel of the considered (sub-) organi-
   zation (called specificity).

In the remainder of this subsection, we shall consider these dimen-
sions in some more detail and we will describe their relation with
rigidity and variability.

ad 1. Commitment

This dimension indicates the obligations the organization feels with
respect to its personnel.

Commitment may concern different aspects: job security, offering of a
career, etc. If the commitment is high, then career planning is usual-
ly important.

A high degree of commitment causes a high degree of rigidity of man-
power availability, since job security and the offer of a career im-
plies that the numbers and types of employees cannot be changed easily.

The degree of commitment may be different for different countries. In
the United States, for instance, the restriction that employees cannot
be dismissed involuntarily, exists usually less strictly than in the
Netherlands or in Scandinavian countries.

The degree of commitment may also be different for different (sub)-
organizations or personnel groups within a given country. In Dutch
public services, for instance, the degree of commitment is high:
careers are usually offered to the personnel, employment is ensured
and so on. On the other hand, in (some) smaller private industries
the degree of commitment is (relatively) low. In some organizations,
career prospects are explicitly formulated for highly qualified em-
ployees, but not for the other employees.

In a way, the degree of commitment indicates the necessity of taking
into account the individual expectations together with the organi-
zation's goals.

ad 2. Inflexibility

The degree of inflexibility is the degree to which the organization
has to follow fluctuations in the consuming market. The degree of in-
flexibility also indicates the degree to which the organization is un-
able to change the production level autonomously, or is unable to
start with other products or services. In fact, this dimension com-
bines the rigidity and the variability of the manpower requirement.
A high degree of inflexibility corresponds with a high degree of rigi-
dity and variability of manpower requirement. Thus, it indicates the
importance of manpower planning activities.

If a high degree of inflexibility concerns the inflexibility with res-
pect to the production level, then recruitment planning and alloca-
tion planning will usually be important. This may occur, for instance,
in a situation of high competition. If, on the other hand, the inflexi-
bility exists with respect to starting new types of products or servi-
ces, then different numbers of personnel with different qualifications
may be required. Thus, recruitment planning, training and development
planning as well as allocation planning may be important.

The degree of inflexibility may be different for different groups of
personnel within one organization. The degree of inflexibility of a
staff department of an industrial firm, for instance, may be low com-
pared with the production units if the size of the staff department is
independent of the fluctuations in the consuming market.

ad 3. Specificity

The degree of specificity of the personnel of the considered (sub-)
organization is the degree to which the personnel requires qualifica-
tions (experience). A high degree of specificity of the personnel in-
dicates that the employees can hardly perform other tasks than those
they perform now. A high degree of specificity indicates the impor-
tance of manpower planning.

Two types of specificity can be distinguished:

+ internal specificity;
+ external specificity.

Personnel with a high degree of internal specificity is personnel per-
forming tasks that require particular qualifications, but such tasks
also occur in other organizations. In many organizations, sales mana-
gers form an example of this type of personnel.
Personnel with a high degree of external specificity is personnel per-
forming tasks that require particular qualifications, which are not
required by tasks in other organizations. Army officers are an example
of such a personnel group.

A high degree of specificity is related to a high degree of rigidity
and variability of manpower availability.

1.6.6. *Discussion of our typology*

The typology given in subsection 1.6.5 has been developed for man-
power planning purposes. It classifies organizations (or sub-organi-
zations or personnel groups of a (sub-) organization). The way of dis-
tinguishing personnel groups, hence the level of aggregation, will be
discussed in some detail in section 5.4.

In this subsection we will classify some personnel groups of organi-
zations according to our typology and we will explain the important
manpower planning activities. We shall indicate whether the personnel
group has the dimensions to a high or low extent. It should be remar-
ked here that the typology is only a rough classification. In some

instnaces, only the quantitative aspects of a dimension can be found
in an organization to a high degree (e.g. market flexibility).

Table 1.1 shows the classification of some personnel groups. Notice
that the classification of the examples has been executed according
to prevailing standards in relevant Dutch organizations. It is even
not maintained that e.g. the group of sales managers in all organiza-
tions is of the second type.

dimensions	types			
. specificity	+	+	+	+
. inflexibility	+	+	-	-
. commitment	+	-	+	-
manpower planning activities	A , B C , D	B , C D	A , C D	C , D
examples	police-officers army-offibers	sales managers	engineers in a re-search lab of a large private industry	nursing personnel in hospitals
	(1)	(2)	(3)	(4)

dimensions	types			
. specificity	-	-	-	-
. inflexibility	+	+	-	-
. commitment	+	-	+	-
manpower planning activities	A , B	⨯	A	⨯
examples	postal workers	female cashiers in large retailing firms	secreta-ries in public services	gatemen in factories
	(5)	(6)	(7)	(8)

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Tabel 1.1. Theoretical classification types of organizations and per-
sonnel groups.

Each column describes a type of organization, the relevant
manpower planning activities and an example of a (sub-)-
organization or personnel group of this type.
+ indicates that the dimension occurs to a high extent
- indicates that the dimension occurs to a low extent
x indicates that no activities are necessary.

The characters A,B,C and D indicate the manpower planning
activities as mentioned in subsection 1.6.2 : career plan-
ning, recruitment planning, training and development plan-
ning and allocation planning, respectively.

The eight types of organizations will be discussed in some detail in
subsection 1.6.8.

1.6.7. *Comments on our typology*

As we mentioned before, our purpose was to give an idea of the rele-
vant manpower planning activities for different types of (sub-) orga-
nizations or personnel groups.
We will give in this subsection some indicators with which
the place of an organization within our typology can be determined
roughly.

In our typology, one has to indicate whether the considered organiza-
tion has the different dimensions to a high or low degree. In practice,
one may investigate which manpower planning activities are important
by means of a score based on indicators. A high score means that the
considered dimension is present to a high extent.

We will now introduce some indicators for the dimensions commitment,
inflexibility and specificity.

Indicators for a high commitment of an organization to its personnel
may be:

- the personnel may not be transferred to other locations or functions
  involuntarily (legal standing);
- the organization will not dismiss its employees when manpower re-
  quirement is smaller than manpower availability (job-security);

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- the organization offers a career to its personnel.

Indicators for a high inflexibility of an organization may be:

- many changes in the total number of demanded products or services
  are expected (and/or have occurred in the last few years);
- the market share of the organization will probably change many times
  unintentionnally (and/or has often changed unintentionally in the
  last few years);
- a large number of product changes or technology changes (new machi-
  nes, changes in labour productivity) is expected to occur (and/or
  has occurred in the last few years).

Indicators for a high specificity of an organization may be:

- there is a low degree of internal functional mobility of the employees
  (i.e., a large fraction of the employees cannot be transferred to
  other functions because of specialization for instance);
- there is a low degree of external functional mobility of the employ-
  ees (i.e., the employees have not many opportunities to obtain simi-
  lar functions in other organizations);
- recuits need a long training period;
- turnover rates are very low;
- overemployment exists for the personnel group.

1.6.8. *Discussion of the types of organizations*

We will now discuss in some detail the types of organizations and the
examples given in subsection 1.6.6.

Type (1) is characterized by high specificity, high inflexibility and
high commitment.

Examples of this type are police officers and army officers. For these
groups of personnel, the degree of commitment is high: job security
(though employees can be transferred to other locations), employees
are offered a career, etc. The (external) specificity is high, since
this type of employees does not occur in other organizations. Medium
and long term recruitment planning is useful, in order to determine
the required capacities of the training institutions and in order to
change an irregular age distribution. The inflexibility is high, since
manpower requirement may change drastically in the course of time (po-

litical influences). Thus, career planning is useful (high commitment), allocation planning (assignment of locations to the employees), recruitment planning as well as development and training planning.

Type (2) is characterized by high specificity, high inflexibility and low commitment.

An example of this type is the category of sales managers. This personnel group has a high degree of (internal) specificity, since very specific qualifications are required, but there are sales managers in a great variety of organizations. The requirement for sales managers depends heavily on the fluctuations of the consuming market, particularly, the quantitative changes. Because of competition, the market variability may be high. In these circumstances development and training planning, recruitment planning and allocation planning will be important. Career planning may not be required, except for some very large industries, since commitment is often low for this personnel group.

Type (3) is characterized by high specificity, low inflexibility and high commitment.

An example of this type is the category of engineers in a research laboratory of a large private industry. The manpower requirement of the industrial research lab depends on the changes in technology and on the qualitative changes on the consuming market (demand for new products).
The high degree of specificity is caused by the required qualifications. However, young engineers can be recruited without many problems from the labour market. The high commitment of this organization with respect to these high-qualified engineers is indicated by the obligation of offering functions on a higher organization level for experienced personnel some time after their recruitment. Career plan-

ning is therefore necessary (specificity, commitment). Because of
the qualification demands, one should also execute training and
development planning. Allocation planning may help to obtain the
right type of specialists on the functions in which they perform best
and feel well (also on medium and long term!).

Type (4) is characterized by high specificity, low inflexibility and
low commitment.

An example of this type is the nursing personnel of a hospital.
The degree of specificity is high, since the employees have obtained
a specific training.
Medium and long term forecasts of the numbers and types of patients
will not show many fluctuations, which causes a low degree of inflexi-
bility. The degree of commitment is low, turnover is high, such that
career planning is not important. Allocation planning may be useful in
as far as the succession of wardmasters is concerned. Allocation pat-
terns may be developed then for the assignment of the nurses to wards
for periods of several months. Training and development planning is
 relevant because of the required qualifications.

Type (5) is characterized by low specificity, high inflexibility and
high commitment.

An example of this type is the category of postal workers of
the Netherlands Post Office. This public service has a high degree of
commitment. The employees cannot be transferred involuntarily to other
locations; they can only be transferred to similar functions in their
actual locations, careers are offered to all employees, etc. Though
the total working-program is not changing much in time, the inflexibi-
lity is high, since automation is accelerated. The degree of specifi-
city is low. Only a short training period is required, since external
mobility is high and so is internal functional mobility (many types
of unskilled work can be done by these employees). Geographical inter-
nal mobility is low (fixed locations). Important manpower planning ac-
tivities may be career planning, because of high commitment, and re-
cruitment planning because of high inflexibility.

Type (6) is characterized by low specificity, high inflexibility and low commitment.

An example of this type is the category of female cashiers of a large retailing firm. The cashiers can be recruited directly from the labour market, since not much experience (qualification) is required. Because of strong competition in shopping firms, the inflexibility is high (high variability). Turnover rates are usually high. Therefore, recruitment planning is not useful. The commitment is (relatively) low, since no career prospects are offered and sometimes even no job security exists. Usually, no transfers to other affiliations occur, so that allocation planning is not important.

Considering affiliation managers of such a retailing firm we have an example of type (2).

Type (7) is characterized by low specificity, low inflexibility and high commitment.

An example of this type is the category of secretaries in a public service. Though these employees are highly trained, the degree of (external) specificity is low, since secretaries can be found in most organizations. The degree of commitment is usually high in public services and the inflexibility can be low, at least in some public services where the working program does not change much in time and the automation is not accelerated. Thus, the only relevant manpower planning activity may be career planning. This planning activity gains relevance with decreasing turnover rates.

Type (8) is characterized by low specificity, low inflexibility and low commitment.

An example of this type is the category of gatemen of factories. Commitment for these employees is low (except for some very large industries); no career opportunities exist. These functions do not depend on any market conditions and are not specific because they can be done by many unskilled employees. Recruitment from the labour market is directly possible without training, etc. Thus, no manpower planning activities for this personnel group are necessary.

Notice that, for the examples above, we indicated the medium and long term activities that are desirable because of the type of the orga-

nization. However, there may be other reasons for doing some form of
medium or long term manpower planning, for instance in order to deter-
mine future personnel costs. It should also be remarked, that short
term manpower planning can be desirable too. Such short term planning
can be assignment of employees to the different functions. However,
we will not consider short term manpower planning in this book.

1.7. Goals of this book and its restrictions

In this section we will describe the goals of this book and its restric-
tions. The main theme of this book is the treatment of instruments
for corporate manpower planning, with special attention
to the applicability and applications of such instruments. Manpower
planning concerns the regular activity of monitoring manpower require-
ment, manpower availability and the matching process, as well as the
activity of investigating particular problems with respect to the per-
sonnel. An example of such a particular problem is the effect of a low
degree of geographical mobility of employees on the transfer of employ-
ees to other locations.

We consider medium term and long term manpower planning for large orga-
nizations. This type of manpower planning may be characterized by the
following phases:

a forecasting of the requirement for personnel (both qualitatively and
   quantitatively);
b forecasting of the availability of personnel (both qualitatively and
   quantitatively);
c matching of personnel requirement and availability.

According to our insight into the manpower planning process, the require-
ment for personnel has to be known first (to some extent), and after
the manpower availability has been forecasted, the matching can be exe-
cuted through the development of alternative manpower policies and al-
ternative activity programs. Our intention is to emphasize, in parti-
cular, the instruments for the forecasting of manpower availability
and for the development of alternative policies.

Let us consider the above-mentioned phases of manpower planning in
some more detail.

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ad a) Forecasting of the requirement for personnel.

The forecasting of the personnel requirement is a less developed area
of manpower planning. General forecasting techniques can be used, par-
ticularly for the estimation of future manpower demand. However, this
demand may be influenced by many factors which cannot be expressed in
exact quantitative data, e.g. future labour laws, motivations of the
employees, degree of automation. Other factors may be forecasted rather
well, such as the demand for products or services. A good starting-
point for obtaining the necessary information concerning future
developments, lies in the part of the corporate plan describing the
level of the activities (production, amount of services, etc.) for the
medium and long term. The next phase will be the translation of this
corporate production plan in a personnel requirement forecast. Because
of large differences in organization policies concerning manpower, the
nature of the production processes, organization structures and so on,
there are, in our opinion, no general quantitative methods for manpower
requirement forecasting applicable to all organizations and all groups
of personnel.

We will develop a rough outline for manpower requirement forecasting
in chapter 2.

ad b) Forecasting of the availability of personnel.

The availability of personnel with different qualifications in the
future, depends on the actual personnel structure (the number of em-
ployees, their ages, qualifications, schoolings, etc.), recruitments,
promotion, turnover, training and schooling, etc. Extrapolation of
trends concerning the development of these factors in the past gives
a forecast of the manpower availability. However, it may be important
to assess the impact on the future manpower supply of changes in the
numbers of recruits, career prospects, training programs, etc. as will
be explained in c). Therefore, methods for manpower availability fore-
casting should offer the possibility to evaluate such consequences.
This turns out to be an important condition for the applicability of
manpower availability forecasting methods (chapter 3).

We developed a manpower planning instrument that forecasts the conse-
quences of alternative manpower policies (concerning recruitment,

career prospects, etc.) for the evolution of the personnel distribution. This instrument has been developed to be used by personnel managers (chapter 4).

ad c) The matching of personnel requirement and availability.

The final phase of manpower planning relates availability and requirement to each other. One has to search for manpower policies (with respect to recruitment, career patterns, training and development and allocation) and for corresponding activities plans. This is called the matching process of manpower requirement and availability.

In our approach, the matching process requires a very flexible use of manpower availability and requirement forecasting instruments (chapter 5).

The manpower availability forecasting system FORMASY which we used in our applications (see, for instance, Van der Beek/Verhoeven/Wessels [11], Verhoeven/Wijngaard [85] and chapter 6), will get special attention in this book. FORMASY, which helps in the design of manpower policies, may be seen as a decision support system. Decision support systems for other fields of applications are described in, for instance, Mc.Cosh/Scott Morton [25].

In our view, the attention we paid to applicability and applications of the instruments fills part of the gap between theory and practice of manpower planning which exists at the moment.

The magnitude of the manpower planning area puts some restriction on this book. Firstly, we only consider manpower planning instruments for a large organization interested in manpower planning for groups of personnel (multi-category approach, section 1.5). Secondly, we deal with medium and long term matching for groups of personnel and we consider the activities career planning, recruitment planning, development and training planning and allocation planning. We emphasize the importance of quantitative methods and the development and application of interactive manpower planning systems.

In this book, the organization activities plan, environmental factors (situation on the labour market, social laws, etc.) as well as the attitude of employees are assumed to be given and to be uncontrollable

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by the manpower planning results. We will use such data but we will not study the data separately. Moreover, organization structures, reward systems as well as psychological and social aspects will not be drawn into the scope of this book.

CHAPTER 2

MANPOWER REQUIREMENT FORECASTING

2.1. Introduction

The estimation of future personnel requirement is a very important and
also a very difficult phase of the manpower planning process. In this
chapter we will consider manpower requirement forecasting, assuming
that it is independent of the manpower availability forecast. In this
way one obtains a good starting point for the matching phase, which
may result in adaptations of both manpower requirement and availabili-
ty forecasts. In chapter 5 the matching phase will be considered in
some detail.

Future manpower requirement mainly depends on the organization activi-
ties plan (cf. fig. 1.5). Of course, many factors will influence the
operations of the organization, e.g. changes in the demand for pro-
ducts or services, technology, the economic situation. The degree in
which these factors play a role, depends on the type of organization
and the considered personnel group. In manufacturing industries, for
instance, changes of technology and competition effects will be essen-
tial. For public services, however, the government policies may be much
more important. Direct personnel strength, i.e. the number of employees
directly involved in the production or in the services delivered by the
organization, will usually depend more on competition and on technology
changes, than is the case with the number of supporting staff. There-
fore, no general method for manpower requirement forecasting exists
which is valid for all organizations and all personnel categories. By
some authors general statistical techniques have been proposed and ap-
plied for requirement forecasting. In section 2.2 we will describe these
statistical techniques for manpower requirement forecasting. Furthermore,
subjective and informal methods may be useful to forecast manpower re-
quirement. Such methods are discussed in section 2.3. In section 2.4 we
consider how manpower requirement forecasting is executed in a number
of large Dutch organizations, thus illustrating the extent to which
the methods previously mentioned, are used in practice. Finally, in
section 2.5 we will describe an outline for manpower requirement fore-
casting.

We will use the terms "demand", "requirement" and "need" for personnel as
synonyms. These terms refer to the necessary numbers and types of per-
sonnel in the organization. As we mentioned in section 1.5 we will con-
sider categories of personnel instead of individuals.

So far, not many publications have appeared on manpower requirement
forecasting (see Bowey [17]). Also, reports of regularly use of require-
ment forecasting methods are exceptional. Bartholomew/Forbes [6]
have described some requirement forecasting techniques.

2.2. Statistical techniques for personnel demand forecasting

In this section we consider some models for manpower requirement fore-
casting based upon statistical techniques. We distinguish (cf. Van
Winkel [90]):

- models based upon extrapolation of manpower trends (univariate models);
- models relating manpower requirement to organizational and environ-
  mental circumstances (multivariate models).

In the following subsections, these types of models will be discussed
in some detail. A model is defined here as a mechanism which de-
termines the manpower requirement.

2.2.1. *Models based upon extrapolation of manpower trends (univariate models)*

In this subsection the models are discussed which only reflect the
evolution of manpower requirements and which do not consider expli-
citly the influence of various factors on the manpower requirement.
These models can be distinguished in:

<u>a</u> models including a determistic trend;
<u>b</u> models including a stochastic trend.

Denote by M_t the manpower requirement at time t. It is supposed that now
we live at time 0 and the manpower requirements M_t for t = $-k, -k+1, \ldots$
$\ldots, -1, 0$ are given.

ad <u>a</u>   Models including a deterministic trend

In these models the manpower requirement forecast for a specific cate-
gory of personnel is found by extrapolation of the relationship be-
tween manpower requirement and time.

As an example we consider the linear model, i.e. we suppose that M_t can be written in the following form:

$$(2.1) \qquad M_t = a + b \cdot t + \varepsilon_t \quad ,$$

where a and b are constant but as yet unknown; a and b have to be estimated from the past. The ε_t are uncorrelated random variables with zero means.

Estimates of a and b can be obtained using the weighted regression criterion, i.e. $\hat{a}$ and $\hat{b}$ are chosen as estimates if they minimize

$$(2.2) \qquad \sum_{t=-k}^{0} \beta^t (a + b \cdot t - M_t)^2 \quad ,$$

where $0 \leqslant \beta \leq 1$. By using the discount factor $\beta < 1$, one indicates that recent realizations of manpower requirement are more relevant than previous realizations.

Now the predictor for the requirement at time t becomes (see fig. 2.1):

$$(2.3) \qquad \hat{M}_t = \hat{a} + \hat{b} \cdot t .$$
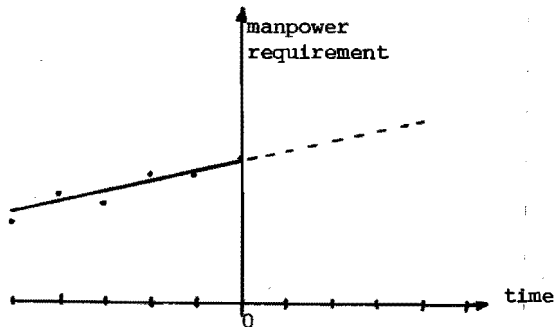
Figure 2.1. The linear model for manpower requirement forecasting.

In the model above, and in fig. 2.1, a linear relationship between manpower requirement and time has been assumed. Fitting of the data may also be based upon other relations, for instance on an exponential growth curve.

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The exponential model has the form:

$$(2.4) \qquad M_t = a \cdot e^{b \cdot t} + \varepsilon_t$$

where a and b again are obtained by smoothing of past data and ε_t has the above mentioned characteristics.

The predictor for the manpower requirement at time t is then:

$$(2.5) \qquad \hat{M}_t = \hat{a} \cdot e^{\hat{b} \cdot t} ,$$

where $\hat{a}$ and $\hat{b}$ are the estimated values of the coefficients.

Linear and nonlinear models are described extensively in Goldfeld/ Quandt [37].

An essential problem concerning the application of this type of models is: how can the manpower requirement in the past be known? We will meet this question in several other types of statistical models. One possible value for the manpower requirement in the past is the manpower size in the past, possibly adapted for existing vacancies and/or the need for more personnel as it was felt by management.

The extrapolations for this type of models are only useful for short or medium term forecasts, since the modelled type of trend may only be valid for a small number of time periods. Exactly for this reason the weighted regression criterion is used. If the annual growth rate has been high in recent years and one assumes this trend to hold for a long time period, then the manpower requirement estimates would become impossibly high. An example of this effect has been given by Bartholomew/ Hopes/Smith [7] .

One should also notice that cyclical effects may occur in the historical data corresponding to a trade-cycle. In fact, the cyclical effect is a good example of a deterministic trend.

An example of this type of extrapolation method is given by Rowntree/ Stewart [68] who investigated the manpower requirement for the four types of work of the Land Registry of the British Civil Service.

ad **b** Models including a stochastic trend

We will consider here the auto-regressive models as an example of a
model which includes a stochastic trend. In such a model the manpower
requirement is - apart from noise effects - explicitly determined by
past values of the manpower requirement.

An auto-regressive model of order k has the following form:

(2.6) $M_t = \alpha_1 \cdot M_{t-1} + \alpha_2 \cdot M_{t-2} + \ldots + \alpha_k \cdot M_{t-k} + \varepsilon_t$

where k denotes the number of past periods which directly influence the
manpower requirement. The coefficients $\alpha_1, \alpha_2, \ldots, \alpha_k$ denote
the weights for the historical values of the manpower requirement.
These weights are estimated by fitting to past data. The error term is
represented by ε_t which has the usual characteristics:

(2.7) $\mathbb{E}(\varepsilon_t) = 0$ and $\mathbb{E}(\varepsilon_t, \varepsilon_{t-\ell}) = \begin{cases} 0 & \text{for } \ell \neq 0 \\ \sigma_\varepsilon^2 & \text{for } \ell = 0 \end{cases}$

$\mathbb{E}(\varepsilon_t)$ indicates the statistical expectation of ε_t.

Since the predictors do not have a simple form we will not give them
here, but we refer to Van Winkel [90]. This type of forecasting
methods has been described extensively in Box/Jenkins [18] and in
Brown [19].

Further explanations concerning the auto-regressive model for manpower
requirement forecasting are given in Bartholomew/Forbes [6] . Applica-
tions of this type of models for a firm have been given by Young/
Vassiliou [95] and by Cameron/Nash [21].

2.2.2. *Discussion on univariate models*

In the univariate models, described in subsection 2.2.1, the value of
manpower requirement is supposed to depend only on past values of the
manpower requirement. Thus, the model assumes an upward trend in the
past to continue, also if management knows that in subsequent . years
the organization's activities will decrease, while labour productivity
will increase. Formulated in a different way, it is unsatisfactory

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that management policies and the opinions of management with respect
to future developments and influences from the outside are not consi-
dered in these models. This implies that these models may not be appro-
priate for manpower requirement forecasting since it is not likely
that management will accept methods which do not reflect her opinions.
The role which these models can play in manpower requirement forecas-
ting may be considered, however, as presenting an instrument for stimu-
lating discussions with respect to the evolution of the manpower re-
quirement.

It should also be remarked that, if different types of manpower are
required in a fixed proportion, then it is sufficient to have one model
for requirement forecasting, otherwise for each type of manpower a
different model is required.

Application of these models may be limited by the lack of data concer-
ning the manpower requirement in the past. Usually, the total manpower
size of past years will be known, but the question remains whether
this manpower size reflects the real manpower requirement or not (cf.
subsection 2.2.1.a).

In our view, the models may only be useful if a rough estimate of the
total manpower requirement of a (sub-) organization is required. If
detailed estimates concerning smaller units of the organization (or
for different types of personnel) are demanded, then it may be better
to investigate which factors determine the manpower requirement (see
subsection 2.2.3). In any case, the forecasts obtained with univariate
models have to be compared with the views of management and adapted
afterwards.

2.2.3. *Models relating manpower requirement to organizational and
       environmental circumstances (multivariate models)*

In this subsection we consider the models for manpower requirement fore-
casting which explicitly formulate the manpower requirement as a func-
tion of various variables such as the organization's activities, techno-
logy, etc. We distinguish the following types of models:

<u>a</u> a simple model based upon the current value of the manpower require-
ment and the expected change in output level;

<u>b</u> a more sophisticated model based upon the current and past values of
the manpower requirement and the changes in output levels;

<u>c</u> regression models;

<u>d</u> economic models.

The model types <u>a</u> and <u>b</u> use time-dependent coefficients, the model
types <u>c</u> and <u>d</u> use time-independent coefficients.

For the models ad <u>a</u> and ad <u>b</u> one uses the output levels of the organi-
zation and forecasts for these output levels.

Define:

Y_t ≡ output level at time t (expressed in number of products
or services);

$\hat{Y}_t$ ≡ forecast at time 0 for the output level at time t.

ad <u>a</u> A simple model based upon the current value of the manpower re-
quirement and the expected change in output level

In the model the manpower requirement is assumed to be proportional to
the output level (i.e. the number of products or services delivered by
the organization):

$$(2.8) \qquad M_t = M_0 \cdot \frac{Y_t}{Y_0} \ .$$

The predictor for the manpower requirement is then:

$$(2.9) \qquad \hat{M}_t = M_0 \cdot \frac{\hat{Y}_t}{Y_0} \ .$$

Some remarks have to be made on this model. Firstly, the actual manpo-
wer requirement has to be estimated. We mentioned this problem before
in subsection 2.2.1. Secondly, the output level has to be forecasted.

Because this is the only factor considered for the manpower requirement, these forecasts have to be relatively precise. Thirdly, it is assumed that economies of scale- which means that an increase in the output level leads to less than proportional increase in the manpower requirement - will not occur. Notice that this model can be applied for every type of product or service if the actual manpower requirement for every product or service as well as the expected change in output level can be determined.

The model has been tested for the British engineering industry by Bosworth/Evans/Lindley [14].

ad **b** A more sophisticated model based upon the current and past values of the manpower requirements and the changes in output levels

This model can be formulated as:

$$(2.10) \quad M_t = \frac{M_0}{Y_0} \cdot Y_t + \left(\frac{M_0}{Y_0} - \frac{M_{-1}}{Y_{-1}}\right) \cdot Y_t \quad .$$

This model, which has been developed by Ghosh [35], can be considered as an extension of the model described ad **a**.

In this model, the changes in the labour productivity are included in the forecasts of the manpower requirement. The predictor becomes then:

$$(2.11) \quad \hat{M}_t = \frac{M_0}{Y_0} \cdot \hat{Y}_t + \left(\frac{M_0}{Y_0} - \frac{M_{-1}}{Y_{-1}}\right) \cdot \hat{Y}_t \quad .$$

As we already mentioned concerning (2.9) , an important problem is the estimation of future output levels. This is also true for (2.11). Therefore, we will consider this question somewhat further here.

Future output levels may be forecasted by application of the forecasting techniques such as the methods described in subsection (2.2.1). However, if it is relevant to consider the influence of factors as, for instance, technology changes on the relation of output level and manpower requirement, then a more detailed analysis is required. Often,

such technology changes can be predicted, since there exists a time -
lag between the introduction of a new technology and its adoption.
Together with the growth curve of a product or service (fig. 2.2), the
data with respect to the impact of technology changes can give im-
portant information for the output level estimates and for the rela-
tion of manpower requirement and output level for a specific group of
products and service. Purkiss [67] applied this method of output level
estimation for the British Steel Industry.
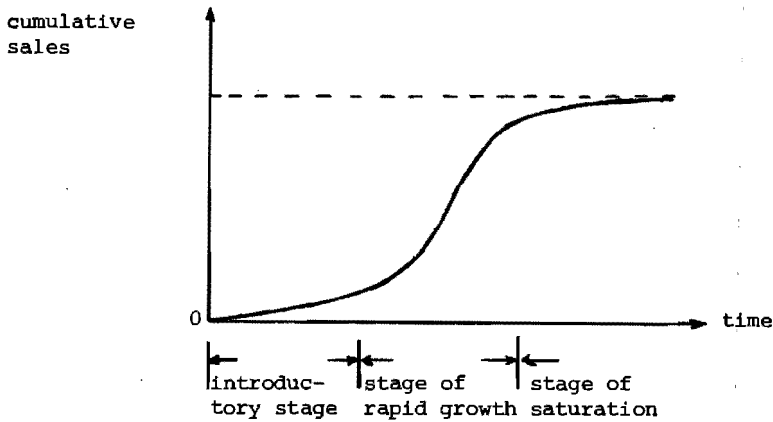
Figure 2.2. Growth curve showing the life-cycle of a product or service

ad c   Regression models

In manpower requirement regression models a relationship is formulated
for the manpower requirement and a number of variables which are assu-
med to determine the personnel demand. If the manpower requirement de-
pends on q variables which depend on time, then we obtain the following
model:

(2.12) $M_t = \alpha_0 + \alpha_1 \cdot X_{1t} + \alpha_2 \cdot X_{2t} + \ldots + \alpha_q \cdot X_{qt} + \varepsilon_t$

where $X_{1t}, X_{2t}, \ldots, X_{qt}$ are the values of the considered explanatory
variables at time t, ε_t indicates the error with the usual characte-

ristics (2.7) and $\alpha_0, \alpha_1, \ldots, \alpha_q$ are the coefficients for the constant term and the explanatory variables respectively.

The coefficients can be estimated now from the application of (2.12) on historical data, i.e. on the realizations of $M_t, X_{1t}, X_{2t}, \ldots, X_{qt}$ for $t = -k, -k+1, \ldots, 0$. If the values of the explanatory variables can be forecasted, then the future manpower requirement can be forecasted by:

$$(2.13) \quad \hat{M}_t = \alpha_0 + \alpha_1 \cdot \hat{X}_{1t} + \alpha_2 \cdot \hat{X}_{2t} + \ldots + \alpha_q \cdot \hat{X}_{qt} \quad,$$

where $\hat{X}_{it}$ is the forecast of variable X_i for time t at time 0. Notice that the problem of forecasting the explanatory variables $X_1, X_2, \ldots, X_q$ arises.

An application of regression models for manpower requirement forecasting has been given by Drui [28]. He determined the manpower requirement for the finance department of a firm. The explanatory variables he uses, are the total company employment, the total numbers of direct personnel, sales and the number of processed reports.

Lapp/Thompson [53] forecasted the demand for engineers in Ontario with the gross national product level as the only explanatory variable.

One problem deals with the interpretation of the resulting equation. The value and even the sign of the regression coefficients may be affected if some relevant explanatory variable is omitted.

These problems are discussed in detail in Bartolomew/Forbes [6] and in Draper/Smith [27].

Notice that (2.12) might also contain lagged variables.

ad d Economic models

Economic models for manpower requirement forecasting can be based upon the specific form of the production function. The output level of the production process is supposed to be determined by the input levels of labour and capital according to the production function of Cobb-Douglas (see Klein [50]):

(2.14) $P_t = c \cdot M_t^\alpha \cdot K_t^\beta \cdot U_t$,

where c is a constant, K_t is the amount of capital used in period
t (the value of the capital stock), U_t is assumed to be a log-normally
distributed error term and P_t is the output level expressed in value
added and M_t is the amount of labour used in period t.

The variables α and β express the output elasticities with respect to
labour and capital, i.e. the marginal increase of the output level
because of a small amount of extra input of labour or capital respec-
tively. Generally holds $|\alpha| \leq 1$ and $|\beta| \leq 1$ and, in the case of comple-
mentarity of labour and capital, $\alpha + \beta = 1$.

Taking logarithms of (2.14) we obtain:

(2.15) $\log P_t = \log c + \alpha \log M_t + \beta \log K_t + \log U_t$

which is an ordinary regression equation.

A   modified version of (2.15) includes the impact of technology im-
provements by a rate $e^{\gamma t}$ on the output level. In that case the relation-
ship for the manpower requirement becomes (cf. 2.15)

(2.16) $\log M_t = \dfrac{-1}{\alpha} \log c - \dfrac{\gamma}{\alpha} \cdot t + \dfrac{1}{\alpha} \log P_t - \dfrac{\beta}{\alpha} \log K_t - \dfrac{1}{\alpha} \log U_t$.

The predictor for the manpower requirement at time 0 for time t follows
from:

(2.17) $\log \hat{M}_t = -\dfrac{1}{\alpha} \log c - \dfrac{\gamma}{\alpha} \cdot t + \dfrac{1}{\alpha} \log \hat{P}_t - \dfrac{\beta}{\alpha} \log \hat{K}_t$.

Application of these models implies the necessity of forecasting the
output level and capital stock level.
In (2.16) one may include also other variables such as the numbers of
hours actually worked or a variable expressing the capital utilization.

Estimations of such relationships are given by Fair [32] and by Wabe in [87] , who considers the British engineering industry.

2.2.4 *Discussion on multivariate models*

In this subsection we will discuss the following aspects of multivariate models:

<u>a</u> reality of the model;

<u>b</u> application on numbers of employees;

<u>c</u> forecasting of variables;

<u>d</u> estimation of manpower requirement in the past.

ad <u>a</u> Reality of the model

In ouw view, the multivariate models are more useful for manpower re-
quirement forecasting than the univariate models. The fact that multi-
variate models can include those factors which determine the manpower
requirement, underlines the reality of these models. Naturally, the
use of the right explanatory variables and also of a sufficient number
of variables in order to forecast the personnel requirement accurate-
ly, is essential. The usefulness of these models is illustrated also
by the possibility of incorporation of the management policies with
respect to the future activities of the organization (output levels)
and, for instance, automation decisions.

ad <u>b</u> Application on numbers of employees

So far, we have considered the quantitative manpower requirement fore-
casting. The described models have to be applied on numbers of employ-
ees. It should be remarked however, that the personnel requirement is
investigated for groups of functions with similar characteristics (re-
quired qualifications, types of work, etc.). By applying the above-
mentioned models on such groups of functions it is possible to consider
the forecast of the required number of employees with the required quali-
fications. It should be remarked, that it may be difficult to determine
for all groups of functions which variables influence the manpower
requirement. In the multivariate models, the relationship between

personnel demand and, for instance, output level or used amount of capital will not always be known. For large groups of direct personnel or for indirect personnel with activities connected with the output level (e.g. the marketing employees) the multivariate models may be particularly useful.

However, for small groups of employees (or functions) or for certain categories of indirect personnel, as, for instance, the departmental heads, possible changes in the organization structure will have consequences for the manpower requirement and also for many other variables. Thus, the application of mathematical models will be less useful then and there will be more need for the opinions of management for manpower requirement forecasting.

ad c Forecasting of explanatory variables

For all multivariate models forecasts of the explanatory variables have to be available (except, of course, if lagged variables with a sufficiently large time-lag are used). The extent to which such forecasts can be made will depend heavily on the type of organization and on the personnel group considered. Estimating the output levels may be (relatively) easy for a stable organization, but it is difficult for an organization for which the development of the market cannot be forecasted. Technology changes have a great impact on the personnel demand. However, sometimes it is difficult to forecast these changes as well as to determine the impact. Probably, the forecasting of the explanatory variables is one of the important problems in the application of multivariate models.

ad d Estimation of manpower requirement in the past

In many organizations there is a lack of historical data with respect to the manpower requirement level in the past and the values of the explanatory variables in the past. The question whether the manpower distribution in the past can be used as an estimate for the manpower requirement has been discussed already in subsection 2.2.2. In our view, the knowledge and views of management are necessary for the determination of past manpower demand levels.

2.3. Subjective methods for manpower requirement forecasting

2.3.1. *Subjective methods for manpower requirement forecasting*

Subjective methods are those forecasting techniques which use direct-
ly the experience and judgements of experts. The application of sub-
jective methods for manpower requirement forecasting may be useful to
estimate directly the future manpower requirement, but also to forecast
explanatory variables by collecting the view of management on the or-
ganization's activities in the future (the types and numbers of out-
put), technology changes, organization structure changes, etc. We dis-
tinguish the following methods:

a) collecting of management opinions;

b) delphi method;

c) work-study.

ad a Collecting of management opinions

A fast and relatively simple way to obtain forecasts concerning man-
power requirements is to ask management which developments it expects
in the future. Management is best aware of changes in the workload,
possible automation projects, changes in organizational structure,
etc. It can translate these developments in required numbers and types
of employees.

These forecasts can be made on top-management level for the total orga-
nization or on the level of division managers for their department.
In the latter case, if the figures have been given without commitment,
the forecasts might be overestimating in order to ensure a certain
manpower strength in the future (wishful thinking). On the other hand,
the division managers know usually very well the specific qualities
of their department and the expected developments concerning person-
nel demands which makes the exercise recommendable.

A   possible disadvantage of this procedure is the time managers have
to spend on it.

More information on this method for manpower requirement forcasting is
given in Lawrence [54].

ad b Delphi method

The delphi method, originally developed by the Rand Corporation in the late 1940's (see, for instance, Gordon/Helmer [38]), consists of the collection of experts' information in a structured way. The delphi method is a special procedure to obtain management opinions. A research team formulates some questions concerning the future development with respect to a certain subject. This subject is in our case the manpower requirement. The questions may concern, for instance, the expected evolution of the labour productivity, technology changes, output levels, etc. The participants in this procedure answer the questionnaire anonymously: each participant knows neither the other participants nor their answers.

In every following round, each participant obtains as information the answers given by the group in the previous round, including the most important arguments as well as the response he gave himself. This procedure is continued until the answers agree. It is expected that convergence of the opinions occurs if every expert is confronted with the opinions of his colleagues. In summary, the main characteristics of this method are:

- anonymity of the participants such that no domination of some experts can occur;
- feedback of the information such that the quality of the responses may increase.

An advantage of the delphi technique is that the experts do not need to be present at the same time and they can study the problem in detail. On the other hand it should not take too much time to answer the questions which must be formulated clearly and the number of participants may not be too large (20 - 30 persons). The number of rounds until agreement is achieved, will usually be two or three.

More information on this technique is given by Milkovitch/Annoni/Mahoney [59] who applied this technique for manpower requirement forecasting.

ad c Work-study

A very detailed approach for manpower requirement estimation is the work-study technique. When applying this technique, one considers the

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different functions in relation with the organization's activities plan.

The background for the use of this method for manpower requirement forecasting is the possibility that the contents of some functions have to be changed if the output levels change, if technology changes, etc. It should be remarked that we consider work-study for groups of functions and not for functions individually. In fact, work-study is a very detailed approach which requires a thorough knowledge of the production process (or the process of service rendering) and of the organization structure. Also, the expected output level has to be given. Based on work-study principles, standards may be developed for the numbers and qualifications of employees which are necessary to per- form the various tasks. Of course, these standards have to be tested continuously on their up-to-dateness with respect to efficiency and performance of the organization. The development of standards and the grouping of tasks depend partly on human judgement and for this reason work-study is considered as a subjective method. However, its subjectivity is less obvious than in the methods ad a and ad b, since also technical norms will play an important role here.

Halpern [41] describes an application of work-study techniques for manpower requirement forecasting with the British Civil Service.

2.3.2. *Discussion on subjective methods*

The methods considered in this section may have some advantages above the models described in section 2.2. In particular the fact that man- agement is directly involved in the manpower requirement forecasting procedure, instead of becoming confronted with relatively untranspar- ant models might be considered as advantageous. Subjective methods are very useful if the qualitative demand for manpower is investigated. Work-study techniques can be applied, in particular, for small groups of functions, since these methods are much more detailed.

The application of subjective methods can be executed in several ways. One may estimate with these methods, for instance, either the expect- ed change of technology or the expected change of the future workload or the expected organization change. Also combinations of these types of changes can be investigated. Combinations of statistical and sub- jective methods are also possible, e.g. the application of regression

analysis where the expected values of the explanatory variables are obtained by means of collecting management opinions. Or, extrapolation of the workloads and applications of work-study to determine standards for certain activities.

Often, alternative scenarios for future developments are used. In that case, alternatives are formulated on the basic scenario. This may result, for instance, in scenarios based on upper estimates of variables and in scenarios based on lower estimates. Thus, different views of management can be projected in order to stimulate discussions.

2.4. The practice of manpower requirement forecasting

2.4.1. *Introduction*

In sections 2.2 and 2.3 some methods for manpower requirement forecasting have been described which may be useful in practice. However, of most methods mentioned in literature, it is not reported that they are used regularly for manpower requirement forecasting. One gets the impression that the methods follow from research by operations research staff members and that the results have not been applied by the manpower planning or personnel department. Therefore, it is interesting to investigate which methods are really used for manpower requirement forecasting in an organization. Of course, a complete survey of manpower requirement forecasting procedures and the degree of acceptance of several methods in large organizations cannot be given here, but we will discuss some aspects of manpower requirement forecasting in a number of large Dutch organizations, both industries and public services. The results have been obtained by interviews with personnel managers and members of personnel or planning departments.

In fact, when we asked the personnel managers of large organizations how manpower requirement estimates are obtained, then the usual answer was: this activity is not done at all, or at least not in a systematic and formal way. One gets the impression that the organization

runs as it is and manpower demand forecasting is not considered very important. However, it is interesting to consider that the personnel numbers and qualifications do change in every organization. The questions are now: on which arguments are the decisions concerning changes in personnel demands built and which methods have been used to obtain the necessary information? Of course, the personnel group under regard and the type of organization play an important role in manpower requirement forecasting (remember the manpower planning typology of section 1.6). We will consider in subsection 2.4.2 some practical cases of manpower demand forecasting.

2.4.2. *Cases of manpower requirement forecasting*

Case 1. In a defense organization in the Netherlands a very detailed manpower requirement estimation procedure is applied. In this organization a function registration system is used in which all functions are denoted by numbers indicating the activity group to which it belongs, for every activity group the department to which it belongs and for every department the number of each function. Moreover, some extra informations belonging to the function may be included. For all functions, also called positions, the corresponding rank and a function name is attached. This registration system is continuously assessed and analysed by means of a function analysis procedure in which all functions are considered individually and the level and numbers of tasks for that function are judged. This detailed function registration system plays an important role in manpower requirement estimation.

In a rolling corporate planning procedure every two years a new ten years' plan for the entire organization is layed. Rolling planning means that after each planning period a new plan is made for up-dated figures. In the meantime, the plan is adjusted because of the governmental budgets to be proposed every year. The corporate plan indicates organization developments, the moments of introduction of new weapon systems and the years in which obsolete equipment will be replaced. In this long term plan the personnel planning and the planning of any of the other resources (finance, equipment and materials) are linked together: besides the investments also the materials and personnel costs are considered. The corporate plan has to correspond with the organization goals cf. the political goals. These goals are translated into

an operation plan representing the tasks to be executed. From this operational plan the materials plan, the personnel plan and the finance plan are deduced in such a way that an interaction between these plans is possible (feedback) which results in readjustments of the original plans while satisfying the organizational goals. These adjustments may be necessary - for instance - because of changes in the political situation, the technology, the labour market and - particularly - the available budgets.

Furthermore, manpower requirements depend on possible changes in the organization structure which result from frequent efficiency studies. However, changes in the organization structure are usually a consequence of changes in the levels and types of activities and of technological improvements.

Im summary, manpower requirements depend in short term and medium term, if technology is not changing much, especially on the intended activities. In long term also technological improvements have to be considered.

Work-study techniques are often employed to determine standards for the relationship between the number and quality of necessary employees and the workload. The personnel consequences of the introduction of new technologies (weapon systems, machineries, etc.) are usually rather well-known, because of foreign experiences, particularly from the United States.

Manpower requirement estimation is done for 10 years ahead, function by function in this defense organization and it is necessary to obtain a detailed matching of functions and employees. Because of the specificity of this organization (and of its employees) this matching is very important and may have consequences for the number and qualifications of recruits, the career policies, education and training programs and allocation patterns.

A detailed matching is necessary since all military units have a fixed organization structure. Personnel requirements can be forecasted reasonably for a period of about ten years since the introduction of new weapon systems can be foreseen and takes some time.

Case 2. The second case is the directorate for the local police forces in the Netherlands. This public service has no function registration system and manpower requirements are not estimated in a formal and structural way. As in the first case, the police officers have had a special education and training and can be regarded as being (externally) specific in the sense of section 1.6 (typology). Though the technology is not chaning much or irregularly, manpower demand estimation is necessary because of the specificity of the personnel and the changes of the workload. In practice, however, the strength of every local police force mainly depends on the number of inhabitants of the municipality and on the allowed strength of the entire police force which is determined by political priorities. This distribution policy is not necessarily a good one, since the need for policemen may also depend on other local factors and it is questionable whether the local workloads depend directly on the numbers of inhabitants. The local workloads do have some influence on the allowed strength of the police force since some municipalities obtained an additional number of policemen because of the local situation. Such assignments, however, are not based on a thorough investigation of the local situation but on the signals coming from the local police management.

The directorate has developed a number of general organization charts in which a reasonable function distribution for a local police force is given. Such organization charts, depending on the number of inhabitants, are considered as guidelines for the municipalities in building the organization structure.

Since a few years now, one tries to estimate real personnel demands. In the large cities a part of the workload is measured by the number of requests for police assistence. Of course, many other tasks have to be performed such that this cannot be the only explanatory variable. Therefore, other investigations are carried out in which one tries to translate the organizational goals into tasks and, afterwards, to find some relationship between the number of necessary policemen for every task and the service rendered to the public (for instance, a relationship between the fraction of solved offences of certain types and the numbers and qualifications of policemen with the task to solve these offences).

Further investigations are set up on order to achieve a better organization structure. From top-level one has started a work-study project (see Project Group Organization Structures [65]) in which the times policemen spend on all kinds of activities have been summed up. Some centralization is arising since several police forces, not belonging to the local police forces, have been formed for special tasks. On the other hand, some decentralization takes place within the forces of the big cities since the work of the policemen in the beats gets more attention.

In summary, on top-level the manpower requirement forecasting is not a part of the decision process, but one seems to notice the importance of the subject since some experiments have been started recently. On lower levels, in the big cities, the importance has been noticed earlier, since problems were arising with respect to allowed numbers of policemen on one hand and the increasing demand for police help on the other hand. The investigations with respect to the manpower requirements in the big cities have resulted in several internal reports.

Moreover, it is possible to investigate the necessary qualifications for policemen by executing manpower requirement forecasting.

Case 3. As a third example of manpower requirement planning we will consider a division of a large multinational private company. The personnel department of this division is involved in personnel demand forecasting for highly educated personnel, mainly employees with an education in advanced technology or with an academic degree. This activity is done for every unit in the organization (development group, mechanization group, production group, etc.) and concerns about 2000 employees. Every year a questionnaire is sent to the plant managers and the departmental heads. The questions consider the expected developments in the next four years concerning production size, technology and organizational changes (e.g. centralization/decentralization, make or buy decisions). The managers are asked to translate the answers into a forecast of manpower requirements in their department for all categories of functions corresponding to pay-classes. Moreover, some questions are posed with respect to the qualitative filling of the organization at this moment (the distribution of employees according to age, experiences, necessary education in the future), the number of vacancies, etc. This procedure exists since about two years and its goal is to gain more insight in possible future discrepancies between demand and supply for personnel. The decisions based on this approach concern

possible transfers of employees to other divisions, necessary recruitments, promotions or decisions for training.

Manpower requirement forecasting in a formal way is not done for the lower level employees because recruitments are possible if necessary, career paths are short, turnover fractions are relatively high, such that demand and supply can be matched more easily and the workload is relatively stable. As we discussed in section 1.3, medium and long term manpower planning is not important in such situations.

In fact, the management opinion procedure applied by this organization division seems to work quite well. A possible development in the future may consist of efforts to determine the relationship between workload and the required numbers of employees.

2.4.3. *Discussion*

Many organizations have a procedure for manpower demand estimation corresponding with the outline of the last case above. However, often this procedure is not a standard procedure. The management itself, notices continuously whether a shortage or a surplus of personnel will arise in the near future. In such a situation of an expected dis-crepancy, management will ask for actions such as recruitment, trans-fer, promotion, training, etc. Thus, the principle is applied that the manager who does not complain will probably have the right numbers and types of employees. The lack of standard procedures for manpower requirement forecasting is also illustrated by the lack of reports on standard procedures. An exception is, for instance, the manpower planning system applied by Hoesch (see Beth - von der Warth/ Steinecke [12]).

A difference between the first and the last case of subsection 2.4.2 is the applied degree of detailedness. In the defense organization the manpower requirement estimation is executed function by function while in the industrial organization the manpower requirements are forecasted roughly for pay classes. Also, the length of the planning horizon differs. In the defense organization a horizon of 10 years is chosen whereas in the industrial organization only a 4-years planning horizon is used. These differences mainly proceed from the degree to which future developments with respect to the activities program can be fore-casted.

The cases of the previous subsection indicate that manpower require-
ment forecasting is important. However, its relevance depends on the
type of organization and on the considered personnel group. In section
2.5 we will, roughly, indicate for which groups of personnel the man-
power requirement forecasting is particularly important.

2.5. Outline of a manpower requirement forecasting procedure

2.5.1. *Outline*

In this subsection we will describe an outline of an estimation pro-
cedure for manpower requirements.

a) As a first step one should estimate the actual manpower requirement
in order to get a good starting-point.

The actual manpower requirement may follow from the organization
chart or the function registration system. Thus, the available num-
bers and types of functions are known. Since the multi-category
approach is applied, these functions have to be clustered such that
numbers of function groups result. Now, for every function group
the amount and types of actual activities should be described as
well as the necessary experience and qualifications to perform these
activities. Usually, the function description indicated the type of
work for every function. For certain functions, the yearly work-
load (the numbers and types of tasks to be executed) may be hard
to determine. Particularly for some categories of indirect person-
nel this estimation may be difficult.

It should be remarked that the clustering has to be executed in
such a way that manpower requirement and manpower availability es-
timates can be compared with each other. Thus, one must be able to
identify the characteristics of the functions with the characteris-
tics of the employees; for instance, function level with grade, re-
quired experience with grade seniority, required qualifications
with the training and development of the employee.

b) In the second step, one compares the actual formal manpower require-
ment, which has been obtained in step 1, with the actual manpower
availability.

The comparison of actual manpower requirement and availability gives insight in the number of vacancies (or in the surplus of personnel). Also, possible discrepancies between the function requirements and the qualifications of the employees can be found.

c) In the third step, one confronts the foregoing results with the opinions of management (for instance, of the departmental heads).

The confrontation of the results of the previous steps with the opinions of management indicates whether the actual formal manpower requirement, as estimated in the first step, agrees with the real personnel demand in the view of management. Based upon this comparison – which should take into account possible disturbing influences by seasonal effects, the trade cycle and so on –, the real actual manpower requirement can be determined.

d) In the next step, the output levels for all activities have to be forecasted.

The output level for each organizational activity can be forecasted according to the medium term organization plan. Since these plans are approved by management, the forecasted output levels are, in fact, the production (or service) targets for the medium term. If the organization plan is not sufficiently detailed, extrapolation techniques may be helpful here.

e) In the fifth step, the output levels for all activities have to be translated in workload forecasts for each function group.

The manpower requirement forecasts have to be given for each function group. Thus, the forecasted output levels for the different activities have to be converted in workload forecasts for the function groups. In these workloads, the seasonal effects, economies of scale or other disturbing factors have to be incorporated.

f) In the next step, the workloads have to be adapted for possible organizational changes and overhead activities.

Organizational changes and overhead activities may lead to a change of the workload for several function groups. In this step, the opinion of management is again particularly important since the determination of overhead activities will be rather difficult. Estimation of the level of activities is particularly relevant for those

departments which perform tasks depending in size on the number of direct personnel (e.g. the personnel department) or even on the amount of products or services to be delivered (e.g. the marketing department). In the last case, the number of employees in the indirect department, indirect in the sense that the products or services are not directly handled, depends on the output level.

g) In the seventh step, the forecasted workload is translated in manpower requirement forecasts.

For the conversion of workload into manpower requirement, standards must be available. Applications of work-study techniques can give these standards. If the standards have been adapted to technology improvements, then for direct personnel it is (relatively) easy to forecast the manpower requirements. For the indirect personnel it is recommendable to let management do the conversion since it is difficult to develop standards for the relation of workload and personnel demand for indirect personnel. The use of data with respect to the numbers of indirect employees and the workload in the past for these employees may stimulate the discussions.

2.5.2. *Discussion*

In this subsection we will discuss some aspects of the outline given above.

The outline of a manpower requirement forecasting procedure is only a rough outline. The application of this procedure and, in particular, the necessity of executing each step depends on the type of organization and the personnel group which is considered. Organizations may be in different circumstances with respect to the importance of manpower planning. Sometimes, manpower planning has to be executed only roughly, sometimes a very detailed approach is required (recall section 1.3). If manpower requirement forecasting is executed, since particular problems have to be considered, then some aspects should have particular attention. For instance, if the introduction of large automation projects is discussed, the impact of technology changes on the required training and development of employees will be very important for manpower requirement forecasting.

The importance of manpower requirement forecasting also depends on the

type of personnel. Usually, the forecasting of personnel demand in
long term for direct employees with a low degree of training is im-
portant for the estimation of future salary costs and for the estima-
tion of the total number of employees. The last mentioned forecast
may be important in the negociations with the unions with respect to
future employment levels and e.g. for housing decisions. For direct
personnel, a detailed consideration is usually not needed. This cannot
be said for direct employees with long career paths or if a high de-
gree of commitment exists.

The considerations above indicate that medium and long term manpower
demand estimations are particularly useful if matching problems in the
future between supply and demand may possibly occur. Indications for
such situations are e.g. sudden changes in the output level, automation
projects, transfer of production to other locations. Short term man-
power requirement estimation should always be executed, since the work has
to be done and one has to foresee certain peaks of the workload. The
planning period which is considered, thus, depends on the type of pro-
duct or service under regard and on the organizational structure.
These aspects will not be discussed here further.

Finally, in our view, it is essential that management is involved in
the manpower requirement estimation procedure. It is insufficient to
use only statistical techniques. We believe that the results with these
techniques may help in stimulating discussion, but collecting the opin-
ions of management is at least as important.

CHAPTER 3

MANPOWER AVAILABILITY FORECASTING

3.1. Introduction

In this chapter, we will consider mathematical models for the fore-
casting of the evolution of the manpower distribution and their pos-
sible use in manpower planning. Manpower availability forecasting is
a somewhat confusing term, since we will not only consider mathemati-
cal models with which the manpower availability can be forecasted, but
we will also describe some mathematical models which combine the fore-
casting of manpower availability and the matching with manpower re-
quirement. For all these models we use the term manpower availibility
forecasting models.

The first mathematical models for medium and long term manpower avail-
ability forecasting were given by Seal [71] and Vajda [79] in the late
fourties.

Many early papers on manpower availability forecasting consider, in par-
ticular, the effect of wastage which has a considerable impact on the
evolution of the personnel distribution (see e.g. Silcock [74]). The
first applications of Markov models are described in the papers of
Young/Almond [94] and Gani [33] in the early sixties. From that time
on, many mathematical models have been developed for manpower planning.
Markov models, renewal models (see Bartholomew [3] ,[5]) and optimi-
zation models (see Charnes/Cooper/Niehaus [23]) have received most
interest. All these models describe the evolution of the manpower dis-
tribution. The important variables for this evolution are recruitment,
withdrawal (wastage) and internal transfer (promotion or another
change of position).

In section 3.2 we will describe the following manpower availability
forecasting models: Markov models (and longitudinal models), renewal
models and optimization models. As we mentioned in section 1.5, we
will only discuss multi-category models which consider the develop-
ment of categories of personnel. In section 3.3 these models are dis-
cussed and evaluated with respect to their value for the manpower mat-
ching process (subsection 3.3.1), their usefulness for the design of

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manpower policies (subsection 3.3.2) and some computational aspects
(subsection 3.3.3). In section 3.4 we explain why we choose a Markov-
type forecasting model. Finally, in section 3.5, the conditions are
discussed which a manpower planning system should satisfy. In our
view, manpower planning systems based on Markov models satisfy these
conditions better than planning systems based on other types of models.

3.2. Mathematical models for manpower availability forecasting

3.2.1. *Introduction*

In this section, we describe some mathematical models for manpower
availability forecasting. In subsection 3.2.2 we explain the Markov
model (and the longitudinal model), in subsection 3.2.3 the renewal
model is described, whereas in subsection 3.2.4 optimization models
are considered. Notice that in some types of models the forecasting of
the availability and the matching are combined.

For all these models, we assume that the categorization of employees
(i.e., the choice of the categories in which the employees are clas-
sified) has been given in advance. The problem of categorization will
be discussed in section 3.3.

3.2.2. *Markov models*

3.2.2.1. *The basic model*

The object of a Markov model is to forecast the number of employees in
each of the categories at equidistant points in time ($t = 0,1,2,...$).
In a Markov model, the number of employees which makes a transition
from one category to another category in a given period, is assumed
to be a constant fraction of the size of the first mentioned category
at the beginning of the period. These fractions are called transition
fractions. The actual number of employees in all categories, the tran-
sition fractions and the future recruitment in all categories have to
be given. The future number of employees in all categories (the future
manpower distribution) is forecasted.

Define:

$n_i(t) \equiv$ the number of employees in category i at time t;

$p_{ji} \equiv$ the transition fraction from category j to category i;

$r_i(t) \equiv$ the number of recruits in category i in the time interval $(t-1, t]$.

Then we have:

$$(3.1) \qquad n_i(t) = \sum_{j=1}^{K} n_j(t-1) \cdot p_{ji} + r_i(t), \quad \text{for } i, j = 1, 2, \ldots, K$$
$$\text{for } t = 1, 2, \ldots$$

where K is the number of categories.

If there are employees leaving the organization from category i, the following formula is valid:

$$(3.2) \qquad \sum_{j=1}^{K} p_{ij} < 1.$$

We can write (3.1) also in vector notation.
Define:

$N(t) \equiv (n_1(t), n_2(t), \ldots, n_K(t))$, i.e. the row vector of the number of employees at time t;

$R(t) \equiv (r_1(t), r_2(t), \ldots, r_K(t))$, i.e. the row vector of the number of recruits in the time interval $(t-1, t]$;

$$P \equiv \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1K} \\ p_{21} & p_{22} & \cdots & p_{2K} \\ \vdots & & \ddots & \\ p_{K1} & & & p_{KK} \end{bmatrix}$$, i.e. the matrix of transition fractions for the different categories.

Thus, a different formulation of (3.1) is:

$$(3.3) \qquad N(t) = N(t-1) \cdot P + R(t), \quad \text{for } t = 1, 2, \ldots$$

Markov models are also called push models, since the transition fractions are given and the future distribution of manpower over the cate-

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gories (called manpower distribution) is determined by the values of
these transition fractions. Thus, the employees are pushed through the
manpower system.

Example 3.1. Consider a manpower system with three categories. The
transition matrix P is given (fig. 3.1) and the actual manpower dis-
tribution (table 3.1).

$$P = \begin{matrix} & & 1 & 2 & 3 \\ & 1 & \begin{bmatrix} .6 & .3 & 0 \\ 2 & 0 & .4 & .3 \\ 3 & 0 & 0 & .6 \end{bmatrix} \end{matrix}$$

Figure 3.1. Transition matrix P for example 3.1.

	category			total
	1	2	3	
t = 0	140	100	60	300

Table 3.1. Actual manpower distribution over the catefories for
example 3.1.

Suppose we recruit 80 employees in category 1 every year. Table 3.2
shows the manpower distribution over the categories based on the Mar-
kov model.

	category									total
	1			2			3			
	E	S	T	E	S	T	E	S	T	
t = 0			140			100			60	300
t = 1	80 +	84 =	164	42 +	40 =	82	30 +	36 =	66	312
t = 2	80 +	98 =	178	49 +	33 =	82	25 +	40 =	64	324
t = 3	80 +	107 =	187	54 +	33 =	86	25 +	39 =	63	336
t = 4	80 +	112 =	192	56 +	35 =	91	26 +	38 =	64	347
t = 5	80 +	115 =	195	85 +	36 =	94	27 +	38 =	65	354
t = 6	80 +	117 =	197	59 +	38 =	96	29 +	39 =	67	360
t = 7	80 +	118 =	198	59 +	39 =	98	29 +	40 =	69	365
t = 8	80 +	119 =	199	59 +	39 =	99	29 +	42 =	71	369
∞	80 +	120 =	200	60 +	40 =	100	30 +	45 =	75	375

Table 3.2. Forecast of example 3.1 of the manpower distribution

for eight years ahead and the forecasted long term distribution of em-
ployees over the categories with recruitment of 80 employees per year
in category 1 and with transition fractions as given by fig. 3.1. The
first column for each category (E) represents the number of new en-
trants, the second column (S) indicates the number of employees who
stay in the category and the third column (T) gives the total number
of employees in the category. All numbers have been computed exactly
and were rounded off afterwards to the nearest integer values.

Markov models formulated in the way above are deterministic models.
If all flows (recruitment, wastage, promotion or internal transfer)
are controllable and predictable, then it is not necessary indeed to
have a stochastic model. However, a deterministic model is rather un-
natural in situations where the flows are unpredictable and uncontrol-
lable to a certain extent. In most organizations, wastage is not exact-
ly controllable nor predictable. A realistic stochastic model for wast-
age is a model where to each category i, a wastage probability p_{i0} is
assigned. Each person in category i has each year a probability p_{i0} to
leave the organization. The expected number of employees leaving from
category i is then $n_i \cdot p_{i0}$, where n_i is the number of employees in
that category. So, we obtain similar forecasting expressions as (3.1)
and (3.3) but now the forecasts are statistical expectations. If all
transitions (promotion, wastage, recruitment and internal transfer) are
modelled in this way, we have the situation where the evolution of each in-
dividual employee through the manpower system is described by a Markov chain.

In fact, this purely stochastic situation and the purely deterministic
situation are only extreme cases. It is also possible that some tran-
sitions are stochastic (e.g. wastage), while other transitions are
deterministic (e.g. promotion).

Essential for a Markov model is that the number of employees who
make a transition from category i to category j, in a given period,
is independent of the evolution of the employees in previous years and
only depends on the number of employees in category i at the beginning
of the period. Markov models have been described, for instance, in
Bartholomew/Forbes [6], Young Almond [94].

3.2.2.2. *Steady-state distribution*

Markov models can be used to forecast the distribution of employees

over the distinguished categories. The forecasted manpower distribution indicates then the consequences of wastage, promotion policies and recruitment policies. If recruitment is constant in time, then it is possible to calculate the stationary or steady-state distribution. The stationary distribution is the long term forecasted number of employees in all categories if recruitments, but also promotion and wastage fractions are constant.

Define:

$\hat{n}_i \equiv$ the number of employees in category i in the steady-state situation;

$r_i \equiv$ the recruitment in category i.

In the steady-state situation we have:

$$(3.4) \qquad \hat{n}_i = \sum_{j=1}^{K} \hat{n}_j \cdot p_{ji} + r_i \qquad , \text{ for } i = 1,2,\ldots,K$$

where

$$(3.5) \qquad \hat{n}_i = \lim_{t \to \infty} n_i(t) \qquad , \text{ for } i = 1,2,\ldots,K.$$

The value of this steady-state distribution lies in the possibility to compare the long term manpower availability forecast with the long term manpower requirement forecast. In this way, one may investigate whether manpower policies, based on medium term forecasts, are acceptable on long term. In section 4.4 we will discuss the stationary distribution for the Markov model in some more detail.

3.2.2.3. *Determination of transition probabilities*

The way to determine the transition fractions(or transition probabilities respectively) depends on the situation in which the Markov model is used. In the purely deterministic situation, it is simple to observe these fractions, since the transition fractions are fixed and deterministic.

In the stochastic situation, however, the transition probabilities have to be estimated. In order to obtain a first estimate of the transition probabilities, one may use historical data. Suppose that data is available for the periods from t = -T until t = 0.

Define:

$m_{ij}(t) \equiv$ the number of employees who made a transition from category
i to category j in the time interval $(t-1,t]$.

The transition probabilities p_{ij} can be estimated now by:

$$(3.6) \qquad \hat{p}_{ij} = \frac{\displaystyle\sum_{t=-T+1}^{0} m_{ij}(t)}{\displaystyle\sum_{t=-T+1}^{0} n_i(t-1)} \qquad , \qquad \begin{array}{l} \text{for } i = 1,2,\ldots,K \\ \text{for } j = 0,1,2,\ldots,K \end{array}$$

where p_{i0} denotes the wastage probability from category i.

In (3.6) all previous years have equal weights. If one assumes, for instance, that the number of transitions in recent years is more important for the estimation of the transition probabilities, then one may introduce weights in (3.6).

Usually, T should not be chosen too large, since historical data from many years ago may not be appropriate to obtain reliable transition probabilities. Moreover, the quality of the forecast is not much improved by taking many years of historical data. In 3.2.2.4 we will consider the influence of the estimation of the transition probabilities on the quality of the forecasts in some detail. From our experience, it appeared to be sufficient in general to take T = 3 or T = 4.

Another possibility to determine the transition probabilities is the use of estimated transition probabilities from similar organizations for similar categories of personnel. It may also be useful to estimate the transition probabilities for a given personnel group from the transitions of employees on a higher level of aggregation within the organization, for instance, the estimation of wastage probabilities of highly trained engineers based on the wastage for all engineers in the organization.

3.2.2.4. *Quality of the forecasts*

Bartholomew [4] describes the following causes of prediction errors:

1) statistical causes;
2) estimation causes;
3) specification causes.

ad 1) Statistical causes

Statistical causes of prediction errors occur in the stochastic situation. Under the condition that all employees move independently through the categories, we have the following formula for the covariance of the numbers in category i and j at time t, according to Bartholomew [3], pp. 27-28:

(3.7) $\quad \text{cov}\{n_i(t), n_j(t)\} =$

$$= \sum_{k=1}^{K} \sum_{\ell=1}^{K} p_{ki} \cdot p_{\ell j} \cdot \text{cov}\{n_k(t-1), n_\ell(t-1)\}$$

$$+ \sum_{k=1}^{K} (\delta_{ij} \cdot p_{ki} - p_{ki} \cdot p_{k\ell}) \cdot \mathbb{E}n_k(t-1)$$

$\qquad$ for $i,j = 1,2,\ldots,K$

$\qquad$ for $t = 1,2,\ldots$

where

$$\delta_{ij} = \left\{ \begin{array}{l} 1 \quad \text{if } i = j; \\ 0 \quad \text{otherwise.} \end{array} \right.$$

The covariances are equal to zero for $t = 0$. The variance $V_i(t)$, which indicates the quality of the forecast of the number of employees in category i at time t, is given now by:

(3.8) $\quad V_i(t) = \text{cov}\{n_i(t), n_i(t)\}.$

Particularly important in judging the quality of the forecast is the variation coefficient which is given by:

(3.9) $\quad \dfrac{\sqrt{V_i(t)}}{\mathbb{E}\, n_i(t)} \quad .$

Under the assumption of independent behaviour of all employees the variation coefficients are relatively small - if the content of the categories is not too small - (see, for an example, Wessels/Van Nunen [89]). In the deterministic situation, where the transition fractions are fixed, the variances are equal to zero. Reality will be between these extremes.

ad 2) Estimation causes

The quality of the forecast depends on the estimation of the transition probabilities. In the situation of complete independent behaviour of the employees, the expected number of employees $\mathrm{Em}_{ij}(1)$ going from category i to category j in the time interval $(0,1]$ is estimated by $n_i(0) \cdot \hat{p}_{ij}$. Thus, the quadratic difference of this estimated value with the theoretically best forecast is:

$$(3.10) \quad n_i^2(0) \cdot [\hat{p}_{ij} - p_{ij}]^2.$$

If p_{ij} is estimated according to historical data (cf. (3.6)), then the expectation of this quadratic difference (given the numbers $n_i(t)$ and p_{ij}) is equal to

$$(3.11) \quad n_i^2(0) \cdot \frac{p_{ij}(1-p_{ij})}{\displaystyle\sum_{t=-T+1}^{0} n_i(t-1)} \quad ,$$

since

$$\sum_{t=-T+1}^{0} n_i(t-1) \cdot \hat{p}_{ij}$$

has a binomial distribution

$$B\left(\sum_{t=-T+1}^{0} n_i(t-1), p_{ij}\right).$$

Since the variance of $m_{ij}(i)$ is equal to $n_i(0) \cdot p_{ij}(1-p_{ij})$, the influence of the estimation of the transition probability on the quality of the forecasts is small if

$$\sum_{t=-T+1}^{0} n_i(t-1)$$

is substantially larger then $n_i(0)$. As we mentioned in 3.2.2.3, it is usually sufficient to take $T = 3$ or $T = 4$. In the deterministic situation, there is no influence of the estimate on the quality of the forecasts.

ad 3) Specification causes

The quality of the forecast also depends on the choice of the model which can not be tested generally. However, it is very important to

define the categories of personnel correctly, such that all relevant characteristics of employees are included in the model. The definition of the categories will be considered in some detail in section 3.3.

The quality of the forecast has been discussed in some detail in Bartholomew [3] , van der Beek [8] , Wessels/van Nunen [89].

3.2.2.5. *The longitudinal model*

In Markov models the evolution of the manpower distribution over a number of categories is considered. These models are called cross-sectional models. A specific type of Markov model is the longitudinal model in which the evolution of a group of employees entering the system at the same time is observed. The recruits of each year are distributed over the different groups which are called cohorts. For every cohort different transition fractions are used. The usefulness of this type of model lies in the fact that it is possible to analyse the situation in which the evolution of the employees depends on the type of cohort where they are belonging to. In longitudinal models the cohorts enter the system and disappear from it after some time. The number of employees in the various categories is then the sum of the contributions of each of the cohorts to these categories.

Define:

C $\equiv$ the number of cohorts;

$g_c(t)$ $\equiv$ the number of employees of cohort c entering at time t;

$n_i(t)$ $\equiv$ the total number of employees in category i at time t;

$p_{ic}(u)$ $\equiv$ the fraction of employees entering cohort c at time t, who are counted in category i at time t + u;

τ $\equiv$ the maximum number of periods an individual is counted in the model.

The following data is given: $C, \tau, g_c(t)$ and $p_{ic}(u)$, for all $c = 1, 2, \ldots, C$; $i = 1, 2, \ldots, K$ and $t = 1, 2, \ldots$

The following formula can be given:

$$(3.12) \quad n_i(t) = \sum_{u=0}^{\tau} \sum_{c=1}^{C} p_{ic}(u) \cdot g_c(t - u),$$

for $i = 1, 2, \ldots, K$; $t = 1, 2, \ldots$

Obviously, longitudinal models are equal to Markov models with an extended number of categories. If, in the Markov model, types of employees are distinguished for which different transition fractions are valid, a longitudinal model is obtained. Therefore, we will not discuss the longitudinal models separately in the remainder of this book. Longitudinal models are described extensively in Grinold/Marshall [40].

3.2.3. *Renewal models*

3.2.3.1. *The basic model*

The object of a renewal model is to forecast the manpower flows which are necessary to obtain given numbers of employees in all categories. As in Markov models, the situation is observed at equidistant points in time. The actual manpower distribution, the desired manpower distribution in the future and wastage fractions have to be known. The promotion flows and recruitment are determined by filling the vacancies. Therefore, renewal models are also called pull models. Notice that in this type of model the availability forecasting and the matching process are integrated.

We will only consider the renewal models for the deterministic situation. This means that wastage is also considered as a deterministic flow. This is, in general, a shortage of the model. With respect to the quality of the forecast, similar causes of prediction errors can be distinguished as given in 3.2.2.4.

Consider - as an example - a strictly hierarchical manpower system, where the filling of vacancies in all categories is only possible from the category below or by recruitment in category 1 (fig. 3.2).
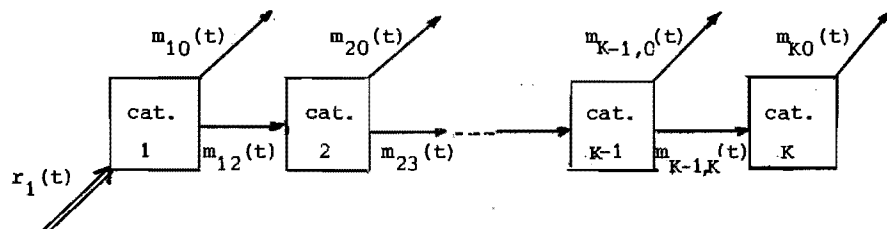
Figure 3.2. A strictly hierarchical manpower system with K categories.

The flows from category i to category j in the time interval $(t-1,t]$ are indicated by $m_{ij}(t)$ and recruitment in category 1 in the time interval $(t-1,t]$ is denoted by $r_1(t)$.

Define:

$n_i(t)$ $\equiv$ the desired number of employees in category i at time t;

$n_i(0)$ $\equiv$ the actual number of employees in category i at time $t = 0$;

$m_{ij}(t)$ $\equiv$ the number of employees who make a transition from category i to category j in the time interval $(t-1,t]$;

$r_i(t)$ $\equiv$ the number of recruits in category i in the time interval $(t-1,t]$;

where $i = 1,2,\ldots,K$; $j = 0,1,2,\ldots,K$; $t = 1,2,\ldots$ and $m_{10}(t)$ indicates wastage from category i during the time interval $(t-1,t]$.

Now, $m_{ij}(t)$ and $r_i(t)$ have to be computed, for $i,j, = 1,2,\ldots,K$ and $t = 1,2,\ldots$, while $n_i(t)$ is given, for $i = 1,2,\ldots,K$ and $t = 0,1,2,\ldots$. Wastage follows from:

$$\text{(3.13)} \quad m_{10}(t) = n_i(t-1) \cdot P_{10} \quad \begin{array}{l} \text{for } i = 1,2,\ldots,K \\ \text{for } t = 1,2,\ldots \end{array}$$

where P_{10} is the (given) wastage fraction from category i (as in the Markov model for the deterministic situation).

The promotion flow from category $K-1$ to category K follows from:

$$\text{(3.14)} \quad m_{K-1,K}(t) = n_K(t) - n_K(t-1) + m_{K0}(t) \quad , \text{ for } t = 1,2,\ldots$$

Remark. Equation (3.14) is only valid if $n_K(t) - n_K(t-1) + m_{K0}(t) \geq 0$, since otherwise the desired category size would be exceeded. If the desired category size has decreased more than the wastage flow, the following adaption of (3.14) is necessary:

$$\text{(3.15)} \quad m_{K-1,K}(t) = \max\{0, n_K(t) - n_K(t-1) + m_{K0}(t)\}, \text{ for } t = 1,2,\ldots$$

Moreover, equation (3.14) is only valid if $m_{K-1,K}(t) \leq n_{K-1}(t-1) + - m_{K-1,0}(t)$, since otherwise more employees would be promoted from category $K-1$ than the number of employees in that category. Thus, the following adaptation of (3.14) may be given:

(3.16) $m_{K-1,K}(t) =$

$= \min\{n_K(t) - n_K(t-1) + m_{K0}(t), \; n_{K-1}(t-1) - m_{K-1,0}(t)\}$.

A possible remedy would be the filling of a remaining shortage of em-
ployees in category K by promotion of employees from category K - 2.
Integration of (3.15) and (3.16) gives:

(3.17) $m_{K-1,K}(t) =$

$= \max\{0, \; \min[n_K(t) - n_K(t-1) + m_{K0}(t), \; n_{K-1}(t-1) - m_{K-1,0}(t)]\}$

□

If $m_{K-1,K}(t)$ is determined, then the transition flow from category
K - 2 to category K - 1 is computed, etc. Thus, the following formu-
la can be given (where exceeding of the bounds as mentioned in the
remark above is excluded):

$$m_{K-2,K-1}(t) = n_{K-1}(t) - n_{K-1}(t-1) + m_{K-1,0}(t) + m_{K-1,K}(t)$$
$$\vdots$$
(3.18) $$m_{12}(t) = n_2(t) - n_2(t-1) + m_{20}(t) + m_{23}(t)$$

$$r_1(t) = n_1(t) - n_1(t-1) + m_{10}(t) + m_{12}(t)$$

for t = 1,2,...

Renewal models are described, for instance, in Bartholomew [3], Bar-
tholomew/Forbes [6].

Example 3.2. Consider the manpower system of example 3.1. The actual
manpower distribution is given (table 3.1) as well as the constant
wastage fractions for category 1, 2 and 3, which are 0.1, 0.3 and 0.4
respectively. One wants to obtain a given manpower distribution in
the following 8 years. The question is how many recruits are needed and
what will be the numbers of promotions from each category. We will

consider two cases here:

1 the total manpower size increases by 3% each year, whereas the dis-
  tribution of the employees over the categories remains unchanged.
  We call this the dynamic case;

2 The total manpower size as well as the distribution of employees
  over the categories does not change. We call this the static case.

1. In the dynamic case, application of (3.13), (3.14) and (3.18) for
t = 1,2,...,8 gives the results as presented in table 3.3. Thus, the
desired manpower distribution and the numbers of employees which leave
the categories (wastage) determine the forecasted numbers of promotions
and recruitments.

	category									
	1			2			3			total
	E	S	T	E	S	T	E	S	T	
t = 0		140			100			60		300
t = 1	77 + 67 = 144			59 + 44 = 103			26 + 36 = 62			309
t = 2	79 + 69 = 149			61 + 46 = 106			27 + 37 = 64			318
t = 3	82 + 71 = 153			62 + 47 = 109			27 + 38 = 66			328
t = 4	84 + 73 = 158			64 + 48 = 113			28 + 39 = 68			338
t = 5	87 + 76 = 162			66 + 50 = 116			29 + 41 = 70			348
t = 6	89 + 78 = 167			68 + 51 = 119			30 + 42 = 72			358
t = 7	92 + 80 = 172			70 + 53 = 123			31 + 43 = 74			369
t = 8	95 + 83 = 177			72 + 55 = 127			32 + 44 = 76			380

Table 3.3. Forecast for the renewal model (dynamic case) of the man-
power flows for eight years ahead with constant wastage frac-
tions. The first column for each category (E) represents the
number of new entrants, the second column (S) indicates the
number of employees who stay in the category and the third
column (T) gives the total number of employees. All numbers
have been computed exactly and were rounded off afterwards
to the nearest integer values. Remind that the desired ca-
tegory size increases by 3% a year.

2. In the static case, where the manpower distribution is constant
and equal to the actual level, we obtain a steady-state behaviour of
the system. The number of promotions, wastage and recruitment are
constant then for each year, starting from the given wastage frac-
tions. The numbers of promotions and recruitments as well as the man-
power distribution are given in table 3.4.

	category			total
	1	2	3	
	E | S | T	E | S | T	E | S | T	
t = 0	140	100	60	300
t = 1	68 + 72 = 140	54 + 46 = 100	24 + 36 = 60	300
⋮	⋮	⋮	⋮	

Table 3.4. Forecasts for the renewal model (static case) of the man-
power flows. Wastage fractions and the desired manpower distribution
are assumed to be constant. The first column for each category (E)
represents the number of new entrants, the second column (S) indicates
the number of employees who stay in the category and the third column
(T) gives the total number of employees.

In table 3.4 it is demonstrated that constant recruitment of 68 people
and promotion of 54 and 24 employees from category 1 and 2 respective-
ly gives the stationary distribution. Thus, if the transition matrix
of the Markov model (fig. 3.1) would be changed (see fig. 3.3) and
68 people are recruited each year, the forecast of the Markov model
would give similar results (stationary distribution) as table 3.4.

$$
P = \begin{array}{c} 1 \\ 2 \\ 3 \end{array}
\begin{array}{ccc} 1 & 2 & 3 \end{array}
\left[\begin{array}{ccc}
.514 & .386 & 0 \\
0 & .46 & .24 \\
0 & 0 & .6
\end{array} \right]
$$

Figure 3.3. Transition matrix P for example 3.2. The promotion frac-

tions from category 1 and 2 are $\frac{54}{100} = .386$ and $\frac{24}{100} = .24$, respectively.

3.2.3.2. *Steady-state distribution*

Renewal models can be used to forecast the transitions of employees in order to obtain a given future manpower distribution. If the wastage fractions are constant, the policy with respect to promotion and recruitment which maintains a given manpower distribution can be computed easily. For this situation we have the following formulae:

$$m_{K-1,K}(t) = m_{K0}(t)$$

$$(3.19) \quad m_{i,i+1}(t) = m_{i+1,0}(t) + m_{i+1,i+2}(t) \quad , \text{ for } i = 1,2,\ldots,K - 2$$

$$r_1(t) = m_{10}(t) + m_{12}(t),$$

where $t = 1,2,\ldots$.

Remind from our remark on (3.14) in 3.2.3.1 that formulae (3.19) are only valid if the bounds on the number of employees in each category are not exceeded. Otherwise, modifications of such formulae are necessary, for instance, as suggested in the above-mentioned remark.

3.2.3.3. *Estimation of input data*

The input data which has to be estimated concerns the wastage fractions and desired future manpower distribution. The wastage fractions can be estimated in a way similar to the estimation of the wastage probabilities p_{i0} in the Markov model (3.6).

The estimation of the desired future manpower distribution can be executed by using the forecasting techniques for the manpower requirement as we described in chapter 2.

3.2.3.4. *Extension of the strictly hierarchical renewal model*

In 3.2.2.1 we considered a renewal model in which the filling of vacancies in all categories is only possible from the category below or by recruitment in category 1. However, if vacancies can also be filled

from another category or by recruitment, then the number of promotions
is not determined uniquely by the desired manpower distribution. Con-
sider, for instance, the manpower system where external recruitment
is also allowed in category 2 (fig. 3.4).
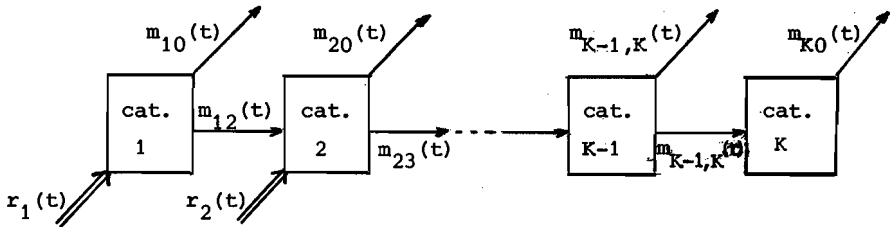
Figure 3.4. A manpower system with recruitment in two categories. The
notation corresponds with the notation of fig. 3.2.

Now, the relation for $m_{12}(t)$ in (3.18) has to be replaced by:

(3.20) $r_2(t) + m_{12}(t) = n_2(t) - n_2(t - 1) + m_{20}(t) + m_{23}(t).$

In fact, this means that one has to give a rule to distribute the to-
tal inflow in category 2 over the promotion flow from category 1 and
the recruitment flow in category 2. Possible rules are:

- recruit as many as possible from category 1;
- recruit from category 1 and from the external category in a fixed
  proportion.

This will be discussed in some more detail in subsection 3.3.2.

3.2.4. *Optimization models*

3.2.4.1. *The basic model*

As we have seen in subsection 3.2.2, the use of Markov models can
show the impact of constant transition fractions on the evolution of
the manpower distribution. In subsection 3.2.3 we considered renewal
models with which the impact of a given manpower distribution on the
numbers of transitions can be computed. Optimization models for man-
power planning can do both. These models combine the forecasting of

manpower availability and the matching with manpower requirement.

Many formulations of optimization models are possible. We will consider here some examples which can be found (somewhat modified) in literature (see, for instance, Grinold [39], Uebe/Beckman/Fischer/Marwitz [78]).

Consider – as an example – a strictly hierarchical manpower system (cf. fig. 3.4).

Define:

$n_i(t)$ ≡ the number of employees in category i at time t;

$\bar{n}_i(t)$ ≡ the minimally required number of employees in category i at time t;

$n_i^*(t)$ ≡ the maximally allowed number of employees in category i at time t;

p_{i0} ≡ the wastage fraction from category i;

$\bar{p}_{ij}$ ≡ the minimal promotion fraction from category i to category j;

p_{ij}^* ≡ the maximal promotion fraction from category i to category j;

$m_{k\ell}(t)$ ≡ the number of employees who make a transition from category k to category ℓ in the time interval $(t-1,t]$;

$d_{k\ell}$ ≡ the costs for an employee who makes a transition from category k to ℓ;

c_i ≡ the yearly salary costs for an employee in category i;

for i,j, = 1,2,...,K; for k,ℓ = 0,1,2,...,K; for t = 1,2,...,T. $m_{k0}(t)$ indicates the wastage from category k in the period $(t-1,t]$, whereas $m_{0k}(t)$ indicates the recruitment in category k in this period. The planning horizon is denoted by T.

Suppose $\bar{n}_i(t)$, $n_i^*(t)$, $n_i(0)$, p_{i0}, $\bar{p}_{ij}$, p_{ij}^*, $d_{k\ell}$ and c_i are given for i,j = 1,2,...,K, for k,ℓ = 0,1,2,...,K, for t = 1,2,...,T. The flows $m_{k\ell}(t)$ and the number of employees in all categories $n_i(t)$ have to be chosen now such that a given criterion is optimal.

One possible objective is to minimize:

$$(3.21) \qquad \sum_{t=1}^{T} \left\{ \sum_{i=1}^{K} c_i \cdot n_i(t) + \sum_{k=0}^{K} \sum_{\ell=0}^{K} d_{k\ell} \cdot m_{k\ell}(t) \right\}.$$

Restrictions with respect to the numbers of promotions are:

$$(3.22) \quad n_i(t-1) \cdot \bar{p}_{ij} \leq m_{ij}(t) \leq n_i(t-1) \cdot p^*_{ij}, \quad \text{for } i,j = 1,2,\ldots,K$$
$$\text{for } t = 1,2,\ldots,T.$$

Restrictions with respect to the manpower distribution are:

$$(3.23) \quad \bar{n}_i(t) \leq n_i(t) \leq n^*_i(t) \qquad\qquad , \text{ for } i,j = 1,2,\ldots,K$$
$$\text{for } t = 1,2,\ldots,T.$$

Minimization of (3.21) under the conditions (3.22) - (3.23), the defining relations (3.14)-(3.15) and the condition that all variables are nonnegative, gives the flows and the manpower distribution in the future.

In optimization models usually a finite horizon is chosen. One may also compute the steady-state manpower distribution and the corresponding numbers of employees which make a transition. We will not discuss this in more detail.

Since all flows are deterministic, the statistical causes of prediction errors need not to be discussed here. We refer for the other causes of prediction errors to 3.2.2.4.

Optimization models are described, for instance, in Grinold/Marshall [40], Smith [75], Vajda [80].

3.2.4.2. *Goal programming*

A goal programming model is a specific type of optimization model. In a goal programming model a number of goals are established which the decision maker desires to achieve. Such goals are, for instance, minimum total salary costs, avoiding overemployment, a certain employment of minorities, etc.

An example of a goal programming model is obtained if one wishes –
apart from the minimization of (3.21) – to minimize the deviations of
the promotion flows from certain desired promotion flows in order to
obtain a stable number of promotions. Then one has to add to the ob-
jective function (3.21) the following term:

$$(3.24) \quad P_1 \cdot \sum_{t=1}^{T} \sum_{i=1}^{K} \sum_{j=1}^{K} \left| m_{ij}(t) - n_i(t - 1) \cdot p_{ij} \right|.$$

If one also wants to minimize the deviations of the manpower distri-
bution with some desired manpower distribution the following term must
be added:

$$(3.25) \quad P_2 \cdot \sum_{t=1}^{T} \sum_{i=1}^{K} \left| n_i(t) - n_i'(t) \right|,$$

where $n_i'(t) \equiv$ the desired number of employees in category i at time t.
P_1 and P_2 are the weights assigned to each goal by the decision
maker.

A solution to the programming problem may lead to an adaptation of the
priorities of the decision maker whereafter the new goal programming
problem can be solved until acceptable values of the decision varia-
bles are obtained. The technique of goal programming has been describ-
ed, for instance, in Ignizio [44]. Applications of goal programming
for manpower planning are given in Charnes/Cooper/Niehaus [23] and in
Kahalas/Gray [46].

3.2.4.3. *Aggregation*

If categories are partly defined by characteristics like age, length-
of-service and so on, the goals have to be formulated, in general, on
aggregated flows or aggregated categories. The number of people in a
certain grade may be important, but not the distribution of these em-
ployees over age and length-of-service. In the same way, the distri-
bution over age of the numbers of employees promoted from a certain
grade is not important.

Thus, if $C = \{c_\ell\}$ is the collection of all categories after aggrega-
tion over age, then we obtain for (3.24) – (3.25) the following formu-

lae:

$$(3.26) \quad \sum_{t=1}^{T} \sum_{\ell} \sum_{k} \left| \sum_{i \in c_{\ell}} \sum_{j \in c_k} m_{ij}(t) - \sum_{i \in c_{\ell}} n_i(t-1) \cdot p_{c_{\ell} c_k} \right| ,$$

$$(3.27) \quad \sum_{t=1}^{T} \sum_{\ell} \left| \sum_{i \in c_{\ell}} n_i(t) - n'_{c_{\ell}}(t) \right| ,$$

where $n'_{c_{\ell}}(t) \equiv$ the total desired number of employees in all categories of c_{ℓ} and $p_{c_{\ell} c_k} \equiv$ the desired transition fraction from aggregated category c_{ℓ} to aggregated category c_k.

3.2.4.4. *Estimation of important data*

As in renewal models, we assume that the expected wastage will be realized in the future. Thus, the described optimization models presume a deterministic situation.

The input data which has to be estimated depends on the exact formulation of the model. For the basic model, for instance, wastage fractions have to be estimated, as well as the upper and lower bounds for the transition fractions and for the numbers of employees in all categories. In section 3.3 this will be discussed in some detail.

3.3. Discussion of the models

In this section we will discuss the models described in section 3.2. We will consider here, in particular, whether these models are appropriate for the manpower planning approach we suggested in subsection 1.2.5. Therefore, the following features of the models will be discussed in the subsections:

1. definition of the categories, i.e. which characteristics of employees can be included in the models?
2. usefulness for the design of manpower policies, i.e. can these models show the impact of alternative manpower policies?
3. computational aspects of the models.

3.3.1. *definition of the categories*

In this subsection we will consider which characteristics of employees should be included in the definition of categories and which models are appropriate for such a category definition.

The definition of the categories has to satisfy the following conditions:

a the characteristics which are included in the models have to be such that matching of requirement and availability of personnel can be done;

b the wastage of personnel is forecasted adequately;

c alternative career policies can be designed.

We will consider these conditions in some detail now.

ad a. As we mentioned in section 1.5 with respect to multi-category models, the degree of aggregation and thus the definition of the categories depends on the organization level where the planning is executed. If management is interested, for instance, in manpower planning for highly trained engineers, relevant characteristics in manpower requirement may be the function level, the training and development level and the experience of the engineers. These characteristics have to be included then also in the manpower availability forecasting model. In section 4.3 we will give some examples of relevant characteristics for different aggregation levels.

ad b. The models should also offer the opportunity to include the characteristics of employees which are correlated with wastage, such as the age, length-of-service (sometimes) or sex (sometimes). In order to obtain reliable forecasts for the numbers of employees which will leave the organization it may be useful to distinguish retirements, being strictly age dependent, and other reasons for withdrawal or wastage. Wastage for the other reasons will be called from now on turnover.

Some general characteristics of wastage patterns are: turnover decreases with the age of the employee, (except for high age groups because of illness) with length-of-service (except for high length-of-service because of illness), increasing skill or salary. Besides, wastage is higher for women then for men. More about this subject can be found in Bartholomew [5] , Bowey [16], Tuggle [77].

ad c. As mentioned in subsection 1.4.4 the design of alternative career policies has a great impact both on the organization and on the individual employees. The career opportunities of the employees occupy a special place in manpower planning as we discussed in our view

on manpower planning (subsection 1.2.5). Therefore, the model one would like to use for manpower availability forecasting has to be such that career policies can be made visible and the design of alternative career policies is facilitated. Relevant characteristics of employees with respect to the career prospects may be the function level (grade) and the grade seniority which indicates the number of years an employee has spent in his current grade.

In the remainder of this subsection we will discuss whether the different models are flexible with respect to the category definition.

In Markov models the categories can be chosen such that several characteristics of employees are included in the model. Such an extended Markov model may contain, for instance, the characteristics grade and grade seniority. In particular the career policies can be represented very well in such a model, since the career opportunities may be expressed by the average grade seniority at which promotion occurs. Of course, the Markov model is more appropriate for types of organization with a high degree of commitment (remind section 1.6) than for other organizations. This can also be illustrated by the type of organizations where Markov models have been applied (see section 4.3, chapter 6 and Verhoeven/Wessels/Wijngaard [86]).

Wastage is assumed to be a push flow in a Markov model which is a realistic assumption. Moreover, the age of the employees may be included in the model which enables the forecasting of retirement and turnover separately.

It should be remarked that extension of the number of categories implies that many transition fractions have to be given, but many of these are trivial (for instance the yearly transitions to a higher age or grade seniority). Furthermore, it is not necessary to estimate these fractions separately. One can use a certain level of aggregation in the estimation, for instance, by summarizing over the age classes.

Examples of Markov models with extended categories will be given in section 4.3 and have also been given by Bartholomew/Forbes [6].

In renewal models it may be difficult to include additional characteristics of employees. If one desires to take into account the age of the employees, one has to indicate in advance from which age clas-

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ses a possible vacancy will be filled. Also, if one wants to consider the grade seniority, in order to design alternative career policies, one has to indicate from which grade seniorities a possible vacancy will be filled. Thus, renewal models are not very appropriate in indicating the impact of career policies. In fact, the pull element emphasizes the restrictions of the allowed manpower distribution. Renewal models may be useful, particularly, in organizations where the design of alternative career policies is less important. Many applications of these models can be found in the Civil Service in Great Britain. It should be remarked that the introduction of certain characteristics such as age and grade seniority in a renewal model gives the combination of a pull and a push element. On one hand, one has to indicate how vacancies have to be filled (pull), on the other hand, the age and grade seniority of employees increase each year by one (push). Examples of renewal models with extended categories are given by Nash/Goddard [60] and by Sherlock [72].

In optimization models it is also possible to include additional characteristics but the size of the models will become then very large. This is discussed in some detail in subsection 3.3.3. In our view, an extension of the number of categories in optimization models is not always easy, since it may not be possible to translate the preferences of management with respect to detailed manpower flows in costs and restrictions of the model. For instance, if the grade seniority of employees is included in the model, it may be difficult to give mimimum and maximum promotion fractions for all grade seniorities. Therefore, optimization models may be particularly useful for organizations with strictly formulated goals and restrictions. Applications can be found especially in defense organizations in the United States. There, the goals are mainly formulated in the numbers of employees in certain (aggregated) categories and also in equal employment terms.

3.3.2. *Usefulness for the design of manpower policies*

In this subsection we will discuss the usefulness of the manpower availability forecasting models for the design of manpower policies.

Markov models are essentially based on career policies and are therefore very will applicable for comparing the impact of alternative

career policies. Renewal models are essentially based on the manpower
requirements and therefore show the consequences of given requirements.
Both types of models can be useful for the matching process: in push
models one can vary the career policies until the computed availabi-
lities agree with the requirements; in pull models one can vary the re-
quirements until the resulting career policies are acceptable. So, the
choice for one type of model is not a very fundamental one, since both
types of models can be used for the same purpose. The main point is
the fact that these models can show the impact of alternative policies.

In principle, this is also the case for optimization models. By choos-
ing the right restrictions, the optimization model can be very close
to either a Markov model if there are strict promotion restrictions,
or to a renewal model if the allowed number of employees is strictly
formulated. However, it is very difficult to translate the preferences
of management with respect to manpower flows in costs and restrictions
of a linear programming model. This is especially true since costs of
some aspects are essentially difficult to compare (e.g. the salaries
and deviations in the objective function (3.21) combined with (3.24))
and since many costs are essentially nonlinear (e.g. deviations only
become important if they surpass some bound or if they occur together
with some other feature). Moreover, the number of situations that can
arise is so large and the situations are so different, that it is
practically infeasible to check all these situations with respect to
preference.

It is not only difficult to construct a linear programming model, it
is also difficult to evaluate the results. The usual post-optimal
analysis does not give sufficient information about the sensitivity
of the solution with respect to the conditions and costs involved.
Notice that the costs of deviations of the goals are partly artificial.

It is very well possible, and not simply verifiable, that quite a lot
of costs are caused by some combination of conditions which are in fact
not needed so strictly (for another discussion of this aspect, see
Wessels/van Nunen[89]). If goals and restrictions are often changed,
the use of optimization models becomes very expensive.

3.3.3. *Computational aspects*

In this subsection we will make some remarks on computational aspects (computation time and storage capacity) of the manpower availability forecasting models. For Markov and renewal models the computation times are usually relatively low.

Consider, for instance, a manpower system with 5 grades and 10 grade seniorities (see fig. 3.5). A category is, thus, defined by (grade, grade seniority).
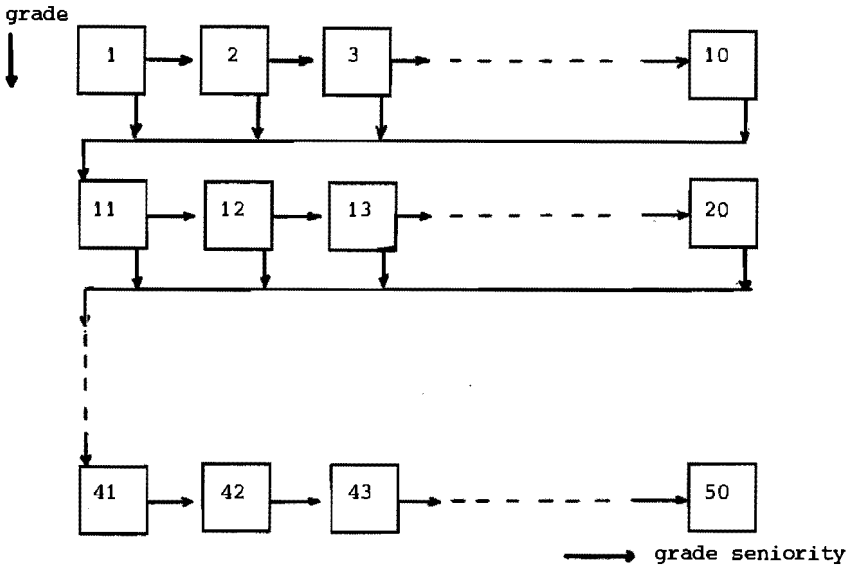
Figure 3.5. Schematic representation of a manpower system with 5 grades and 10 grade seniorities in all grades. Wastage is not represented here. From all categories in the first 4 grades, there are two flows out of the category which have to be computed (promotion and wastage). The third transition out of a category is straightforward, since grade seniority increases by 1 each year. In category 50 there is only one flow out of this category (wastage).

Thus, for the Markov model, the computation time depends on the number of categories and on the length of the planning horizon. A complete run for this example with a planning horizon of 10 years took only a few seconds process time on a Burroughs B7700 computer. For the renewal model similar considerations can be given, assuming that the

manpower distribution over the grades has been given as well as the distributions of the input in each of the grades over the grade seniorities.

It should be remarked that computation time increases with the number of categories and the number of transitions. If, in the example above, age is included instead of grade seniority, the number of categories may be about $5 \times 50 = 250$. However, a reduction of the numbers of categories and transitions is often possible since some combinations of grade and age will not occur in practice. This will be discussed in some more detail in section 4.6.

Usually, the solution of an optimization model takes (relatively) much computation time. For the example of fig. 3.6 and for an optimization model cf. (3.21) - (3.23) we have about 900 variables and 1400 constraints. The restrictions are set then on the numbers of employees in each grade and on the promotion flows from each category, while the planning horizon is 10 years. Solution of this problem takes app. 3 minutes processtime on a Burroughs B7700 computer.

Similar conclusions can be drawn with respect to the required storage capacity. In Markov models, it is important to store the transition matrix efficiently. It is sufficient to store the elements which can be positive (cf. fig. 3.1). In renewal models no transition matrix is necessary but the manpower requirement as well as the priority rules for the filling of vacancies have to be stored. The size of optimization models is (relatively) large as we mentioned above. Moreover, the optimization packages require storage capacity themselves.

3.4. Conclusions

In this section we will draw some conclusions with respect to the question which type of model is most appropriate for manpower planning.

Manpower planning models have to satisfy the conditions mentioned in section 3.3. Based upon this discussion we do not recommend optimization models for medium and long term manpower planning. Simply said,

it is not clear in these models which judgement has been built in. Moreover, because of the large numbers of variables and constraints changing policies may lead to many changes of parameter values.

In our view, for manpower planning the most appropriate approach is mathematically a very simple one: present the impact of alternative policies to management and let management do the evaluation. This can be achieved by designing a manpower planning system which facilitates an easy analysis of policy changes and which provides management with the forecasted impact of these changes. In section 3.5 we will discuss this in some more detail.

Thus, in our view, Markov and renewal models are the most valuable models for manpower planning. Of these two models we prefer a Markov model as a basis for a manpower planning system. The Markov model, namely, fits best for our manpower planning approach as introduced in subsection 1.2.5. The three phases of the manpower planning process can, thus, be distinguished, where the Markov model can be used for the pure manpower availability forecasting. Alternative parameter values for recruitment and promotion lead to changes in manpower availability which may agree better to the manpower requirement. Also desirable adaptions of manpower requirements become apparent in this way. More-over, application of Markov models enables the direct consideration of individual prospects since the transitions are assumed to be push flows. Thus, existing career policies are embedded directly in the forecasting procedure. In renewal models and optimization models the manpower availability forecasting and the matching process are inter-fering and, particularly in renewal models, the individual prospects of employees are not considered explicitly.

3.5. Manpower planning systems

In section 3.4 we made the choice for a Markov model as a manpower availability forecasting model. A manpower availability forecasting model is only part of a manpower planning system. Here, we will dis-cuss which demands should be met by a manpower planning system.

Manpower planning systems have to support management in taking the right decisions concerning manpower policies. The underlying model has to be understandable by management. Moreover, a manpower planning

system should help in the design of policies by presenting the forecasted impact of alternative policies to management in a meaningful way. One is not interested in the consequences of one particular set of input data. Management must be able to change recruitment policies, career patterns, etc. in an easy way and has to obtain the results of such changes immediately in a conveniently arranged form. This means that an interactive computer program is needed which can be used, for instance, via a typewriter terminal. Alternative policies can be evaluated immediately then and one has the opportunity to base changes in parameter values on previous results. For practical reasons, interactive planning systems must have low computation times which again makes the application of optimization models inattractive.

The evaluation of the impact of a given policy has to be done by experts (a personnel manager or, for instance, a staff member of the personnel or planning division). This means that manpower planning systems using a forecasting model of the evolution of the manpower distribution have to be made such that they can be used by them. Thus, the codes for the operation of the system (change of policies, calculation of the results, etc.), have to be expressed in manpower planning terms. In our view, the human assessment of the alternatives is absolutely necessary for manpower planning systems.

In summary, a manpower planning system should meet the following demands:

- it has to be based upon a model in which the evolution of manpower availability is described adequately and in which the decision variables are indicated clearly;
- input and output have to be organized in such a way that the system can be used by experts for manpower planning rather than experts for computer software;
- it has to contain many options to implement easily alternative policies;
- it has to present the results in a conveniently arranged form;
- no criteria have to be built in for evaluation of the results; evaluation is done by management;
- it has to be an interactive planning system.

Keen/Scott Morton [48] describe the conditions which have to be satis-

fied by such decision support systems for other areas of application. In chapter 4 we will describe the manpower planning system FORMASY of which we claim that it satisfies the above-mentioned demands.

FORMASY: AN INTERACTIVE MANPOWER PLANNING SYSTEM

4.1. Introduction

In section 3.4 we argued that Markov models can serve as a suitable
basis for a manpower planning system. When applying such models, it
is possible to evaluate the impact of alternative policies on the
evolution of the manpower size and distribution by changing transition
fractions and/or recruitment.

In section 3.5 some practical conditions have been given which a man-
power planning system should satisfy. In this chapter we will present
an interactive manpower planning system, based on a Markov model,
which satisfies these conditions. This planning system is called
FORMASY which stands for: FOrecasting and Recruitment in a MAnpower
SYstem.

We will discuss in section 4.2 the main characteristics of FORMASY.
Some examples of manpower structures for which it has been used
are given in section 4.3. In section 4.4 we explain the various
options of FORMASY illustrating the applicability of this manpower
planning system of practical personnel planning. In section 4.5 we
consider the estimation of the transition fractions. The computational
efficiency of the program system is discussed in section 4.6. Finally,
in section 4.7, the usefulness of FORMASY for manpower planning is
considered.

4.2. FORMASY

The basis of FORMASY is a Markov model for the evolution of the man-
power distribution. The categories, in which the employees are clas-
sified, are defined by four labels: g, q, e and s. These labels can
be applied with some phantasy, but their primary purpose will be in-
dicated below. Furthermore, the age of an employee in the category
(g,q,e,s) is considered. Thus, the following characteristics of em-
ployees are incorporated in the model:

. g is the grade or function level (g = 1,2,...,G);

. q is a variable index (g = 1,2,...Q);

. e is a variable index (e = 1,2,...,E);

. s indicates the grade seniority, i.e. the number of years the employee already spends in his current grade (s = 1,2,...,S);

. a is the age of the employee.

The variable indices q and e can be used, for instance, to indicate the qualification or experience, the level of training and development, the potential abilities, the mobility of the employee, etc. The variable a (age) is only used to predict the retirement. So, if age is also an explanatory factor for promotion or turnover, then one of the variable indices should be reserved for age (see section 4.3, example c).

It should be remarked that the flexibility of FORMASY with respect to the category definition is a main advantage over existing manpower planning systems such as MANPLAN (see Nash/Goddard [60]) or CAMP (see Dudding/Piskor [29]); see also Huisjes/van Tuyll van Serooskerken/ Wijbenga [43] and Siebelt/Taal/van Wijk [73].

In the remainder of this chapter we use "category" for a group of employees defined by (g,q,e,s) and "class" for a group defined by (g, e). Thus, in every class several grade seniorities may occur.

In a model with the variables indicated above an employee in category (g,q,e,s) usually makes a transition to (g,q,e,s+1). If his grade changes in a certain year to g', then his next category is (g',q,e,1). Of course, every year his age increases by one. Sometimes the variable indices may also change. If e represents, for instance, the training level of the employee then an employee, who finished a training program but stays in his current grade, moves from category (g,q,e,s) to (g,q,e+1,s+1). This transition structure makes it possible to construct efficient computer programs and it facilitates the input of the transition fractions, since only the possible transitions have to be considered. We will discuss this aspect in some detail in section 4.6 (see further subsection 3.3.3, section 4.3 and Verhoeven/Wessels/ Wijngaard [86]).

It has appeared in practice, that a Markov model with a category definition as given above is rich enough to serve as a basis for a man-

power planning system. On the other hand, such a system is not too
complex with respect to data-collection and computational efficiency
as will be considered in subsequent sections.

FORMASY has been written originally in BEA (Burrough's Extended Algol)
which is a version of ALGOL 60 and has been implemented on the Bur-
roughs B7700 computer at Eindhoven University of Technology (see Ver-
hoeven [82]). Translations have been made, for instance, in FORTRAN,
ALGOL and BASIC and implementation is accomplished at this time on
several other computer systems in large Dutch organizations.

4.3. Examples of FORMASY models

In this section we will give some examples of manpower planning pro-
blems within Dutch organizations. For every example it is indicated
how the model structure may be chosen and how this can be implemented
in FORMASY.

Example a.

In the Netherlands Public Works Office, the engineers of three
different training levels have their own grade system. For all three
groups there are five grades, after lumping of some of the top-grades
in which only a small number of employees can be found. This aggrega-
tion is allowed since employees in these top-grades cannot be promoted
to other grade systems and will leave the grades only by wastage.

For the two higher level groups of engineers there is no need for ex-
tra indices. The groups are homogeneous with respect to training and
the experience of the employees is indicated properly by the grade
and the grade seniority. The lower level group of engineers (called
surveyors) is a less homogeneously trained group of employees with
corresponding by different types of experience for people in the same
grade. The age of the employees is included in order to predict the
retirements.

One is interested in the career opportunities within these grade sys-
tems as well as in the development of the manpower supply and the
matching with the manpower requirement.

We will describe now the models for the three groups of engineers.

1. For the top-level engineers and for the middle-level engineers we obtain a model with

   $G = 5$; $Q = 1$; $E = 1$;

   $S = 10$ and 13 respectively (see figures 4.1 and 4.2).
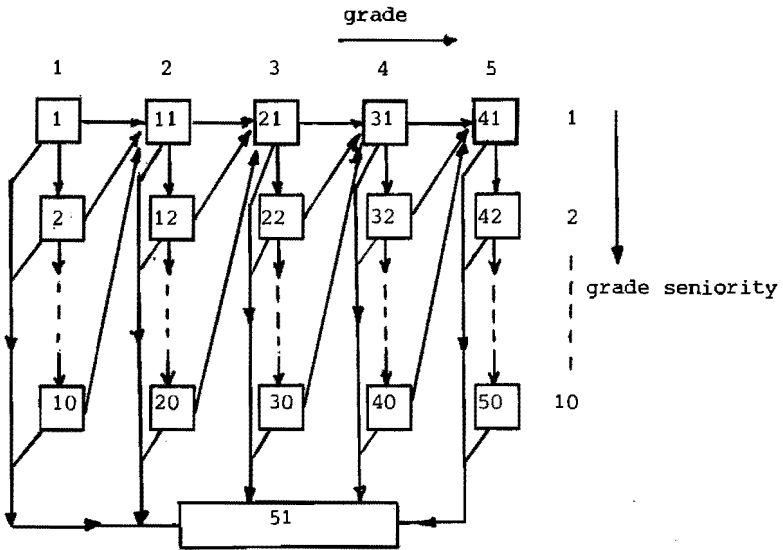
Figure 4.1. The positions or categories for the top-level engineers of example a.1 with the transition possibilities.
Position 51 denotes the class of the former employees.
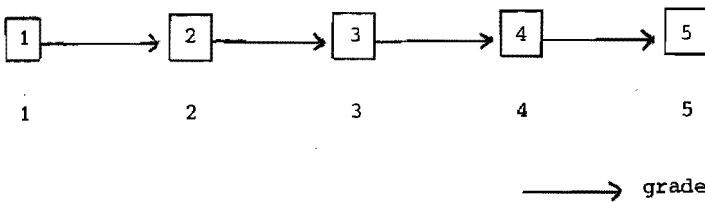
Figure 4.2. A simplified version of fig. 4.1, where the grade seniority refinement has been suppressed and the class of the former employees has been deleted.

2. For the surveyors four levels of training appear to be relevant.
   This leads to a model with

   G = 5 ; Q = 4 ; E = 1;

   S = 12.

   Some lumping of categories is possible here, since for older people
   the fact that they reached a certain grade implies that their ex-
   perience compensates a lack of theoretical knowledge. Thus, the ca-
   reer prospects are assumed to be equal for experienced employees
   and higly trained employees. This clustering leads, excluding the
   class of the former employees, to 13 × 12 categories instead 20 × 12
   (see fig. 4.3).
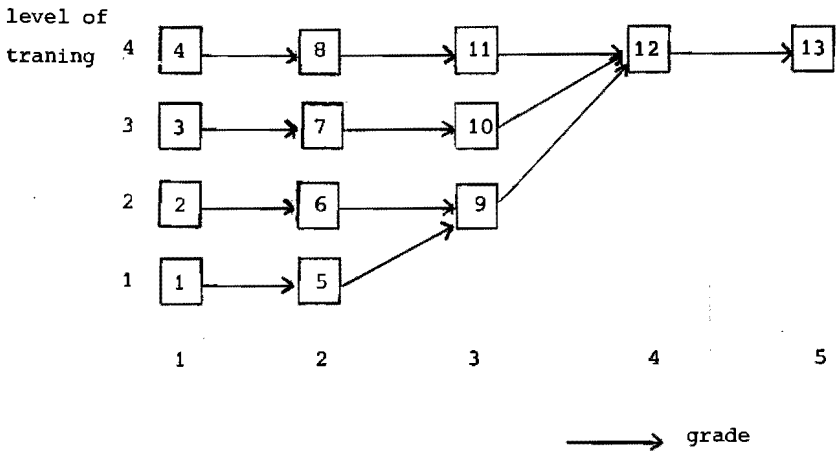
Figure 4.3. The classes for the surveyors of example a.2 and the
              transition possibilities. As in fig. 4.2 the grade se-
              niority and the former employees have been deleted.

This example will be discussed in some more detail in section 5.2
and has been described extensively in Van der Beek [9], Van der
Beek/Verhoeven/de Waij [10] and in Van der Beek/Verhoeven/Wessels
[11].

Example b.

1. In the Netherlands, the Ministry of the Interior has a Directorate
   Police for the local police forces. With respect to the future avai-
   lability of management, one is interested in the career of individual

employees and in the necessary recruitment for the medium and
long term. The Markov model, in this example, has essentially five
grades (as in the foregoing example the top-grade in the model
aggregates some sparsely occupied actual top-grades), but the low-
est grade has a subdivision in three subgrades (see fig. 4.4). In
two of these subgrades recruitment is possible. The difficulty,
now, is that for the promotion to the next main grade one counts
the total number of years spent in the lowest main grade. So, the
number of years spent in the last subgrade has no influence. This
can be accounted for in the model by using one of the variable in-
dices to indicate the subgrades. The grade seniority then indi-
cates the number of years spent in the main grade. The age is
again only used for predicting the retirements.
In this way we obtain a model with

$G = 5 ; Q = 3 ; E = 1;$

$S = 10$ (see fig. 4.4).
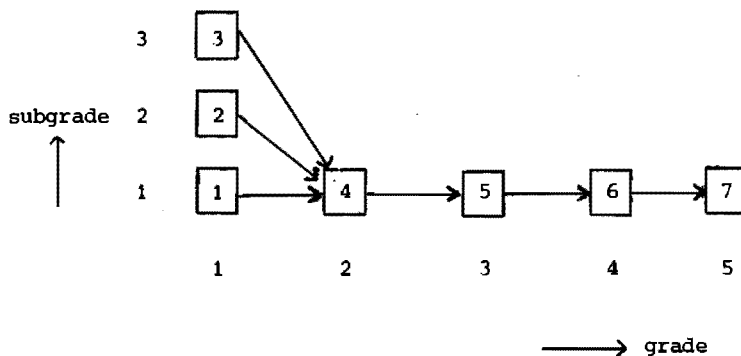
Figure 4.4. The classes for members of the police management in
example b.1 and their transition possibilities (the
class "gone" has been deleted).

This example has been described in Van Meeteren [57] and, roughly,
in Verhoeven [83].

2. FORMASY has also been used on local police force level for the po-
licemen with lower ranks. The characteristics in this model are
grade, grade seniority and sex, since female police officers have
much higher wastage rates. One is especially interested here in the

career opportunities and in the necessary recruitment. Moreover, one is interested in the consequences of changes in the ratio of male and female recruits. More female recruits improves the career possibilities of male employees because of the higher wastage rates for women.

This model has

$G = 5$; $Q = 2$; $E = 1$;

$S = 13$; (see fig. 4.5).
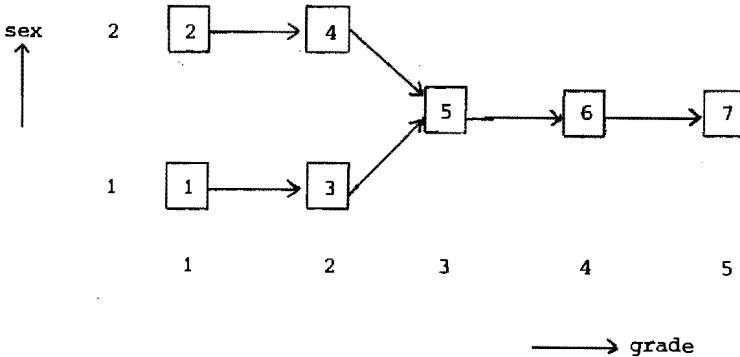
Figure 4.5. The classes for policemen with lower ranks where in the two lowest grades also the characteristic sex has been included.

This application has been described by Van Meeteren [58].

Example c.

In a large industrial firm one is interested in the development of the total manpower size, the necessary recruitment and in the future distribution of the employees over some main grades. These main grades define the function levels of the employees. Promotion within this model is determined by grade and age whereas the wastage fractions depend on grade, age and length-of-service. It turned out that wastage fractions were high for small length-of-service. Therefore, three levels of length-of-service have been included in the model (0-1 year, 1-2 years, more than two years). For this situation, age and length-of-service can be used as variable indices, whereas grade seniority has not been included in the model).

G = 5 ; Q = 3 ; E = 49 (ages 16-64 years);

S = 1 ; (see fig. 4.6).

length of service
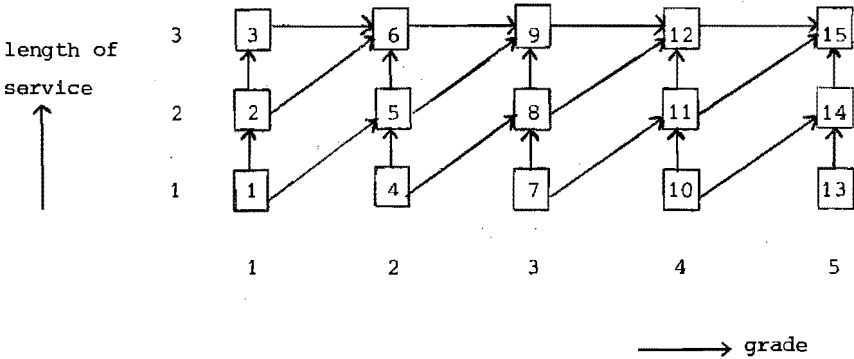
Figure 4.6. The classes and transitions in the industrial firm of example c (now the age and the class "gone" have been deleted)[1].

This example is discussed, for instance, in Verhoeven/Wijngaard [85].

Example d.

In a staff department of a large industrial firm one wants to obtain a given number of employees with certain professional levels and stable recruitment policies. In the model ten grades are distinguished. Promotion is mainly determined by grade seniority (S = 10) and professional level. One distinguishes three professional levels of which the highest is equivalent to a completed university training (masters' or doctors' degree). A person's professional level can change either if formal degrees are obtained or, if one's professional level has been reestimated internally. The model obtained in this way has:

G = 10 ; Q = 3 ; E = 1;

S = 10 (see fig. 4.7).

---

1) in this example "class" is defined by (grade, length-of-service).
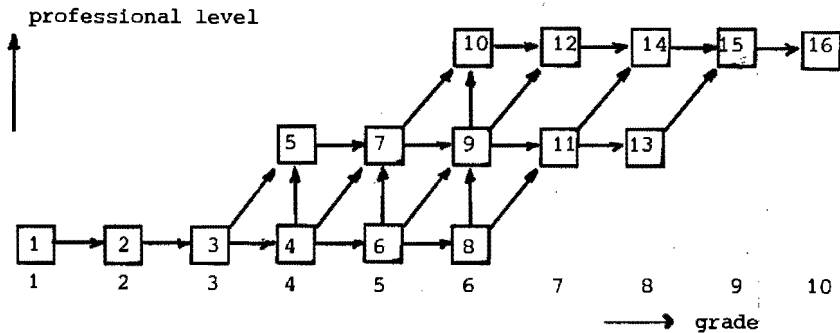
Figure 4.7. The classes and transition possibilities in example d
(the class "gone" has been deleted).

In the situation of this example also an even more refined model has
been used which incorporates an age index. For this index we used the
second variable index. This index gives an indication for the age of
the employee, viz. $e = 1$ if the age is between 16 and 34, $e = 2$ if the
age is between 35 and 44, $e = 3$ if the age is between 45 and 65. It
will be clear that in a Markov model such a rough age index cannot in-
dicate the age classes properly, since one does not know exactly when
the index has to be changed if the exact age has not been included.
However, such a rough index can be of help, if some promotion proba-
bilities are influenced partly by age. This example has been described
in Kessels [49] and in Esser [30].

4.4. Options of the FORMASY system

By using FORMASY, valuable information can be obtained for the design
of manpower policies. In this section we will describe in detail the
options of the program system which make it possible to obtain this
information. For which types of manpower planning problems these op-
tions can be used will be discussed in chapter 5.

We will distinguish the following options:

1. forecasts with respect to the manpower distribution over the cate-
   gories. These options provide the forecasts of the manpower distri-
   bution, the statistical errors for these forecasts, the steady

state distribution of employees, the age distributions and fore-
casts of the salary costs.

These options will be discussed in the subsections 4.4.1 - 4.4.5.

2. data with respect to average career schemes, career planning (sub-
section 4.4.6).

3. simulation possibilities of the model (changes of transition frac-
tions, recruitment).

These options will be described in subsection 4.4.7.

The examples of tables and figures in this section have been taken
from the application for the middle-level engineers of section 4.3
(example a.1).

4.4.1. *Forecast of the manpower distribution*

The forecasted manpower distribution over the categories is computed
for an arbitrary planning period chosen by the user. The following
data is needed for this forecast:

- the actual manpower distribution over the various categories, in-
cluding the age;
- promotion and turnover fractions for all categories. These fractions
are assumed to be constant;
- for each future year within the planning horizon the number of re-
cruits and its distribution over the various categories.

The forecasting procedure for the number of employees in each class
when grade seniority, age and retirement is not taken into account is
described by (3.1). The introduction of grade age and age is straight-
forward. All promotions take place to grade seniority one and every
year-in the case of no promotion-the grade seniority of the employee
increases by one. Each year, age increases by one until the retirement
age is reached. In section 4.6 we will describe the computation method
in some more detail.

The forecasts are printed in the form of a table or a histogram which
can be given for each of the included characteristics of employees
(grade, qualification, grade seniority, etc.). Examples of such tables
are table 4.1 and table 4.2; a histogram is presented in fig. 4.8.

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```
MANPOWER DISTRIBUTION IN PLANNING PERIOD
..................................

                        GRADE
YEAR *    TA    TA1    THA    THA1   THABD   *   TOTAL

1977 *    238   547    376    180     70     *   1411
.............................................
1978 *    208   531    394    184     75     *   1392
1979 *    190   504    412    190     75     *   1371
1980 *    184   473    425    200     79     *   1361
1981 *    182   440    436    210     81     *   1349
1982 *    182   410    448    222     86     *   1348
```

Table 4.1. Actual manpower distribution over the grades and the fore-
casts for the planning period (in this example 5 years).
The names of the grades are: TA, TA1, THA, THA1 and THABD.

```
        YEAR : 1980
        ------------------

GR.SENIORITY     TA   TA1   THA   THA1  THABD
-----------------------------------------------
     1    **     65    55    64    34    15
     2    **     54    61    68    33    15
     3    **     37    64    66    30    14
     4    **     13    70    42    16     4
     5    **      7    59    44    23     7
     6    **      3    47    30    15     4
     7    **      4    22    23    10     7
     8    **      1    18    20    10     3
     9    **      1    33    25     9     6
    10    **      0    13    15     7     2
    11    **      0     6     8     6     1
    12    **      0     3     5     3     2
    13    **      0    22    15     2     1
-----------------------------------------------
```

Table 4.2. Forecasted manpower distribution over grade and grade se-
niority in an arbitrary year chosen by the user (here:
1980), based on the knowledge of 1977.

```
--------A-------A-----A----A-----A----A----A----A----A----A----A----A
                              . .                                ,
    TA   111111111111111111111111                                    238
    TA   111111111111111111111111                                    238
   TA1   222222222222222222222222222222222222222222222222222222       547
   TA1   222222222222222222222222222222222222222222222222222222       547
   THA   33333333333333333333333333333333333333333                    376
   THA   33333333333333333333333333333333333333333                    376
  THA1   444444444444444444                                           180
  THA1   444444444444444444                                           180
 THABD   5555555                                                       70
 THABD   5555555                                                       70
```

Figure 4.8. Histogram of the actual number of employees in 1977. The
forecasted number of employees in each grade is reflected
by two lines indicating the number of the grade. Each line
represents the total number of employees in the grade. One
figure stands for 10 employees. The scaling factor is
chosen automatically. Such a histogram can be printed for
each year of the planning period.

4.4.2. *Statistical errors*

Another option of FORMASY gives the statistical errors of the forecasts.
In 3.2.2.4 we discussed the quality of the forecasts for Markov models.
In the stochastic situation, the standard deviations of the forecasted
numbers of employees in the grades give some information about the dis-
persion of the forecasts. Only in the stochastic situation it is use-
ful to compute the standard deviations since these are zero in the
deterministic situation.

FORMASY can give the standard deviations for the stochastic situation.
However, recruitment is supposed to be deterministic. Table 4.3 indi-
cates the standard deviations of the forecasts of table 4.1 in integer
numbers.

```
             STANDARD DEVIATIONS OF THE FORECASTS
             ...................................

                                  GRADE
             YEAR  *   TA   TA1   THA   THA1  THABD
             -----------------------------------------
             1978  *   7    11    10     7     5
             1979  *   7    13    12     9     6
             1980  *   7    14    14    10     7
             1981  *   7    15    15    11     7
             1982  *   7    15    15    12     8
             -----------------------------------------
```

Table 4.3. Standard deviations of the forecasted numbers of employees
            in the grades (table 4.1) in integer numbers.

In fact, the computational effort to calculate these standard devia-
tions is (relatively) high when age and grade seniorities are includ-
ed as characteristics. However, one may omit the first term after the
equation sign of formula (3.7) to obtain an upper bound for the stan-
dard deviations. The contribution of the covariances stems from the
fact that it is possible to reach category j from category i along
different paths. But the numbers of employees following these differ-
ent paths are always negatively correlated since each employee can
only follow one path. Thus, deleting the covariances gives an upper
bound of the standard deviation. This upper bound can be computed much
faster and requires less storage capacity, whereas the deviations from
the real covariances are usually relatively small. However, we will
not discuss this point further here.

The standard deviations indicate that the considered number of employ-
ees may not be too small. In our experience, about 30 employees in
each grade is sufficient to give an indication of the evolution of
the manpower distribution over the grades.

4.4.3. *Steady-state distribution of employees*

Another option of FORMASY is the computation of the expected number
of employees in each grade in the long run. This is called the steady-
state distribution or stationary distribution. We described this al-
ready in subsection 3.2.2.2. The steady-state distribution shows the
consequences of constant policies with respect to promotion and re-
cruitment on the very long term. When age is included in the model,
the steady-state distribution is equal to the forecast for year T,

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where T is such that the recruits of the first year of the planning
period have been retired then already.

With FORMASY one may also compute the necessary number of recruits to
keep the total expected number of employees constant in the long run
under the same conditions of constant policies. First compute the
consequences of an arbitrary recruitment policy with the desired re-
lation between recruitment in the different classes. Then one changes
the total forecasted number of employees while maintaining the rela-
tive distribution over the grades by changing the recruitment, but
maintaining the relative distribution of recruitment over the classes.
Define:

$\bar{n}(0) \equiv$ total number of employees at time zero;

$\bar{n}(t) \equiv$ total number of employees at time t under the arbitrary recruit-
    ment policy $\bar{r}$;

  $\bar{r}_i \equiv$ yearly recruitment in class i.

Now, the necessary constant recruitment r_i to keep the total number
of employees-as well as the distribution of employees over the classes
- constant in the long run, can be computed by:

(4.1) $r_i = \bar{r}_i \cdot \dfrac{\bar{n}(0)}{\bar{n}(t)}$,

where i = 1,2,...,K and t indicates the time in which the steady-
state situation would be obtained.

An example of the steady-state distribution computed with FORMASY is
given in table 4.4.

STEADY-STATE MANPOWER DISTRIBUTION FOR LAST CHOSEN RECRUITMENT
•••

```
---------------------------------------------
YEAR : 2020
                       GRADE
          TA    TA1    THA   THA1 THABD      TOTAL
----------------------------------------------------
  TOTAL:  180 . 313    311    208.  116  **  1128
---------------------------------------------------
```

NECESSARY RECRUITMENT TO MAINTAIN THE TOTAL NUMBER OF EMPLOYEES :
CLASS   1:   82

THE MANPOWER DISTRIBUTION WILL BE THEN :

```
                       GRADE
          TA    TA1    THA   THA1 THABD      TOTAL
----------------------------------------------------
  TOTAL:  227   394    391    262   146  **  1422.
----------------------------------------------------
```

Table 4.4. Steady-state manpower distribution over the grades. The
first forecast shows the steady-state distribution for
given constant recruitment and the second forecast shows
the distribution for the changed constant recruitment of
82 employees. The total forecasted number of employees in
then close to the actual number of employees in 1977.

4.4.4. *Forecast of the age distribution*

One point of interest in manpower planning is the change in the age
distribution of the employees. Although probably no one can determine
exactly what an ideal age distribution will be for an organization,
it is obvious that a balanced age distribution is of great interest
because of the continuity of experience and knowledge within the or-
ganization. This continuity may be secured by stable recruitment po-
licies. In the examples of section 4.3 we already mentioned the im-
portance of this stability (example b).

Some aspects of the age distribution will be considered in detail in
section 5.2.

With the help of **FORMASY** one can show the actual distribution of the
employees over the grades and ages (input data) and also the forecast-
ed distribution. Moreover, for all grades the average ages and the
corresponding standard deviations may be computed. In table 4.5 this

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is illustrated.

```
YEAR : 1982
----------------------------------------------------------------

AGE    %
----------------------------------------------------------------
63-64 %3445
61-62 %233445
59-60 %34455
57-58 %3344455
55-56 %233444555
53-54 %23344455
51-52 %33444455
49-50 %233334444455
47-48 %23333344444455
45-46 %2333344444455
43-44 %2233333333444445
41-42 %22233333333344444
39-40 %22222233333333333334444
37-38 %222222223333333333333333333444
35-36 %222222222222222233333333333333333333344
33-34 %12222222222222222222333333333333333
31-32 %1222222222222333
29-30 %11122222222222223
27-28 %1111111111122222222222
25-26 %111111111111111111222222
23-24 %111111111112
22-22 %111
----------------------------------------------------------------
1 FIGURE =   4 EMPLOYEES
----------------------------------------------------------------
AVERAGE AGES OF MANPOWER

-------------------------------------------
   GRADE  !  AVERAGE  !  DEVIATION  !
          !  AGE      !             !
-------------!-------------!-------------!
     TA   !    25.9   !     2.6     !
     TA1  !    34.1   !     6.4     !
     THA  !    40.5   !     7.2     !
     THA1 !    48.2   !     7.4     !
     THABD !   53.2   !     5.8     !
-------------!-------------!-------------!
-------------------------------------------

THE AVERAGE AGE OF TOTAL MANPOWER IS  38.7 YEARS

THE DEVIATION IS  10.0 YEARS
```

Table 4.5. Age distribution of the employees, average ages and stan-
        dard deviations in each grade. Each figure denotes the
        number of the grade whilst the number of figures on each
        line shows the number of employees in the corresponding
        age class. The scaling factor (here: 4) is chosen automa-
        tically. 1 indicates grade TA, 2 = TA1, 3 = THA, 4 = THA1,
        5 = THABD.

4.4.5. *Forecast of the salary costs*

With FORMASY it is possible to compute the actual and future salary
costs for all grades. These computations are based upon a salary

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scheme where for every class there is a minimum salary (for grade
seniority one), a constant yearly increase with grade seniority and
a maximum salary. Such a salary scheme is applied in the Dutch public
services and in several large firms.

Of course, also other methods for the computation of salary costs can
be included as long as the salary depends on the characteristics con-
sidered in the model.

An example of the forecasts of salary costs is given in table 4.6.

```
SALARY COSTS IN MILLION GUILDERS
................................

                         GRADE
YEAR *     TA     TA1    THA    THA1   THABD   *   TOTAL

-------------------------------------------------------
1977 *   10.16   32.10  27.74  15.51   7.00   *   92.51
.......................................................
1978 *    8.89   31.38  28.95  15.77   7.44   *   92.42
1979 *    8.11   29.93  30.21  16.28   7.40   *   91.92
1980 *    7.85   28.25  31.14  17.08   7.76   *   92.09
1981 *    7.75   26.43  31.90  17.98   7.90   *   91.98
1982 *    7.71   24.69  32.87  19.05   8.36   *   92.69
-------------------------------------------------------
```

Table 4.6. Actual and forecasted salary costs for each grade in
          million guilders.

4.4.6. *Data with respect to career schemes*

One further point in the use of Markov models is that several calcu-
lations can be made which are very helpful for the evaluation and
design of career policies. FORMASY can present a number of data with
respect to the average career scheme for the employees. Such data is
for instance, in each class the average grade seniority at which pro-
motion occurs (under the condition that promotion will take place and
for each class the total fraction of employees which will be promoted.
Define for some given class:

T_{ps} ≡ average time until promotion, under the condition that promo-
       tion will take place, for employees with grade seniority

v_s ≡ direct wastage fraction for   employees with grade seniority s;

p_s ≡ direct promotion fraction for   employees with grade seniority s;

π_s ≡ average fraction of employees who will be promoted after some
       time of those employees who have now grade seniority s.

It should be remarked that promotion is defined here as a transition to a different class. The influence of retirement of the employee is neglected.
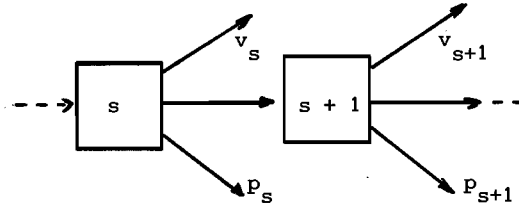
Figure 4.9. Transition scheme indicating the function of grade seniority in the model for one class.

Now, we can give the following formula:

(4.2) $\pi_s = p_s + (1 - v_s - p_s)\pi_{s+1}$,

i.e. the fraction of employees promoted directly plus the fraction of employees who will be promoted later.

T_{ps} can be written as

(4.3) $\dfrac{T'_{ps}}{\pi_s}$,

in which T'_{ps} might be interpreted as the average time until promotion for an employee with grade seniority , if we count the time which is not followed by promotion as zero. T'_{ps} can be computed using the following relation:

(4.4) $T'_{ps} = \pi_s + (1 - v_s - p_s)T'_{p,s+1}$.

These formulae are easy to handle for computation. In the same way, the average grade seniority can be calculated at which turnover occurs.

The average time an employee will spend in his class is computed as well.

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Define:

$T_s \equiv$ average time yet to spend in his class for an employee with grade seniority s.

Then:

$$(4.5) \qquad T_s = 1 + (1 - v_s - p_s)T_{s+1} \; .$$

Another important item concerning the career policies is the average fraction of employees who will be promoted within s years after entering the current class.
Define:

$Q_s \equiv$ average fraction of the entrants in a certain class who will be promoted within s years.

Then:

$$(4.6) \qquad Q_s = \sum_{\ell=1}^{s} \left\{ p_\ell \cdot \prod_{k=1}^{\ell-1} \left(1 - v_k - p_k \right) \right\} \; .$$

The index Q_s gives some information about the career prospect of new entrants in a certain class. However, high turnover fractions will decrease the value of Q_s. This turnover may be caused by employees who do not perform well in the class or who want to leave the class for better positions in other organizations.

Table 4.7 shows an example of the FORMASY results concerning the average career opportunities.

```
TRANSITION  3
--------------
MIN. GRADE SENIORITY    = 1.0
MAX. GRADE SENIORITY    =13.0
AVERAGE GRADE SENIORITY= 6.2

TRANSITION  4
--------------
MIN. GRADE SENIORITY    = 1.0
MAX. GRADE SENIORITY    =13.0
AVERAGE GRADE SENIORITY= 6.3

PERCENTAGE OF ENTRANTS IN CLASS   2 WHO MAKE FOLLOWING TRANSITIONS :
                  PROMOTION    TURNOVER      STAYERS
AFTER 13 YEARS :   71.1         23.1          5.9
TOTAL          :   73.5         26.5          0.0

AVERAGE TIME SPENT IN CLASS   2 : 6.2
```

Table 4.7. Extra information about actual career policies. Transition
           3 is the promotion from grade TA1 to grade THA; transition
           4 is turnover from grade TA1; class 2 is grade TA1. For
           this example we have the following results: T_{p0} = 6.2
           (for transition 3); Q_{13} = 0.711; Q_{∞} = 0.735; T_0 = 6.2.

4.4.7. *Simulation possibilities*

As we mentioned before, a manpower planning system should offer some
possibilities to change parameters. The forecasting of the conse-
quences of changed parameters is called simulation. Simulation helps
the personnel manager to design policies and may support his decisions.

FORMASY offers the following simulation opportunities:

1. forecasting the consequences of a change of transition fractions
   in order to evaluate effects of changes in wastage patterns and
   career policies;
2. forecasting the consequences of a change of recruitment; a recruit-
   ment planning procedure;
3. forecasting the consequences of a change of the retirement age;
4. forecasting by using FORMASY dynamically.

ad 1. forecasting the consequences of a change of transition fractions.

FORMASY contains three options to change the transition fractions:

a) a shift (lengthening or shortening) of the time until promotion

from a certain class.

example. If the historical promotion fractions for all grade se-
niorities out of some class are:

grade seniority	1	2	3	4	5	≥6
historical fractions	.1	.2	.3	.2	.1	.1

then, a lengthening of the time until promotion with one year
would result in the following fractions:

grade seniority	1	2	3	4	5	≥6
new fractions	0	.1	.2	.3	.2	.1

This procedure is helpful in indicating the effects of changes
in promotion possibilities.

b) changing one or more single fractions of a certain transition.
Transition means here a change of class. This results in the
example above with changes in the fractions for grade seniority 2
and 3, for instance, in:

grade seniority	1	2	3	4	5	≥6
new fractions	.1	.3	.4	.2	.1	.1

c) multiplying all fractions of a certain transition by the same con-
stant.
In the example above, by multiplying all fraction with 1.5, this
would lead to:

grade seniority	1	2	3	4	5	≥6
new fractions	.15	.30	.46	.30	.15	.15

This procedure turns out to be very useful for the evaluation of
the effects of a general increase or decrease of turnover fractions.

ad 2. forecasting the consequences of a change of recruitment; a re-
     cruitment planning procedure.

FORMASY facilitates the evaluation of the impact of alternative re-
cruitment policies by allowing the user to choose an arbitrary future
recruitment. Application of the forecasting procedure gives then the
impact of the recruitment on the future distribution of employees
over the categories.

With another option of FORMASY one may compute the necessary recruit-
ment which leads to numbers of employees in all grades equal to or
(if necessary) above given lower bounds. This option is constructed
in such a way that the user may give a maximum allowed number of re-
cruits. Moreover, in case the upper bound for the allowed recruitment
is reached in some year, the user may allow recruitment some years ear-
lier, which leads to over-occupation of the grade for some time.

Using these upper bounds one can take care for stable recruitment.
Also, these upper bounds can be used in case the possibility for the
organization to recruit people from the labour market is restricted.
The overflow feature makes it possible to choose a compromise between
the maximally allowed recruitment and the minimally desired manpower
distribution.

Notice that in this procedure the recruitment is considered on the
level of grades instead of classes. This means that the original
transition matrix has to be reformulated for grades. We will not dis-
cuss this in more detail her.

The recruitment planning procedure has been based upon a dynamic pro-
gramming approach and has been described by Van Nunen/Wessels [62].
Tables 4.8 and 4.9 show an example of application of this procedure.

The procedure shows the impact of changes in the manpower requirement
on the necessary recruitment.

RECRUITMENT IN PLANNING PERIOD

YEAR	*	TA	TA1	THA	THA1	THABD	*	TOTAL
1977	*	27	0	0	0	0	*	27
1978	*	52	0	0	0	0	*	52
1979	*	41	28	0	0	0	*	69
1980	*	40	34	0	0	0	*	74
1981	*	43	28	0	0	0	*	71

Table 4.8. Example of the use of the recruitment planning procedure.
The table gives the forecasted recruitments when the
allowed number of recruits in each year is 80 resp. 50
for the grades TA and TA1. The desired lower bounds for
these grades are 200 resp. 500 each year and no earlier
recruitment is allowed. It is assumed that the recruitment
during 1977 is first counted in the manpower distribution
of 1978. The resulting manpower distribution over the
grades is given in table 4.9.

MANPOWER DISTRIBUTION IN PLANNING PERIOD INCL. RECRUITMENT

YEAR	*	TA	TA1	THA	THA1	THABD	*	TOTAL
1977	*	238	547	376	180	70	*	1411
1978	*	200	531	394	184	75	*	1384
1979	*	200	504	412	190	75	*	1381
1980	*	200	500	425	200	79	*	1404
1981	*	200	500	436	210	81	*	1427
1982	*	200	500	450	222	86	*	1458

Table 4.9. Resulting forecasted manpower distribution including the
recruitments of table 4.8. Notice that in grade TA1 it
takes some time to reach the lower bound.

ad 3. forecasting the consequences of a change of the retirement age.

The user may change the retirement age for every planning year and is
able in this way to assess the impact of alternative retirement ages.

ad 4. forecasting by using FORMASY dynamically.

One limitation of the Markov model is that the transition fractions
are assumed to be constant. Dynamical use of FORMASY removes this ob-
jection. If the user expects certain changes in promotion policies
or turnover fractions, he may compute the impact of these changes with

FORMASY. He applies, for instance, the actual transition matrix for the planning horizon for which he expects this matrix to be correct. The forecasted manpower distribution for this planning horizon can be stored. Then, he re-starts the processing of FORMASY and applies the new transition matrix to the stored manpower distribution over the categories.

All options described in this section are executed interactively by commands of the user. The simulation possibilities may be considered as the main contribution to the applicability of this planning system. We will discuss the advantages in some detail in section 4.7.

In the appendix, an example is given of the use of FORMASY for the case-study of chapter 6. This listing demonstrates how the above-mentioned options are used.

4.5. Estimation of transition fractions

In subsection 3.2.2.3 we described how transition fractions for the Markov model can be determined from historical data. If one wants to obtain some information with respect to the promotion fractions the analysis of historical data is a straightforward first step. If one wants to start with career planning and no data from history is available, then one may try to deduce promotion fractions from an intended policy or one may evaluate by simulation which promotion fractions are sensible.

For the estimation of the turnover fractions one may use:

1. historical data on the considered level of aggregation;
2. historical data on a higher aggregation level within the organization;
3. data from other organizations or from the national level.

We will discuss these possibilities by means of example a of section 4.3, where the three levels of engineers in a Dutch public service have been considered. If one wants to determine the turnover fractions for the highest level engineers, one may compute this data according to formula (3.6) using past data of this same group of engineers. If the number of leavers cannot be obtained in such a detail, then one may

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be satisfied with, for instance, the number of leavers for the entire group of engineers in the past or turnover for the total organization. If this data is not available, then one may try to obtain such information from other public services or from national turnover fractions for people with similar training and qualifications. In this situation, however, the reasons for turnover should be taken into account explicitly.

4.6. Computational efficiency of FORMASY

Concerning the computational efficiency of FORMASY, we will consider the required storage capacity and the computation time of application of this system.

The required storage capacity depends on the way the possible transitions of employees are stored. If we consider the transition fractions p_{ij} in formula (3.1), which are based upon the transitions between classes in the terminology of this chapter, then these fractions are equal to zero in general if $j < i$. This means that no degradations may occur. By this property the matrix of transition fractions can be stored in a very efficient way by only storing the elements which can be positive (see fig. 4.10).

$$P = \begin{bmatrix} p_{11} & p_{12} & p_{13} \cdots \cdots p_{1M} & p_{10} \\ & p_{22} & p_{23} \cdots \cdots p_{2M} & p_{20} \\ & & p_{33} & p_{34} \cdots p_{3M} & p_{30} \\ & \bigcirc & & \ddots & \vdots \\ & & & p_{MM} & p_{M0} \\ & & & & 1 \end{bmatrix}$$

Figure 4.10. Shape of the matrix of transition fractions based on classes, where M is the number of classes and p_{i0} denotes turnover from class i.

Of course, we do consider categories in the FORMASY system and not classes. This means that for all classes of fig. 4.10, a number of transistion fractions have to be stored, namely for every grade seniority, but in order to avoid a very technical discussion we will

not treat this aspect in detail.

Another saving of storage capacity is achieved by deleting the positions which do not occur in practice. Recall from section 4.2 that the total size of the system would be $(G \times Q \times E \times S + 1)$. For the examples of section 4.3, this would lead to the following number of states:

example a.1 : 51 and 66 respectively;

example a.2 : 241;

example b.1 : 151;

example b.2 : 131;

example c : 736;

example d : 301 (or with age classes included: 901).

However, usually a considerable saving on the number of states is possible. This gives for the examples:

example a.1 : nothing can be gained, but 51 and 66 are not very large;

example a.2 : $1 + 13 \times 12 = 157$ states suffice;

example b.1 : since the subgrades only work for the lowest grade, it is sufficient to consider $1 + 7 \times 10 = 71$;

example b.2 : $1 + 13 \times 7 = 92$ states suffices;

example c : nothing can be gained;

example d : $1 \times 16 \times 10 = 161$ states suffice (with age classes included, a reduction to 391 appeared to be possible). Here a further reduction is possible since it is not necessary for all states to consider 10 levels for the grade seniority.

The second aspect, the computation time, will be discussed briefly here. The computation time depends of course on the number of categories and the number of possible transitions between the classes. The forecasting procedure is very simple which leads to (relatively) low computation times. For the example considered in the appendix – which required several executions of the forecasting procedure – the total processing time on a B7700 computer was about 40 seconds.

4.7. Usefulness of FORMASY

The program system FORMASY has been designed to make it simple to simulate the effects of various possible policies with respect to manpower. As before, the term simulation does not mean Monte Carlo simulation. Here, we mean that for several policies, forecasts are computed for the future behaviour of the manpower system. In this sense, the effects of policies are simulated. Using this aspect, FORMASY can be applied as an instrument to match manpower requirement and manpower availability (or to estimate the flexibility of the organization for changes in manpower requirements). It is especially suitable for medium and long term planning. Short term planning (less than a one year-period) has to be so detailed that it is usually preferable to consider individuals rather than categories as we discussed in section 1.5.

The main advantages of FORMASY are the following features:

+ it is an interactive computer program;
+ it can be used by experts in the manpower planning field;
+ it is based on a simulation approach, i.e. there are no optimization criteria built in-to assess the policies;
+ it contains many options to change the policies easily;
+ it has many output facilities.

There are also some conditions for an optimal usefulness of this computer program system:

. the user has to be familiar with manpower planning problems;
. the user should be creative in designing alternative policies and should have the knowledge required to assess the alternatives;
. the required input data is easy accessible;
. the computer system has facilities for interactive use.

The usefulness of FORMASY and the implications for the organization will be discussed in more detail in chapter 5.

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CHAPTER 5

THE USE OF FORMASY

5.1. Introduction

In this chapter we will consider the use of the manpower planning
system FORMASY. Three parts can be distinguished in this chapter. In
the first part, sections 5.2.- 5.3, we will discuss the matching pro-
cess of manpower availability and manpower requirement in some detail.
Particularly the use of a system such as FORMASY for the matching pro-
cess will be described in section 5.2. In section 5.3 we will give
some examples of the application of FORMASY for designing career po-
licies and recruitment policies.

In the second part, sections 5.4 - 5.5, some aspects will be described
which have to be considered before FORMASY can be applied. In section
5.4 we will indicate how the level of aggregation may be chosen, i.e.
how should one choose the function groups such that manpower planning
is possible and useful. In section 5.5 we will discuss how the length
of the planning horizon may be chosen.

Finally, in sections 5.6 - 5.8, some organizational questions with
respect to the use of FORMASY will be described. The requirements for
the personnel registration are considered in section 5.6. In section
5.7 we will discuss the requirements for the employees of the person-
nel department. At last, in section 5.8, the place of FORMASY within
the organization will be described.

5.2. The matching process and FORMASY

5.2.1. *Introduction*

In subsection 1.4.4 we discussed the manpower planning activities:
career planning, recruitment planning, training and development plan-
ning and allocation planning. The importance of these activities for
the matching of manpower requirement and availability depends on the
type of manpower flow or transition which is considered and on the
restrictions on these transitions.

Flows can be purely vertical, a transition to a similar function on a higher organizational level. Flows can also be purely horizontal, a transition to a different type of function on the same organizational level, or a mixture, a transition to a different type of function on a higher level within the organization.

If the career restrictions are very tight, for instance because of a high degree of commitment, then the vertical component of the flows is very important, thus also career planning. If many functions can only be occupied by employees with experience in different types of functions, then the horizontal component of the flows is very important, thus also allocation planning. In may situations both types of planning have to be considered. But, if there is a high degree of flexibility with respect to horizontal or vertical movement, for instance because of a high mobility of employees, it may be sufficient to consider on medium and long term only the vertical or only the horizontal transitions. This is an example of aggregation which will be discussed in some detail in section 5.4. An important variable in each type of planning is recruitment. In certain situations, for instance if some types of employees can hardly be recruited, it may be necessary to pay special attention to recruitment planning. In the same way, training and development may be an important variable in each type of planning.

In the subsequent subsections we will discuss the use of FORMASY for the development of career policies, allocation policies, recruitment policies and training and development policies.

5.2.2. *Career policies*

The design of career policies is a very important activity in organizations today. While machines have an economic lifetime of between about two and twenty years, employees may stay with the organization for forty years or even longer. It is more and more accepted that employees have their own career rights and influence on the career policies. The degree of acceptance of this development by the organization determines the level of commitment of the organization to its personnel (recall section 1.6).

The resctrictions with respect to the vertical flows of employees may be expressed by:

a the organization's restrictions;

b the personnel restrictions;

c the environment's restrictions;

d the stability restrictions.

ad a The organization's restrictions are restrictions caused by the availability of functions on the various organizational levels and by the availability of money to pay the promotions.

ad b The personnel restrictions are restrictions caused by the employees. These restrictions are determined by the interests and the potential abilities of the employees.

ad c The environment's restrictions are restrictions caused by the career opportunities offered by other organizations.

ad d The stability restrictions are restrictions caused by the wish to have stable career policies over time.

Career policies can be described by the following characteristics:

. the position of an employee when entering the organization;

. the different positions an employee occupies subsequently;

. the number of years spent in each position.

The starting position of an employee in the organization has to agree to some extent with the usual level both within the organization and elsewhere in society (c). This is true for the salary level but also for the contents of the tasks.

The different positions an employee occupies during his stay with the organization have to agree with the individual expectations of the employees and his potential ability (b) but also with the organization's requirements (a). After some time he may be able to perform a function on a higher level. Particularly for highly trained employees who start in a learning function and who will stay with the organization for a long time, career planning is very important. Therefore, one has to forecast the future organization requirements and the evolution of the manpower distribution in order to notice possible discrepancies in time.

The number of years until the position of an employee changes, has to
agree with his personal ability and with the organization's demands.
It is important to develop a career plan for all relevant categories
of personnel, the position when entering the organization, the minimum,
average and maximum time between the transitions and the average frac-
tion of employees reaching the given positions. Such a career plan
indicates clearly the prospects for the recruits and the employees
already present within the organization. This may avoid disappoint-
ments and a possible feeling of arbitrariness of promotions (d). Of
course, such a scheme is an average scheme, which leaves the possi-
bility open that the better employees may reach top-positions within
a few years, while other employees may never reach such a top-position.
See fig. 5.1 for an example of this feature
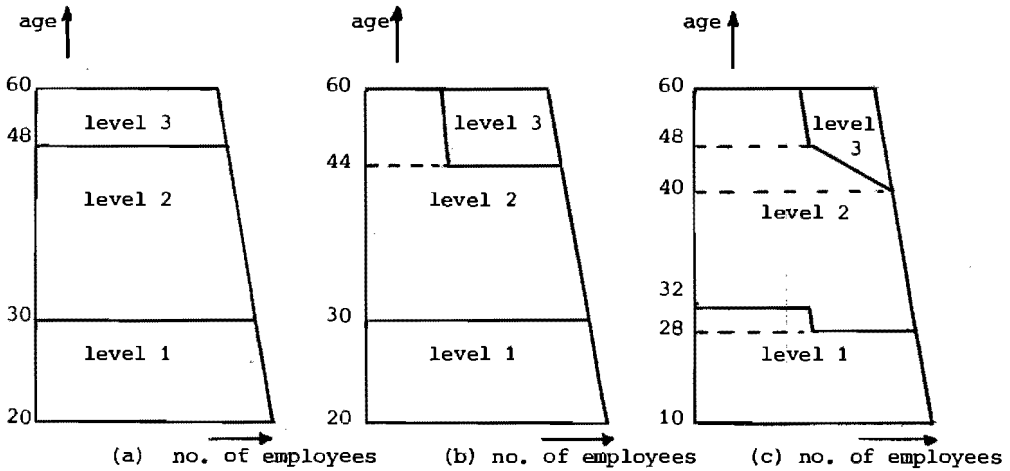
Figure 5.1. Three alternative career policies. Fig. (a) shows the
average career where all employees will reach the top-
level. Fig. (b) illustrates the case of a selection bound
at age 44, such that only a part of the employees will
achieve the third level. Fig. (c) illustrates another case
of selection bounds. Employees are promoted to level 2 at
age 28 or 32. Promotion to level 3 takes place at an age
between 40 and 48. For convenience, we have expressed the
careers according to age but one may also replace age by
e.g. length-of-service.

Many organizations do have a career plan for certain groups of personnel (usually the employees with high training or experience). But often this plan is not formalized. Sometimes only a minimum time for promotion is formalized, because of experience requirements.

With respect to the career opportunities FORMASY can be used in the following way. First, compute the impact of the historical career opportunities (promotion fractions) on the evolution of the manpower distribution. The career plan may depend on the qualifications of the employees. A comparison of the resulting manpower availability forecast with the manpower requirement forecast indicates possible discrepancies. Secondly, alternative career policies can be developed. This means that the position when entering the organization is changed, or the sequence of occupied fractions or the time spent in each of the functions. This process of changing career policies has to be continued until the career policies agree with the organization's requirements.

In section 5.3 we will give some examples of the use of FORMASY for the design of (alternative) career policies.

5.2.3. *Allocation policies*

The allocation policies indicate which numbers of employees will occupy the different types of functions on medium and long term. Allocation planning is important if the organization wants to maintain a given intensity of the horizontal flows. This will be the case, for instance, if for certain functions, one requires experience in other types of functions. Consider, as an example, a bank where the requirement for managers for large affiliations is several years of experience in staff functions and several years of experience as affiliation manager is some smaller affiliations.

The restrictions with respect to the horizontal flows of employees can be classified similar to the restrictions mentioned in subsection 5.2.2 for career policies. The organization's restrictions and the stability restrictions of allocation policies need no explanation. The environment's restrictions are caused by, for instance, the opportunities offered by other organizations. The personnel restrictions are closely related to the willingness of employees to participate in the

allocation patterns (mobility). In subsection 1.4.4 (fig. 1.7) we considered an example with two function levels and three types of functions (A,B and C) on the lowest level. The requirement for functions on the second level is 2 years experience in A-type functions, 3 years in B-type functions and 5 years in C-functions.

The following model structure may be used for the application of FORMASY:

g = type of function (g = 1,2,3 or 4 for A-type, B-type, C-type and level 2 functions);

e = experience of the employee (e = 0,1,2,...,7);

s = function seniority (s = 1,2,...).

The experience of employees can be given as:

e = 0 (no experience), e = 1 (at least 2 years in type A functions), e = 2 (at least 3 years in type B functions), e = 3 (at least 5 years in type C functions), e = 4 (required experience in functions A and B), e = 5 (required experience in A and C), e = 6 (required experience in B and C), e = 7 (fully qualified employees).

We assume implicitly that employees are only transferred if they have obtained the required experiences in their functions. If the transition fractions between the types of functions are given, then forecasts for the number of employees in each type of function can be made. Notice that the possible transition fractions depend on the willingness of employees to participate in the allocation scheme (mobility). Evaluation of these results may lead to changes in the allocation policies. This model could also be used for estimation of mobility which is required to guarantee the matching of required and available experience.

5.2.4. Recruitment policies

Recruitment policies indicate the numbers and types of people which have to be recruited on medium and long term. The restrictions with respect to recruitment policies are again classified similar to the restrictions given in subsection 5.2.2. The interpretation of the environment's restriction is the situation on the labour market. The personnel restriction indicates the willingness of people to join the organization. This willingness will be related to job-security, working

circumstances, etc.

It should be remarked, once again, that recruitment policies have a great impact on career policies. Changes in an existing career plan may be necessary because of unstable recruitment over time.

Consider an example. One group of employees is embodied into a grade system with two grades and the desired number of employees in every grade is fixed. If, in a certain period, extra recruitment was necessary in grade 1 because of an increase in the number of functions in grade 1 and this will continue in the following years, then the average career prospects deteriorate, since there become relatively less functions available in grade 2. A possible action here, might be the internal or external recruitment of older personnel, e.g. less trained people with some experience. This leads to an increase of wastage (retirement) such that the career prospects for the younger employees need not deteriorate. In section 5.3 we will see an example of such recruitment policies.

Often, little attention is given to the desirability to have a stable recruitment policy. Many organizations recruit people in situations of an increase in offtakes, since one does not want to lose part of the market. However one has to realize that these employees may stay for a long time with the organization and that thus their employment and career opportunities have to be ensured. Medium and long term recruitment planning is important therefore.

Recruitment planning is also important if the situation on the labour market changes such that a shortage of certain groups of personnel may occur.

Recruitments may be restricted also by training facilities. In fact, if an organization, such as the police organization, has its own training institute, then the capacity of this institute puts restrictions on the recruitment.

The first question to be answered if recruitment is necessary, is whether the vacancies can be filled from within the organization (internal transfer), possibly after a training course, or whether external recruitment is desired. In this approach also the education and training requirements have to be considered.

In subsection 5.3 we will consider an example of the use of FORMASY for the development of recruitment policies.

5.2.5. *Development and training policies*

Development and training policies indicate the numbers and types of employees who should attend courses in order to be prepared for future positions. The restrictions are classified similar to the restrictions given in subsection 5.2.2. Particularly important is the personnel restriction which indicates the willingness of the employee to participate in development and training programs, but also the ability of the employee to attend such courses. The environment's restriction indicates the development and training opportunities which are offered by other organizations and, for instance, the capacity of training institutes.

Recall that development and training policies may influence and will be influenced by both horizontal flows and vertical flows.

FORMASY has been used for the design of training and development policies for the Dutch police forces. This has been described in Van Meeteren [57].

5.2.6. *Preliminary steps for the application of* FORMASY

In section 5.3 we will describe two applications of FORMASY. Here we will first make some general remarks on the preliminary steps necessary for such applications.

First, one has to determine which questions have to be answered. One possible question is whether the availabe numbers of employees with their qualifications in the future will agree with the required numbers of employees. In the next phase, the relevant characteristics of personnel demand and supply must be given, for instance, training or experience. Before one can apply a system as FORMASY, the level of aggregation and the planning horizon have also to be fixed. The subsequent steps are indicated in fig. 5.2.
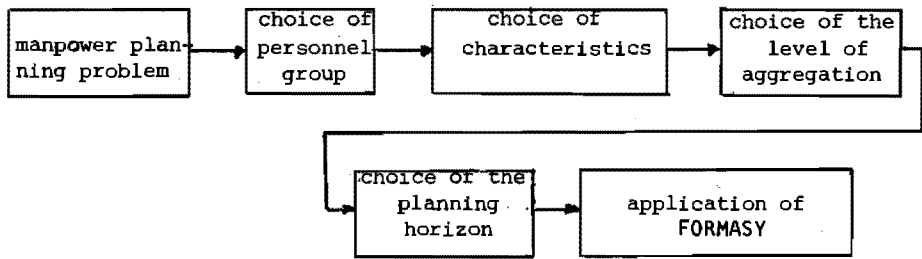
Figure 5.2. Scheme of necessary steps when using FORMASY.

Application of FORMASY means that the following data has to be given:

a the actual manpower distribution;

b the transition percentages and recruitment (preferably based on his-
torical data).

The forecasts of the manpower availability based on this data have to
be compared with the manpower requirement forecasts. Then, transition
fractions and recruitment can be changed in order to diminish the
deviations of manpower availibility from manpower requirement. The
resulting policies have to be evaluated. This may lead to a change of
manpower requirement which restarts the matching process.

5.3. Applications of FORMASY for designing career and recruitment policies

5.3.1. *Application at the Netherlands Ministry of Public Works*

As has been described in section 4.3, example a, the engineers of the
Public Works Office have their own grade system. The model structure
has been described in fig. 4.1 - 4.3. We will consider here two ex-
amples of application of FORMASY:

a avoiding an overstaffing in top-grades;

2 maintaining career prospects by integration of groups.

Example 1: avoiding an overstaffing in top-grades.

For the top-level engineers of this example, as for many other groups
of employees, one meets the following situation. In the recent past
a raise of the size of the group occurred, which was caused by a
steady inflow of young members. At the moment this increase stagnates
and no more increase is expected within the foreseeable future. The
consequences for the distribution of engineers over the grades will
be investigated. Notice that we will consider in particular the ver-
tical flows of employees whereas the horizontal flows are aggregated.
Thus all engineers of various fields of training are brought into one
group. Application of the forecasting procedure (without recruitment)
shows that the current bottom-heaviness of the hierarchical pyramid
will be transformed into a rather strong top-heaviness in a relatively
short time (see table 5.1.)

grade	1	2	3	4	5	total
allowed no. of employees in 1977	288		210	99	86	683
no. of employees in 1977	120	204	120	90	78	612
forecasted no. of employees in 1989	---	5	106	168	123	402

Table 5.1. Allowed, current and forecasted distribution of top-level
engineers over the grades. The forecast for 1989 is based
on the current situation without recruitment and using the
actual promotion policy of the last five years.

From this forecast and the forecast for the intermediate years, it is
easily computed how the total population may be kept on the present
level of 612 by recruitment. In this application, this is simple since
practically there can only be inflow in grade 1. The forecasted re-
cruitment for the forthcoming years is given in table 5.2.

1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
19	21	22	20	21	22	22	22	21	23	21	22

Table 5.2. Forecasted recruitment in grade 1 in order to maintain the
total work force at full strength.

It is clear that this recruitment, which is much lower than recruit-
ment in the past, will take care for the filling of the lower grades.
However, the overrepresentation in the top-grades does remain (see
table 5.3).

grade *	1	2	3	4	5	*	total
allowed *		288	210	99	86	*	683
1977 *	120	204	120	90	78	*	612
1978 *	101	195	143	91	82	*	612
1979 *	113	153	168	93	85	*	612
1980 *	96	140	192	97	87	*	612
1981 *	80	131	207	104	90	*	612
1982 *	95	95	218	111	93	*	612
1983 *	112	70	214	121	95	*	612
1984 *	115	66	200	134	97	*	612
1985 *	116	58	190	148	100	*	612
1986 *	116	56	176	159	105	*	612
1987 *	118	64	154	167	109	*	612
1988 *	118	73	135	170	116	*	612
1989 *	118	76	126	169	123	*	612

Table 5.3. Allowed, current and forecasted manpower distribution over
the grades with recruitment, under the actual promotion
policy.

This prospected overstaffing in the top-grades is not allowed for for-
mal and financial reasons. But also for social reasons it is highly
undesirable, because of the lack of appropriate positions for high-

level employees with several years of experience. The only solution can be found by starting as early as possible some slowing down of promotions in the lower grades. In our view, it is better to keep all employees a bit longer on the lower levels of their career than to allow the generation of a great stock of engineers waiting for promotion.

In the tables 5.4 and 5.5 we show forecasts for alternative promotion policies. Each alternative transition matrix is derived from the original one by shifting all promotions in some grades by one or more years. Always the recruitment policy of table 5.2 is used. Notice the small changes in the total number of employees because of different turnover fractions for the various grades. Since the number of years until promotion has been changed, the employees will stay in a grade for a longer time. This may also change the forecasted turnover.

In one processing session, several of these shifts can be tried out such as to obtain a good indication to what extent the number of years until promotion has to be lengthened in order to obtain reasonable prospects for the distribution of employees over the grades. In a later stage, refinements may be brought in by not only considering pure shifts.

| | | grade | | | | | | |
year	*	1	2	3	4	5	*	total
1977	*	120	204	120	90	78	*	612
1978	*	101	219	122	88	82	*	612
1979	*	113	188	138	86	85	*	610
1980	*	96	180	161	87	87	*	611
1981	*	80	167	184	90	89	*	610
1982	*	95	128	200	94	91	*	608
1983	*	112	93	212	99	92	*	608
1984	*	115	83	215	102	94	*	609
1985	*	116	80	209	110	94	*	609
1986	*	116	73	203	120	96	*	608
1987	*	118	70	190	132	98	*	608
1988	*	118	79	168	142	101	*	608
1989	*	118	87	148	149	104	*	606

Table 5.4. Forecasted distribution of employees over the grades for a
shift of 1 year in grade 2 and 1 year in grade 3.

| | | grade | | | | | | |
year	*	1	2	3	4	5	*	total
1977	*	120	204	120	90	78	*	612
1978	*	101	230	113	85	82	*	611
1979	*	113	224	108	81	85	*	611
1980	*	96	239	108	80	87	*	610
1981	*	80	240	120	79	89	*	608
1982	*	95	201	137	81	90	*	604
1983	*	112	158	156	86	91	*	603
1984	*	115	135	173	88	91	*	602
1985	*	116	117	191	86	90	*	600
1986	*	116	109	201	83	90	*	599
1987	*	118	106	201	84	90	*	599
1988	*	118	99	201	89	90	*	597
1989	*	118	98	194	97	90	*	597

Table 5.5. Forecasted manpower distribution over the grades for a
shift of 3 years in grade 2 and 2 years in grade 3.

Example 2. maintaining career prospects by integration of groups.

In example 1 the situation for the top-level engineers has been investigated in some detail. For the two other groups of engineers in the same organization the situation is similar. So, by planning the three groups separately, the result is a considerable lengthening for the time until promotion for all engineers involved.

However, with regard to tasks as well as salaries, there is a considerable overlap between the three groups. Figure 5.3 shows that the top-grades of the surveyors have the same salary level as the lower grades of the middle-level engineers and similarly for the top-grades of the middle-level engineers and the lower grades of the top-level engineers.
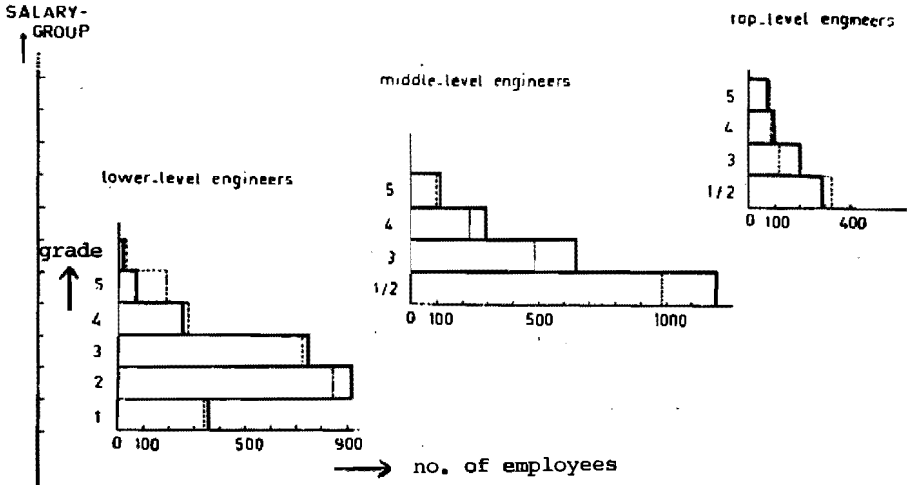
Figure 5.3. Representation of allowed and actual number of employees and the salary levels for the three types of employees.
⊐ allowed number of employees in each grade
⊏⊐ actual number of employees in each grade
In this figure the actual numbers of top- and middle-level engineers in grades 1 and 2 are aggregated, since in the organization the allowed numbers are also aggregated.

The main problem for all three groups is the large numbers of engineers allowed in the lower grades against the small numbers allowed in the top-grades. In a non-growing system this must inevitably lead to rather poor career prospects for those involved. From fig. 5.3. one can see that the lower grades of the middle-level engineers are not fully occupied, whereas the surveyor grades on the same level are over-occupied. This gives the clue to a solution: transfer some of the allowed numbers of lower-grade engineers at the middle-level to the top-grades of the lower level engineers and also some of the allowed numbers of top-level engineers in lower grades to the top-grades of the middle-level engineers. The result of such an operation is: better prospects for all groups although the recruitment of top-level engineers must certainly be diminished further.

Using **FORMASY**, it is simple to find out what might be obtained in this way. By choosing promotion and recruitment policies for all three groups, forecasts can be made and it is easy to compute whether the forecasted numbers fit the allowed numbers after the transfer. Figures 5.4 and 5.5 give the result of such an exercise for the three groups of engineers.
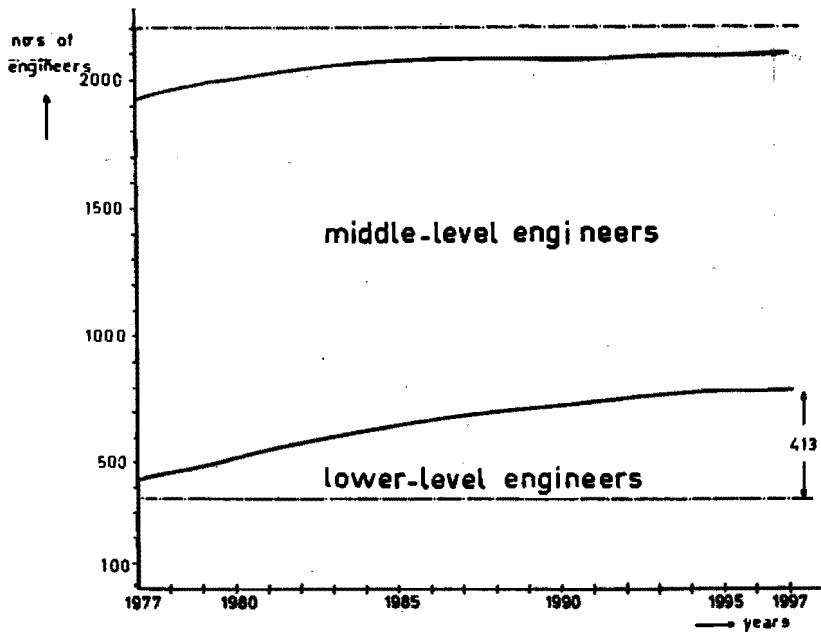
Figure 5.4. Integration of middle-level and lower-level engineers. The figure gives the numbers of employees at the salary level that lower-level and middle-level engineers have in common. The dotted lines show the numbers of functions on this salary level: 370 for the lower-level engineers and 1830 for the middle-level engineers. Futhermore, the striped lines give the forecasted number of lower-level engineers and the total forecasted number of employees for the given promotion and recruitment policy. In the figure it is indicated that transferring 413 middel-level functions to lower-level engineers in the following 20 years would be sufficient to maintain the current promotion and recruitment policy.
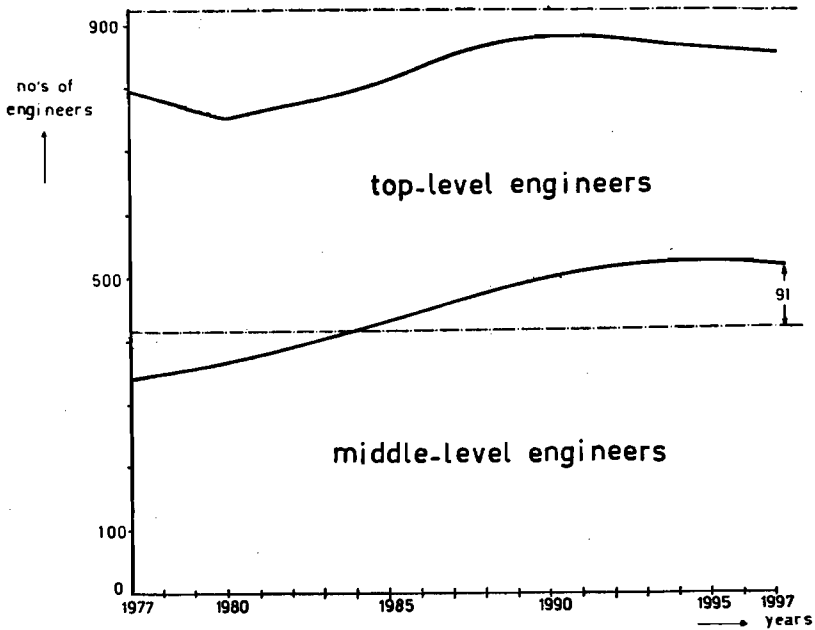
Figure 5.5. An analogous representation as fig. 5.4 for the salary
level that top-level and middle-level engineers have in
common. In the figure it is indicated that transferring
91 top-level functions to middle-level engineers in the
following 20 years would be sufficient to maintain the
current promotion and recruitment policy.

Using the program system it is clarifying to try out some promotion
and recruitment policies in order to find out which combination of
promotion shift and recruitment policy fits best for the purpose. As
figures 5.4 and 5.5 show, an integrated treatment of various groups
may help considerably in reconciling the conditions imposed by the
workload and salary constraints on one hand and the career prospects
on the other hand. In order to realize the developed policies, one
has to execute function analysis, potential appraisal, etc. This appli-
cation has also been described in Van der Beek/Verhoeven/Wessels [11].

5.3.2. *Application at a large industrial firm*

As we have seen in subsection 5.2.2, FORMASY can be applied in order
to match future demand for and supply of personnel by considering the
impact of changes in the historical policies. However, sometimes
the historical transition fractions are not appropriate. Consider the
following example.

The research lab of a large industrial firm employs two types of engi-
neers: engineers with a university degree on master's or doctor's
level and middle-level engineers. Top-management decides to decrease
the total personnel for this research lab by 3% a year. The question
is to which degree this leads to an ageing organization (being cata-
strophic for a research organization) and which recruitment will be
possible in the future.

The model structure for the engineers is given in fig. 5.6. The model
has 3 grades (5 classes); each class has 15 grade seniorities.

The classes 1 and 3 stand for grade 1 and 2 for engineers with a uni-
versity degree (high-level engineers). The classes 2 and 4 indicate
grade 1 and 2 for middle-level engineers. Class 5 stands for grade 3,
both for middle-level and for high-level engineers. The engineers are
recruited in the classes 1 and 2. Rhe retirement age is 60.
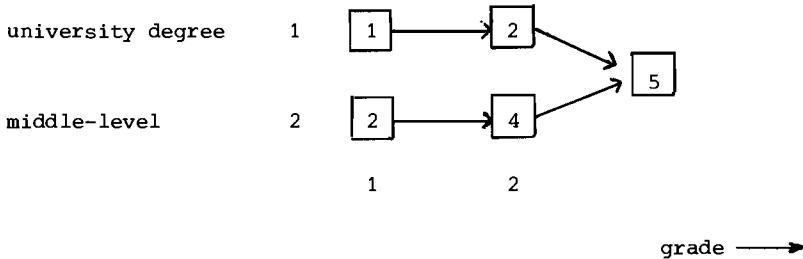
Figure 5.6. The classes and transitions for the engineers of a research
lab of a large industrial firm. There are 3 grades and in
each grade two classes, engineers with a university degree
and engineers with a middle-level degree. In grade 3 the
engineers have been taken together. The grade seniorities
have been deleted in this figure.

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We will forecast the evolution of the manpower distribution over the classes. There have been no promotions in last years but this may not continue in the next years. It is not possible to use historical promotion fractions therefore. In first instance, some promotion fractions are chosen, based on management's ideas on a reasonable career for the engineers. Consider as an example the transitions from class 2 to class 4. According to management about 40% of the people in class 2 can make this promotion and the promotion has to occur after 8 to 10 years service.

Based upon these transition fractions, forecasts for the next 10 years have been made. For the case of no recruitment, the forecasted evolution of the manpower distribution over the grades is given in table 5.6. The corresponding actual and future age distributions are shown in fig. 5.7.

MANPOWER DISTRIBUTION IN PLANNING PERIOD

year	*	G1	grade G2	G3	*	total
1980	*	50	70	120	*	240
1981	*	49	67	118	*	234
1982	*	48	65	115	*	228
1983	*	46	63	112	*	221
1984	*	40	59	110	*	209
1985	*	38	56	109	*	203
1986	*	35	52	108	*	195
1987	*	33	48	107	*	118
1988	*	28	47	103	*	178
1989	*	25	48	98	*	171
1990	*	21	47	92	*	160

Table 5.6. Actual manpower distribution over the grades and the forecasts for ten years ahead if there would be no recruitment. The total number of employees decreases by 33% in this period. G1 indicates grade 1, etc. In this table, the numbers of employees in the classes are lumped in order to obtain the numbers of employees in the grades.

```
AGE   *
---------   ------------------------------------
58-59 *
56-57 *1111233
54-55 *133333
52-53 *11222333
50-51 *1112333333333
48-49 *1111222222233333
46-47 *11122333333333333
44-45 *12222222233333333
42-43 *2333333333333333
40-41 *11111222222223333333333333333
38-39 *11111222223333333333333
36-37 *11111111111122233333333333333
34-35 *1111111122222333333333
32-33 *111122222222222222222233333333
30-31 *1222222222
28-29 *2
26-27 *2
24-25 *
---------------------------------------------------
1 FIGURE  = 1 EMPLOYEE
```

YEAR : 1990
```
----------------------------------------------------

AGE   *
---------------------------------------------------
58-59 *1112222223333
56-57 *11223333333333
54-55 *12222223333333
52-53 *2333333333333
50-51 *1122222222333333333333
48-49 *1122222233333333333
46-47 *1111222222333333333333
44-45 *11122222333333333
42-43 *112222222333333333333
40-41 *122333
38-39 *
36-37 *
34-35 *
32-33 *
30-31 *
28-29 *
26-27 *
24-25 *
---------------------------------------------------
1 FIGURE  = 1 EMPLOYEE
```

Figure 5.7. Actual age distribution and the forecasted age distribu-
tion for 1990 over the grades if there were no recruit-
ments. Each figure stands for 1 employee in this case.
Each line indicates the age class and the number of employ-
ees with the corresponding ages. The figure indicates the
number of the grade of the employee (1 = grade 1, 2 = grade
2, 3 = grade 3). For instance, 8 employees are in the age
class 52-53 in 1980; 2 of them are in grade 1, 3 of them
in grade 2 and also three employees in grade 3.

Now, we will investigate whether the forecasted evolution of the man-
power distribution over the grades agrees with the desired future
manpower distribution. Table 5.7 shows the desired manpower distribu-
tion in the planning period based upon the yearly decrease of 3%. Com-
pare these numbers with those in table 5.6.

MANPOWER DISTRIBUTION IN PLANNING PERIOD

year	*	grade G1	G2	G3	*	total
1980	*	110	50	90	*	250
1981	*	107	49	87	*	243
1982	*	103	47	85	*	235
1983	*	100	46	82	*	228
1984	*	97	44	80	*	221
1985	*	94	43	77	*	214
1986	*	92	42	75	*	209
1987	*	89	40	73	*	202
1988	*	86	39	71	*	196
1989	*	84	38	68	*	190
1990	*	81	37	66	*	184

Table 5.7. Desired manpower distribution over the grades based upon
the yearly decrease of 3%. As in table 5.6, the numbers of
employees in the classes are lumped in order to obtain the
numbers of employees in the grades.

Comparing table 5.6 and table 5.7 we notice a discrepancy between the
actual manpower distribution and the desired manpower distribution.
The actual percentage of employees in the classes, is: class one:
0%; class two: 20,8%; class three: 12,5%; class four: 16,7% and class
five: 50%. The desired manpower distribution for 1980, is: class one
24%; class two: 20%; class three: 12%; class four: 8% and class five:
36% of the employees.

In fact, the comparison of tables 5.6 and 5.7 also shows that only a
few employees can be recruited in this ten years' period. This would
lead to an ageing research lab. In order to prevent this development,

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management wants to consider alternative policies. One alternative
policy is:

- recruitment of 10 employees each year in class 2 (as was the his-
  torical policy), but also 10 employees in class 1 from other divi-
  sions;
- transfer of highly experienced personnel from class 5 to management
  functions in other divisions.
  In the program system FORMASY this can be accounted for by changing
  the turnover percentages e.g. for the grade seniorities 5,6,...,15
  form category 5 from 2% to 12%;
- changing the retirement age from 60 to 58 years.

The forecasted manpower distribution over the grades for this alter-
native policy is given in table 5.8.

MANPOWER DISTRIBUTION IN PLANNING PERIOD

year	*	G1	grade G2	G3	*	total
1980	*	50	70	120	*	240
1981	*	69	67	108	*	244
1982	*	83	64	96	*	243
1983	*	101	62	85	*	248
1984	*	116	59	75	*	250
1985	*	128	58	69	*	255
1986	*	137	57	63	*	257
1987	*	147	59	57	*	263
1988	*	156	62	50	*	268
1989	*	165	62	44	*	271
1990	*	171	64	39	*	274

Table 5.8. Forecasted manpower distribution over the grades for the
alternative with yearly recruitment of 10 people in class
1 and 10 people in class 2, earlier retirement and extra
turnover from grade 3 (class 5).

This table shows clearly that the desired manpower distribution (table 5.7) is also not achieved. However, the problem of the ageing organization has been solved (fig. 5.8). In fact, this example demonstrates that career prospects which seem acceptable for management do not always result in a manpower distribution which is acceptable for management.

```
YEAR : 1990
------------------------------------------------------

AGE    *
------------------------------------------------------
58-59 *
56-57 *1122333
54-55 *1222222333
52-53 *23333
50-51 *11222222223333
48-49 *112222223333
46-47 *11112222223333
44-45 *11112222233333
42-43 *11111111112222223333333
40-41 *111111111111111222333
38-39 *1111111111111111112
36-37 *11111111111111111111111223
34-35 *1111111111111111111111111111122222
32-33 *111111111111111111111112222222
30-31 *1111111111111111122222
28-29 *111111111111111122
26-27 *111111111111
24-25 *1111
------------------------------------------------------
1 FIGURE = 1 EMPLOYEE
------------------------------------------------------
```

Figure 5.8. Forecasted age distribution of the engineers in 1990 according to an alternative policy, including recruitment (cf. fig. 5.7; 1 = grade, 2 = grade, 3 = grade.

We will now consider a second alternative policy in order to change the evolution of the manpower distribution over the grades such that the forecasts come close to the desired manpower distribution given in table 5.7. The new alternative policy is:

- recruitment of 1 middle-level engineer in class 2 and 9 high-level engineers in class 1 each year;
- increasing the promotion fractions from class 3 and decreasing the promotion fractions from class 4;
- transfer of highly experienced personnel from class 5 to management functions in other divisions as in the first alternative;
- retirement age of 58 years.

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Notice that the promotion prospect for high-level engineers will improve and for the middle-level engineers will deteriorate. The forecasted manpower distribution over the grades is given in table 5.9.

MANPOWER DISTRIBUTION IN PLANNING PERIOD

year	*	G1	grade G2	G3	*	total
1980	*	50	70	120	*	240
1981	*	59	67	108	*	234
1982	*	67	63	96	*	226
1983	*	75	61	85	*	221
1984	*	83	53	79	*	215
1985	*	82	52	77	*	211
1986	*	80	52	74	*	206
1987	*	82	55	65	*	202
1988	*	86	53	57	*	196
1989	*	84	48	57	*	189
1990	*	81	45	58	*	184

Table 5.9. Forecasted manpower distribution over the grades for the second alternative with recruitment of 9 people in class 1 and 1 in class 2, improved career prospects for employees with a university degree and deteriorated career prospects for middle-level employees.

A comparison of table 5.7 and table 5.9 shows that the last alternative gives a forecasted manpower distribution which is close to the desired distribution. Of course this is only one possible alternative. We will not discuss here other reasonable alternatives.

This case-study shows how manpower planning can be executed though historical data concerning career possibilities are missing. It also makes clear why manpower planning for such organizations with highly specific personnel is relevant (cf. typology, section 1.6).

5.4. Level of aggregation

5.4.1. *Introduction*

In this section we will consider the choice of the function groups to use in the matching process. On one hand, the groups may not be too small, in order to guarantee a certain reliability of the forecasts. On the other hand, the groups may not be too large, in order to keep the matching meaningful.

Consider as an example two extreme cases: one might consider the entire organization as one personnel group or one might consider personnel groups containing just one individual. In the first case, reliable information can probably be obtained with respect ot the evolution of the manpower size but the question is whether this information is also valuable for subgroups of the organization. For instance, if the total number of employees increases by 5 percent, this does not mean necessarily that both the number of engineers and the number of secretaries will increase by 5 percent. Usually, more detailed information is necessary in the planning process. The other extreme case, however, is not executable in practice, since it is not possible to estimate the exact requirement for all functions individually on medium and long term. The minimum level of aggregation, required to maintain a certain reliability of the forecasts, depends on the degree of uncertainty and on the length of the planning horizon. The maximum level of aggregation, allowed to keep the matching meaningful, depends on the flexibility of manpower requirement and availability. We will explain these factors in more detail in subsection 5.4.2. For the short term planning a detailed approach is desired, whereas the consequences of the decisions for the medium and long term usually can be investigated on a higher aggregation level. As we have seen in section 1.4, manpower planning has to be part of the corporate planning. In the corporate planning the future development of finance, materials, equipment and personnel is considered. We already distinguished three levels of planning: short term (less than one year ahead), medium term (one until ten years) and long term (more than ten years ahead). The long term corporate plan provides the goals and restrictions for the medium and short term plan. Considering the short term decisions, one has to

accept the medium and long term corporate plan as a restriction. This restriction may be expressed in terms of total salary costs or in terms of numbers of allowed employees. Whether the restrictions are given in terms of money or in terms of allowed personnel depends also on the decision structure of the organization. This will be discussed in subsection 5.4.3.

5.4.2. *The level of aggregation*

Two important factors with respect to the level of aggregation are:

1. the length of the planning horizon;
2. the flexibility of manpower requirement and availability.

ad 1. The length of the planning horizon.

Manpower requirement forecasts are based upon the corporate planning. If the length of the planning horizon increases, then the manpower requirement forecasts become less reliable for the later years of the planning period because of the possibility of future changes in the corporate planning. Also, the manpower availability forecasts are less reliable for a longer planning horizon. Thus, for a long planning horizon a high level of aggregation is required, whereas for short planning horizons more detailed computations are possible. In section 5.5 the planning horizon will be considered in more detail.

ad 2. The flexibility of manpower requirement and availability.

The degree of flexibility of manpower requirement is the degree to which the numbers of functions and the types of functions can be changed if necessary. This corresponds with the rigidity of manpower requirement as described in section 1.6 (typology). If the degree of flexibility of manpower requirement is low, then the level of aggregation has to be low, since otherwise a match on a high level of aggregation gives no guarantee for a detailed match of requirement and availability.

The degree of flexibility of manpower availability is the degree to which the organization can transfer employees to other functions or locations (mobility). Dimissing employees of one type and recruiting personnel of another type is also a form of (indirect) mobility.

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If we consider an organization with departments, then a high level of aggregation is allowed if the mobility between the departments is so high that there will never arise a matching problem in a subsystem if the aggregated system has been matched. In the remainder of this subsection this is explained in more detail by means of an example.

Example. Consider a manpower system with two groups of functions on the same organizational level (fig. 5.9).
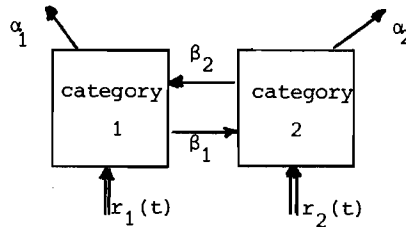
Figure 5.9. A manpower system with two categories of personnel (functions) on the same organizational level. α_i indicates the wastage fraction from category i; β_i denotes the mobility fraction from category i and $r_i(t)$ indicates the recruitment in category i during the time interval $(t-1,t]$.

Define:

α_i $\equiv$ wastage fraction from category i;

β_i $\equiv$ mobility fraction from category i, indicating the maximal fraction of employees in category i who can be transferred to the other category each year;

$m_i(t)$ $\equiv$ the number of required employees in category i at time t;

$n_i(t)$ $\equiv$ the number of available employees in category i at time t;

$r_i(t)$ $\equiv$ recruitment in category i during the time interval $(t-1,t]$;

$b_i(t)$ $\equiv$ the numbers of employees in category i who are transferred to the other category during the time interval $(t-1,t]$.

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For the sake of simplicity we assume the wastage fractions for both
categories to be equal and constant over time: $\alpha = \alpha_1 = \alpha_2$. Suppose
that the system can be controlled by recruitment and by transferring
employees from category 1 to category 2 and vica versa. There is no
restriction on recruitment. The goal is to minimize the deviations
between manpower requirement and availability over a certain planning
horizon of say T years. We assume the costs of deviations between
available and required numbers of employees to be constant over time
and equal for both categories.

We will investigate whether it is possible to solve this matching
problem by using an aggregated model for a long planning horizon and
a disaggregation model for the first planning period. If this is not
possible, then a detailed model for the two-category system has to be
used.

In the detailed model, the recruitment $r_i(t)$ and the numbers of trans-
fers $b_i(t)$ are determined simultaneously for both categories for all
planning years.

The detailed model of the two-category system is:

minimize

$$(5.1) \qquad \sum_{t=1}^{T} \{ |n_1(t) - m_1(t)| + |n_2(t) - m_2(t)| \}$$

under the conditions:

$$(5.2) \qquad n_1(t) + n_2(t) \geq (1 - \alpha) \, (n_1(t - 1) + n_2(t - 1)),$$

$$\text{for } t = 1,2,\ldots,T,$$

$$(5.3) \qquad n_1(t) \geq (1 - \alpha - \beta_1) \, n_1(t - 1),$$

$$\text{for } t = 1,2,\ldots,T,$$

$$(5.4) \qquad n_2(t) \geq (1 - \alpha - \beta_2) \, n_2(t - 1),$$

$$\text{for } t = 1,2,\ldots,T.$$

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Solving this problem gives the solution for $n_1(t)$ and $n_2(t)$, for all $t = 1,2,\ldots,T$. The values of $r_i(t)$ and $b_i(t)$ are determined by the values of $n_i(t)$. For instance, if $n_1(t) < (1 - \alpha)\, n_1(t - 1)$ then $r_1(t) = 0$; $r_2(t) = (n_1(t) + n_2(t)) - (1 - \alpha)(n_1(t - 1) + n_2(t - 1))$, and $b_1(t) = (1 - \alpha)n_1(t - 1) - n_1(t)$; $b_2(t) = 0$.

In the aggregated version of the model, total recruitment $r(t)$ is determined for $t = 1,\ldots,T$.

The aggregated version of the model is:

minimize

$$(5.5) \qquad \sum_{t=1}^{T} \left| s(t) - (m_1(t) + m_2(t)) \right|$$

under the conditions:

$$(5.6) \qquad s(t) \geq (1 - \alpha)\, s(t - 1) \qquad , \text{ for } t = 1,2,\ldots,T ,$$

where $s(t)$ is the total number of employees at time t. Solving this problem gives the solution for $s(t)$, for all $t = 1,2,\ldots,T$. The values of $r(t)$ are determined by the values of $s(t)$, namely:

$$(5.7) \qquad r(t) = s(t) - (1 - \alpha)s(t - 1).$$

The total number of employees, as computed with the aggregated model, has to be distributed over the categories. In order to determine $n_1(1)$ and $n_2(1)$ one may use the following disaggregation model:

minimize

$$(5.8) \qquad \left| n_1(1) - m_1(1) \right| + \left| n_2(1) - m_2(1) \right|$$

under the conditions:

$$(5.9) \qquad n_1(1) + n_2(1) = s^*(1),$$

$$(5.10) \qquad n_1(1) \geq (1 - \alpha - \beta_1)n_1(0),$$

$$(5.11) \qquad n_2(1) \geq (1 - \alpha - \beta_2)n_2(0),$$

where $s^*(1)$ in the optimal value of $s(1)$ as found when using the aggregated model.

Solving the aggregated mdoel and then solving the disaggregation model gives values for $n_1(1)$ and $n_2(1)$. Values for $n_1(t)$ and $n_2(t)$ for $t > 1$ can be obtained in the same way. Aggregation is allowed if these values for $n_1(t)$ and $n_2(t)$ for $t > 0$ are optimal. This is the case if following conditions are satisfied:

(5.12) $\quad m_1(t) \geq (1 - \alpha - \beta_1) \, m_1(t - 1) \qquad$, for $t = 1,2,\ldots,T$,

(5.13) $\quad m_2(t) \geq (1 - \alpha - \beta_2) \, m_2(t - 1) \qquad$, for $t = 1,2,\ldots,T$,

(5.14) $\quad m_1(t) \leq (1 - \alpha) \, m_1(t - 1) + \beta_2 m_2(t - 1) + s^*(t) - (1 - \alpha) s^*(t - 1)$,

$$\text{for } t = 1,2,\ldots,T \text{ ,}$$

(5.15) $\quad m_2(t) \leq (1 - \alpha) m_2(t - 1) + \beta_1 m_1(t - 1) + s^*(t) - (1 - \alpha) s^*(t - 1)$,

$$\text{for } t = 1,2,\ldots,T \text{ ,}$$

where

$$n_1(0) = m_1(0) \text{ and } n_2(0) = m_2(0)$$

and $s^*(t)$ is the optimal solution for the aggregated model.

The conditions (5.12) - (5.13) indicate that manpower requirement may not decrease yearly with more than the numbers of leavers and the number of transferable employees for each category. The conditions (5.14) - (5.15) ensure that if both categories are sufficiently occupied at time t, then it is possible to obtain a sufficient number of employees in at least one of the categories at time t + 1.

For further research on the level of aggregation and its relationship to the planning horizon in manpower planning see Nuttle/Wijngaard [63] and Wijngaard [93].

Consider now some numerical results for the example above. The parameter values are:

$$\alpha = 0.1; \ \beta_1 = 0.2; \ \beta_2 = 0.1; \ T = 2;$$

$$n_1(0) = m_1(0) = 1000; \ m_1(1) = 1200; \ m_1(2) = 900;$$

$$n_2(0) = m_2(0) = 1500; \ m_2(1) = 1300; \ m_2(2) = 1100.$$

An investigation of the conditions (5.12) - (5.15) shows that aggregation is allowed. Solving the aggregated model (5.5) - (5.6) gives the following results:

$$s(0) = 2500 \ ; \ s(1) = 2500 \ ; \ s(2) = 2250;$$

which makes a discrepancy in period 2 obvious. Executing the disaggregation step gives: $n_1(2) = 900 \ ; \ n_2(2) = 1350$.
Solving the disaggregated model (5.1) - (5.4) gives the following solution:

$$n_1(0) = 1000; \ n_1(1) = 1200; \ n_1(2) = 900;$$

$$n_2(0) = 1500; \ n_2(1) = 1300; \ n_2(2) = 1350.$$

This solution is indeed identical to the solution of the aggregated model.
The solution in terms of recruitment and transfers is:

$$b_1(1) = 0; \ b_1(2) = 180;$$

$$b_2(1) = 50; \ b_2(2) = 0;$$

$$r_1(1) = 250; \ r_1(2) = 0;$$

$$r_2(1) = 0; \ r_2(2) = 0.$$

5.4.3. *Discussion*

The choice of the level of aggregation is not unique in general.
A function can be classified roughly in a three-dimensional way: the organizational level of the function, the place where the function is

executed and the organizational sector where the function belongs. Aggregation based on one of these dimensions is called vertical aggregation, geographical aggregation and sectoral aggregation, respectively.

The example above shows that aggregation is possible if the mobility between the subsystems to aggregate is so high that there will never arise a matching problem in a subsystem, if the aggregated system has been matched. The match of requirement and availability in the aggregated plan guarantees the match for each subsystem.

But also if the situation is not so ideal with respect to the mobility between the subsystems, the matching of the aggregated forecasts improves the possibility to obtain a good future match in each of the subsystems. If there are no more possibilities for aggregation (sectoral or geographical for instance) one can choose the dimension over which the mobility is highest. If sectoral mobility is higher than geographical mobility it is probably better to apply sectoral aggregation.

The conditions for vertical aggregation are of the same type as the conditions for horizontal aggregation. But the mobility is asymetrical in this case. It is impossible, in general, that people move to a lower organizational level. Let for instance A and B be two different levels and let the normal career scheme be that people start in B and move to A after a number of years. Assume a constant growth in the number of available functions of 10% a year. If there are no restrictions on the numbers of recruits it is always possible to adapt the number of available people to this growth, although one can get difficulties with experience requirements. Another difficulty can be the existence of fixed career patterns. If one moves from B to A after five years of experience, the number of people at level A is not influenced by recruitment for the first five years. Thus, each restriction on the flows between B and A is a handicap for aggregation.

As mentioned already in subsection 5.4.1, there is also a relation between the level of aggregation and the organization structure. On the central level of an organization one usually considers a high level of aggregation since it is impossible to solve possible discrepancies on a lower level of aggregation. Therefore, budgets are expressed, for instance, in total salary costs. The number of allowed

employees in each category cannot be determined. This has to be done on the lower level of the organization. In the Dutch police organization, for instance, a total budget is given for each of the local forces. The local organization has to fill in the concrete numbers and types of police officers.

5.5. Planning horizon

5.5.1. *Introduction*

As we have seen in subsection 5.4.2, there is a relation between the level of aggregation and the length of the planning horizon. For organizations with a high degree of flexibility (a high degree of mobility) only a short planning horizon will be required.

In this section we will discuss in particular the relation between planning horizon and uncertainty. A simulation experiment has been executed in order to illustrate this relation (subsection 5.5.3).

5.5.2. *Planning horizon*

There are two reasons why a short planning horizon may be sufficient:

1 large flexibility of manpower requirement and availability;
2 large uncertainties with respect to the forecasts.

ad 1. Large flexibility of manpower requirement and availability.

This reason corresponds with the requirement of flexibility for high levels of aggregation (subsection 5.4.2). In situations of a high degree of flexibility of manpower requirement and availability it is relatively easy to obtain a match of manpower demand and supply. If wastage is high, for instance, or if the organization is growing there will be sufficient functions available for the employees such that the career expectations can be satisfied. In these situations a short planning horizon is sufficient.

ad 2. Large uncertainties with respect to the forecasts.

In fact, two types of uncertainties are important, the unpredictable variability (see subsection 1.6.2) in manpower availability and the unpredictable variability in manpower requirement. In subsection 3.2 we

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considered the possible errors in the manpower availability forecasting. As has been shown (table 4.3), the standard deviations of the forecasted manpower distribution over the grades are relatively small on medium term. The unpredictable variability in manpower requirement, however, may be much more important. Many factors will influence this requirement: market share, technology, economical situation, etc. In the case of large uncertainties, a short planning horizon is sufficient.

5.5.3. *Simulation experiment*

In this subsection we will use a simulation experiment in order to illustrate the relation between the length of the planning horizon and the variability (both predictable and unpredictable) of the requirement.

Suppose, we have one category of personnel (for instance one grade or the entire personnel size). The wastage fraction p is known and constant, say 0.05 (fig. 5.10).
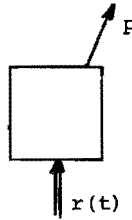
Figure 5.10. One category of personnel with wastage fraction p and yearly recruitment r(t).

The number of employees in the category is assumed to be controlled by a rolling plan procedure. In order to simulate such a controlled process, one has to indicate how the real manpower requirements and availabilities originate, but also how the forecasts are obtained and how the matching is executed.

We distinguish the following phases of a rolling plan procedure (cf. subsection 1.2.5):

<u>1</u> forecasting of manpower requirements;

<u>2</u> forecasting of manpower availabilities;

<u>3</u> matching of forecasted requirements and availabilities by means of recruitment.

Define:

$\hat{m}(t, t + i)$ ≡ estimated manpower requirement for time $t + i$ made at time t;

$m(t)$ ≡ manpower requirement at time t (realization);

$n(t)$ ≡ manpower availability at time t (realization);

$r(t)$ ≡ recruitment in the time interval $(t - 1, t]$;

ad <u>1</u>. Forecasting of manpower requirement.

We assume that the realization of manpower requirement $m(t)$ is obtained by the following process:

(5.16) $m(t) = m_1(t) + m_2(t) + c,$

where

$m_1(t)$ ≡ unknown component of the manpower requirement;

$m_2(t)$ ≡ given, fluctuating component of the manpower requirement;

c ≡ constant;

$m_1(t)$ is supposed to follow an auto-regressive process of order 1 (cf. (2.6)):

(5.17) $m_1(t + 1) = \alpha\, m_1(t) + \varepsilon_t$

where α is the given process coefficient and the noise ε_t has the following characteristics:

(5.18) $\mathbb{E}\,\varepsilon_t = 0$ and $\mathbb{E}\,(\varepsilon_t \cdot \varepsilon_{t-k}) = \begin{cases} 0 & \text{for } k \neq 0 \\ \lambda\sigma^2 & \text{for } k = 0 \end{cases}$ for $t = 0, 1, 2, \ldots$.

In the simulation process, we will vary the values of λ in order
to investigate the influence of a different degree of uncertainty on
the length of the planning horizon $(0 \leq \lambda \leq 1)$.

$m_2(t)$ is also supposed to follow an auto-regressive process of order
1, but is known for T years ahead according to:

(5.19) $m_2(t + 1) = \alpha \, m_2(t) + \delta_t$

where the noise δ_t has the following characteristics:

(5.20) $\mathbb{E} \, \delta_t = 0$ and $\mathbb{E} \, (\delta_t \cdot \delta_{t-k}) = \begin{cases} 0 & \text{for } k \neq 0 \\ (1 - \lambda)\sigma^2 & \text{for } k = 0 \end{cases}$

$$\text{for } t = 0,1,2,\ldots \, .$$

It is assumed that the δ_t are known T years in advance. In a simula-
tion procedure we obtain the manpower requirement forecasts at time t
according to the following formula:

(5.21) $\hat{m}(t,t + i) = \hat{m}_1(t,t + i) + m_2(t + 1) + c,$

for $i = 1,2,\ldots,T$

for $t = 0,1,2,\ldots,$

where

$\hat{m}_1(t,t + i) \equiv$ minimal mean square error forecast for the unknown com-
            ponent of the manpower requirement at time $t + i$, made
            at time t;

$m_2(t + i) \equiv$ given component of manpower requirement at time $t + i$.

The forecasts $\hat{m}_1(t,t + i)$ for the unknown component can be obtained by:

(5.22) $\hat{m}_1(t,t + i) = \alpha^1 \cdot m_1(t)$.

ad 2. Forecasting of manpower availabilities.

Wastage and recruitment bear influence on the manpower availability.
We assume the wastage fraction p to be known and constant over time

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(deterministic situation).

Thus:

(5.23) $n(t + 1) = n(t) \cdot (1 - p) + r(t + 1)$,   for $t = 0,1,2,...$

ad <u>3</u>. Matching by means of recruitment.

The matching of manpower requirement and availability is executed by means of recruitment. The recruitment for time $0,1,2,...,$ is obtained by minimizing

(5.24) $\sum_{i=1}^{T} \left| \hat{m}(t,t + i) - n(t + i) \right|$.

In order to evaluate the outcomes of the simulation process for different planning horizons T we must have a performance criterion. Let M be the number of periods over which the rolling plan is simulated.

The following performance criterion is used to evaluate the outcomes:

(5.25) $\frac{1}{M} \cdot \sum_{t=1}^{M} \left| n(t) - m(t) \right|$.

Results of the simulation for different values of λ, σ^2 and T are given in table 5.10. The simulations have been executed for M = 500 in 5 runs of 100 trials, each with a "warming-up" period of 50 trials. Because of the linear objective function (5.24), the value of the criterion (5.25) changes only for all odd values of the planning horizon.

Table 5.10 clearly shows that in case of large but predictable fluctuations of the manpower requirement ($\lambda \sim 0$, σ^2 large) large planning horizons are necessary, whereas in case of large but unpredictable fluctuations of the manpower requirement ($\lambda \sim 1$, σ^2 large) short planning horizons are sufficient. Small fluctuations (σ^2 small) will also result in short planning horizons.

Notice that many extensions can be investigated. Here, we only considered one category of personnel (high level of aggregation). If the flexibility of manpower availability is low, for instance because of the existence of fixed career patterns, then the planning horizon will lengthen. However, we will not discuss such aspects in more detail. (see also Nuttle/Wijngaard [63]).

σ^2	λ	value of the performance criterion for planning horizon											
		1	2	3	4	5	6	7	8	9	10	11	12
400	0	13.27	13.27	10.03	10.03	9.26	9.26	8.90	8.90	8.85	8.79	8.79	8.75
	.25	15.71	15.71	13.65	13.65	13.34	13.34	12.82	12.82	12.71	12.60		
	.50	17.09	17.09	15.71	15.71	15.43	15.43	15.29	15.29	15.17	15.16		
	.75	18.37	18.37	17.63	17.63	17.41	17.41	17.33	17.33	17.24			
	1	19.72	19.72	19.48	19.48	19.45							
100	0	3.43	3.43	2.55	2.55	2.44	2.44	2.41					
	.25	5.78	5.78	5.16	5.16	5.09							
	.50	6.79	6.79	6.44	6.44	6.40							
	.75	7.63	7.63	7.46									
	1	8.59											
25	0	.50	0.50	0.42									
	.25	2.11	2.11	2.06									
	.50	2.85	2.85	2.82									
	.75	3.45											
	1	4.05											

Table 5.10. Results of the simulation experiment for different values of σ^2 and λ. The last number on each line indicates the minimum value of the criterion; an increase of T would not improve the criterion value. The parameters are: $p = 0.05$; $\alpha = 0.8$; $c = 100$.

5.6. Requirements for the personnel registration

In this section we will briefly discuss the relation between the in-
troduction of manpower planning – and more specifically of systems as
FORMASY – and the personnel registration of an organization. As we
have seen throughout this book, manpower planning requires a lot of
information, both about the personnel and about the functions. First,
information about the numbers and types of functions, now and in the
future, is necessary. Therefore, a (automized) function registration
system can be helpful. In such a system all functions are recorded
together with information about the organizational level and the ne-
cessary qualifications or training. This function registration system
agrees with the organization scheme of this moment. It may also con-
tain information about the future development of the functions, e.g.
the time at which a function will disappear or when new functions will
arise. An example of a part of such a registration system is shown in
fig. 5.11.

(1)	(2)	(3)		(4)	(5)	(6)	(7)	(8)
organization element code	serial number	number of functions		grade (rank)	function name	function code	authority level	function requirements + remarks
		peace-time	war-time					
21.000		manpower planning department						
	010	1	1	col.	off. P	05027	63	also controller
	020	1	1		registr.	850105	63	secr. also diary
					registr.	850103	63	secr. also diary
21.000		planning section						
	010	1		lt. col.	off. P	05026	62	
	030	1*	1*	maj.	off. Klu	09900	63	to be replaced by probationer
	040	1	1	cap.	off. Bez.	050043A	42	
	050	1	1	maj.	off. P.	05025	42	automation knowledge

Fig. 5.11. Example of a part of a function registration system for a Dutch defense organization, containing: (1) department nr., (2) serial number of the function, (3) the number of similar functions both in peace-time and in war-time, (4) grade (rank) corresponding to the function, (5) function name, (6) function code, (7) authority level of the function, (8) function requirements and remarks.

The registration system shown in fig. 5.11 stems from a Dutch defense organization. If fits to the requirement of that organization. Other organizations may want to include different characteristics, but this system indicate, how such a registration system may look like.

Secondly, information is required on the number of employees. This may be obtained by means of a (automized) personnel registration system which stores the information about the actual employees. It may contain data such as: name of the employee, date of birth (age), sex, family status, date of entry in the organization (length-of-service), grade at entrance, date of last promotion (grade seniority), training, experience, expectations with respect to functions, actual functions. For an adequate use of FORMASY it is helpful if such data is available. A personnel registration system gives information about the actual numbers and types of employees and offers the opportunity to compute historical transition fractions by comparing the positions of employees for instance once a year. As we have seen in chapter 4, this data is necessary in order to investigate the consequences of a continuation of the historical policies on the evolution of the manpower distribution. Both the historical promotion and the turnover rates have to be adjusted each year.

5.7. Requirements for the personnel department

In this section we will make some remarks on the requirements for the personnel department. In our view, the personnel department should have the responsibility to examine the evolution of manpower requirement and availability, to notice possible discrepancies and to propose or to take actions in order to solve the matching problems. Thus, this department should no only have a passive role in the registration of functions and employees but also an active role in the design of policies with respect to personnel.

The introduction of a manpower data-base and a manpower planning system such as FORMASY implies certain tasks for the personnel department. In the first place, the structure of the function and personnel registration system has to be (re)designed - such that it can be used for planning purpose -, in cooperation with the computer secondly,

in order to detect trends and systematic changes in both the organi-
zation structure and the personnel distribution, is necessary that the
personnel department updates the function and personnel registration
system, makes from time to time surveys of personnel flows and func-
tion changes and investigates future consequences. The introduction
of a computer-aided manpower planning system such as FORMASY leads to
requirements with respect to the employees who have to use this system
and the staff members who have to interpret the results. The intro-
duction, therefore, has to be done in such a way that possible resis-
tance to computer-aided systems can be overcome, especially by showing
that all computations can be checked easily by hand and are only exe-
cuted by means of a computer program to save time.

The acceptance of these requirements implies that the management of a
personnel department must be qualified to understand the value of man-
power planning in general and of systems like FORMASY in particular.
Moreover, one has to be familiar with computerized function and per-
sonnel registration systems.

5.8. Concluding remarks

Many restrictions both from outside the organization e.g. laws, labour
market, labour costs, etc. and from within such as personnel demands,
career expectations, commitment and so on, enforce the necessity of
manpower planning. The planning of personnel has been a neglected part
of the corporate planning for a long time.

In large organizations, quantitative methods are needed, as well to
forecast the development of the numbers and types of functions, as to
forecast the numbers and types of employees. The design of policies to
avoid discrepancies can be done best by considering the consequences
of alternatives. These consequences may be computed directly using a
manpower planning system such as FORMASY.

By accepting such a manpowe planning procedure, management can take
actions in time, This is not only important for the organization or
management but also for the individual employees. Manpower planning
systems offer the possibilities for a dialogue between management and
personnel (or trade unions) in order to prevent sudden conflicts. In
this way the organization can function better and the employees can
get rational information about career possibilities.

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CHAPTER 6

A CASE-STUDY

6.1. Introduction

The manpower planning system FORMASY and its possible use has been
discussed in chapter 4 and 5. The use of FORMASY for practical man-
power planning will be illustrated in this chapter by means of a case-
study. We will describe the way FORMASY is used in the manpower plan-
ning process at the manpower planning department of the Royal Nether-
lands Airforce.

In section 6.2 we will broadly consider the complete manpower planning
process of this organization. We will describe in this case-study the
use of FORMASY for the group of officers. The model structure for this
group is given in section 6.3. Various planning horizons will be dis-
cussed. Long term planning is regarded in section 6.4, medium term
planning in section 6.5, while in section 6.6 the short term planning
will be described. Detailed manpower planning for task groups is given
in section 6.7. Finally, in section 6.8, a summary of this case-study
is presented.

All policies, models and figures mentioned in this chapter are fictive.
However, they have been chosen in such a way that a certain corres-
pondence with the current situation has been obtained.

6.2. Manpower planning within the Royal Netherlands Airforce

The personnel plan of the Royal Netherlands Airforce is integrated in
the defense planning process, together with the finance and the mate-
rials plan. This personnel plan indicates the numbers and types of em-
ployees in different functions for the next ten years. The plan is ad-
justed every two years. Information about the corporate planning and
the way personnel requirement forecasts are obtained has been given in
subsection 2.4.2 (case 1). Therefore, manpower requirement forecasting
will not be considered here.

Manpower policies within this organization aim at the following goals:

1. An adequate filling - both quantitatively and qualitatively - of
   the peace-time organization as well as of the war-time organization.

This goal implies that a given number of employees in each type of function has to be reached in a situation of peace-time, but also an additional number of reservists (mobilization force) has to be maintained for war-time situations.

2. A planned development of the careers of the regular staff. Promotions are often made after a fixed number of years in a certain rank, but only if adequate higher ranked positions are available. For this reason, career prospects have to be controlled, especially since at the moment an irregular age distribution exists.

3. Flexibility in the structure of the manpower composition in peace-time.
   The possibility of recruitment of short-term volunteers and conscripts, to fill temporary staff shortages, contributes to the maintenance of flexibility.

The manpower planning department controls the careers of the regular staff and is involved in the determination of the numbers of recruits of several categories of military personnel. The management of the Airforce is interested in the evolution of the actual manpower distribution and in the question whether there will arise discrepancies between staff supply and demand.

Special problems are caused by the actual irregular age structure which has been caused by changes in the size of the organization and by changes in recruitment which occurs in only a few age classes. The organization has known a period of growth, then several years of about constant size and has grown again in the last few years. This has resulted in an age distribution with a high fraction of older employees, also a high fraction of younger employees, but relatively low numbers of employees in the intermediate groups (see fig. 6.3). Some consequences of this age structure are the relatively high numbers of retirements in the next few years, good career prospects for the employees in the intermediate age groups and poor promotion possibilities for the younger personnel group. Therefore, it is important to develop strategies which restore the age distribution (see subsection 1.2.3), e.g. by recruitment in different age groups, flexible retirement ages, changes in career prospects, etc.

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Other matching problems of manpower supply and demand concern the training level of the employees, their qualification level and so on. Thus, also training and development planning is important. Allocation planning is another important topic.

Rising salary costs and matching problems as discussed above have resulted in a growing interest in manpower planning instruments within this organization.

Three time-horizons of manpower planning can be distinguished:

a Long term planning.

   This type of planning deals with the construction of equilibrium structures (manpower pyramids) for all groups. This is executed by assuming stable manpower requirements and then developing stable manpower populations. Long term age distributions , career paths and the numbers of recruits are thus determined.

b Medium term planning.

   Medium term planning gives the forecasts for the evolution of the number of employees in the various categories in the subsequent ten years and the determination of recruitment of regular staff and short-run volunteers. The planning is also used to adjust the career paths and to provide forecasts for the development of personnel expenses.

c Short term planning.

   This type of planning delivers the forecasts of the evolution of manpower availability and of the requirements for the following three years – in monthly figures – in all types of functions and all categories of personnel. These forecasts are used for the determination of the numbers of recruits for short term volunteering and of conscripts. These forecasts also provide the calculation basis for the Airforce financial estimates.

This case-study presents some examples of these planning activities for the peace-time strength of military staff.

Manpower planning is executed broadly for the different staff groups (officers, non-commissioned officers, etc.) as well as detailedly for the different task groups (air-operations, ground-operations, electronics and so on). The sections 6.3 – 6.6 cover the broad planning

procedure, whereas section 6.7 deals with the detailed planning.

6.3. Model structure

We will treat the model structure for the group of officers. For the other staff groups similar models have been constructed.

The group of "officers" is divided in five classes according to rank or grade (some higher grades are lumped because of small numbers): lieutenant, captain, major, lieutenant-colonel, and finally colonel or higher ranks. Two training levels can be distinguished. The officers for special services (O.S.S.) have a two years' training. They are partially selected from the lower ranks. The officers who have completed the Royal Military Academy (R.M.A.) have a four or five years' training.

The maximum grade for the O.S.S. officers is normally the rank of "lieutenant-colonel". However, some of the officers with this training, who have attended the course "field officers" (about 15%), can be promoted to the training level of R.M.A. officers when they have the rank of "captain". This enlarges the chances for fast promotion and reaching the highest rank of colonel. In the grade "major" and "lieutenant-colonel" the R.M.A. officers are divided into three qualification levels, namely for those who do not have the potential ability to reach the rank of colonel, for those who have this potential ability and for the officers with an Airforce staff licence or with a university degree. A career scheme for the officers is given in fig. 6.1. In each class, the theoretical possibility of 24 grade seniorities is included.

colonel or higher grades

(COL +)

lieutenant-
colonel (LT COL)

major (MAJ)

captain (CAP)

lieutenant (LT)
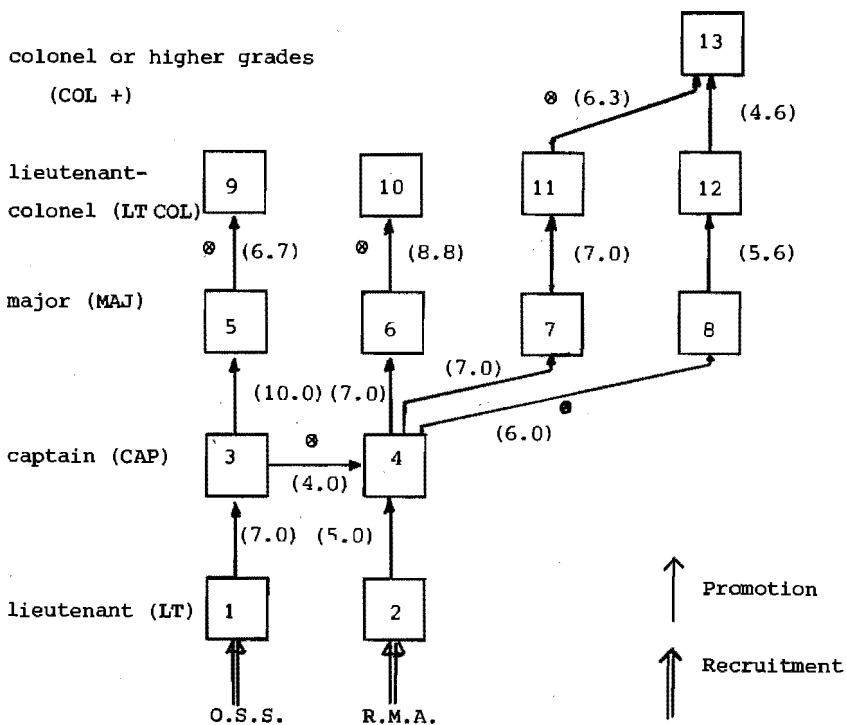
Figure 6.1. Career patterns for officers and the average grade senior-
ities until promotion. In brackets, the average grade
seniority until promotion is denoted. Transitions with ⊗
are selection promotions (i.e. not all officers make these
transitions). The ratio between recruits O.S.S. and re-
cruits R.M.A. = 5 : 3. This relationship is the result of
the overall desired manpower distribution and career paths.
Classes 6 and 10 are determined for officers without po-
tential ability for colonel (qualification level 1), clas-
ses 7 and 11 for officers with potential ability for colo-
nel (qualification level 2) and the classes 8 and 12 for
officers with a university degree or staff licence (quali-
fication level 3).

The average grade seniorities until promotion as well as the input
data needed for the use of the FORMASY system for this model have been

obtained directly from the personnel registration system.

6.4. Long term planning

By means of a special option of the FORMASY system one may compute
the steady-state distribution over the grades for some given recruit-
ment (see subsection 4.4.3). The recruitment has been chosen such
that the ratio between recruits O.S.S. and recruits R.M.A. is 5 : 3.
The computed steady-state distribution is compared with the desired
distribution. Subsequently new recruitments are computed such that
the desired distribution is obtained and assuming that the given ratio
will not change.

The historical age distribution of the recruits is shown in fig. 6.2.
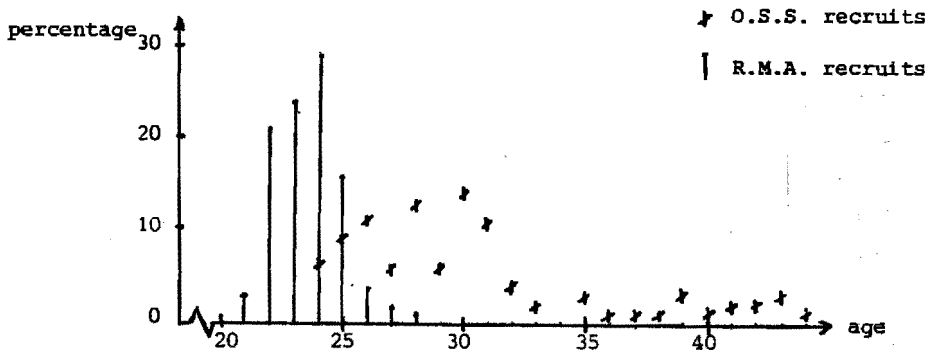
Figure 6.2. Age distribution of recruited O.S.S. and R.M.A. officers
in the last five years.

The actual manpower distribution and the steady-state manpower distri-
bution are presented in table 6.1. The steady-state distribution is
based on recruitment of 45 O.S.S. and 27 R.M.A. officers yearly and
the assumption that historical promotion and turnover rates will re-
main constant in the future.

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	GRADE					
	LT	CAP	MAJ	LT.COL	COL+	TOTAL
actual distribution	318	466	467	220	85	1556
steady-state distribution	435	519	396	158	54	1562

Table 6.1. Actual and steady-state manpower distribution of officers over the grade with a yearly recruitment of 45 O.S.S. and 27 R.M.A. officers and with historical promotion and turnover rates.

The desired manpower distribution over the grades is assumed to be equal to the actual distribution. Table 6.1 shows a forecasted over-occupation of lower grades and a shortage of personnel in the higher grades. The reason for this result is the existing number of years until promotion takes place for each grade. The Royal Netherlands Airforce has recruited in a few years after World War II many young officers and these employees will retire in the next few years (see fig. 6.3). As a consequence, there have been only a few vacancies in the higher ranks in recent years and this has resulted in a slowing down of promotions. If the existing career policies would be maintained, then the forecasted shortage of staff in the higher ranks in the long future would be realized.

```
AGE     %
  54    *33334444455555
  53    *2233333333333344444444444455555555
  52    *122223333333333333333344444444444444444444555555555555555
  51    *12222333333333333444444444444444444455555
  50    *222223333333334444444444444444444555555
  49    *12222233333333333333333344444444444444555
  48    *12222223333333333333333333333333444444444444455
  47    *112222233333333333333333333344445
  46    *111111222333333333333333333444444
  45    *112222333333333333333344444
  44    *11222223333333333333333333333333444444444
  43    *1122223333333333333333333333444
  42    *122222222223333333333333333334444
  41    *112222222222333333333333334
  40    *11222222222222222333333333333
  39    *12222223333333333
  38    *112222222222222333333333
  37    *1111112222222222222222222222222233333333
  36    *1111111222222222222222222222222223333
  35    *111111222222222222222222223333
  34    *111111111112222222222222223
  33    *11111111111111122222222222222222222
  32    *111111111111111222222222222222222
  31    *11111111111112222222222222222
  30    *11111112222222222222
  29    *111111111122222222
  28    *11111111111111122222
  27    *111111111222
  26    *11111111111111111
  25    *11111111111
  24    *111111111
  23    *11111
  22    *1
  21    *
------------------------------------------------
  1 FIGURE = 2 EMPLOYEES
------------------------------------------------
```

Figure 6.3. Actual age distribution of Airforce officers. The retire-
        ment age is 55.

It is possible to decrease the average time until promotion, without
changing the fraction of officers who are promoted. This would give
a speeding-up of promotions without affecting the selection criteria
for promotion. By such a speeding-up of promotions one might obtain a
steady-state distribution of officers over the ranks which looks more
like the actual distribution than the steady-state distribution of the
actual promotion policy (see table 6.1).

After some trial and error efforts, an alternative can be designed as indicated in fig. 6.4 (cf. fig. 6.1).

Figure 6.4. Alternative career pattern for officers.
The figures in brackets denote the shortening of average grade seniorities until promotion, compared with the original averages in fig. 6.1. In this alternative policy, the highly qualified officers even make faster promotion than in the policy of fig. 6.1.

Table 6.2 gives a comparison of the actual distribution of officers over the ranks with the steady-state distribution for the newly designed promotion policy of fig. 6.1.
This alternative career path seems acceptable. The long term age distribution which will result is shown in fig. 6.5.

		GRADE				
	LT	CAP	MAJ	LT.COL	COL+	TOTAL
actual distribution	318	466	467	220	85	1556
steady-state distribution	300	483	466	220	87	1557

Table 6.2. Actual distribution of officers over the ranks compared
with the steady-state distribution for the newly designed
policy (cf. table 6.1).

```
AGE    %
 54   *233333333333444444445555
 53   *22333333333544444445555
 52   *2233333333334444444445555
 51   *2233333333334444444445555
 50   *22233333333334444444445555
 49   *222333333333333444444445555          1 = LT
 48   *222333333333334444444555
 47   *1222333333333333344444444555          2 = CAP
 46   *1222333333333333334444444555
 45   *11222333333333333334444444555          3 = MAJ
 44   *11222223333333333333444444455
 43   *11222222333333333344444455          4 = LT COL
 42   *112222222333333333344444455
 41   *11222222222233333333334444455          5 = COL +
 40   *11222222222222333333333344445
 39   *112222222222223333333333444
 38   *12222222222222233333333344
 37   *11222222222222222233333333344
 36   *112222222222222222233333333334
 35   *11111222222222222222333333333
 34   *1111111222222222222233333333
 33   *1111111112222222222222222333333
 32   *1111111111112222222222222222333
 31   *111111111111122222222222222223
 30   *11111111111122222222222222
 29   *1111111111111222222222222
 28   *1111111111111111222222222
 27   *111111111111111222222
 26   *11111111111111111222
 25   *111111111111111111
 24   *1111111111111
 23   *111111
 22   *111
 21   *
---------------------------------------------
1 FIGURE   =   2 EMPLOYEES
---------------------------------------------
```

Figure 6.5. Steady-state age distribution for the alternative career
scheme for Airforce officers as developed in fig. 6.4.
Compare this age distribution with the current age distri-
bution as exhibited in fig. 6.3.

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Another type of policy that can be considered in order to obtain an appropriate steady-state distribution over the ranks, is an increase of the retirement age from 55 to - say - 58 years. The result of a such a policy, when historical career schemes and turnover fractions are maintained, is given in table 6.3. The recruitment consists of 40 officers O.S.S. and 24 officers R.M.A. each year.

	GRADE					
	LT	CAP	MAJ	LT.COL	COL+	TOTAL
actual distribution	318	466	467	220	85	1556
steady-state distribution	387	475	420	200	74	1556

Table 6.3. Actual distribution of officers over the ranks compared with the steady-state distribution for the promotion policy of fig. 6.1, retirement at the age of 58 and a yearly recruitment of 40 O.S.S. and 24 R.M.A. officers.

With this increased retirement age, only small changes in promotion policies would be necessary in order to obtain the desired steady-state distribution.

6.5. Medium term planning

Apart from recruitment of regular personnel, the Airforce has the opportunity to recruit volunteers on officers level in the grade "lieutenant" on a contract basis of four or six years. After this period they leave the organization. In section 6.4 the recruitment numbers for regular officers have been calculated, who are necessary to maintain the total strength in the long run. If this recruitment policy is really used, then the unfavourable age distribution of this moment will disappear in the long run. However, in short and medium term this would lead to a shortage of officers (because of many retirements). This shortage, now, can be met by the recruitment of more volunteers. The necessary extra recruitment of lieutenants for the next

five years has been calculated with FORMASY and is shown in fig. 6.6
for the alternative career scheme of fig. 6.4. The resulting distri-
bution of officers over the ranks for the next five years is given in
table 6.4.

Number of extra
recruits
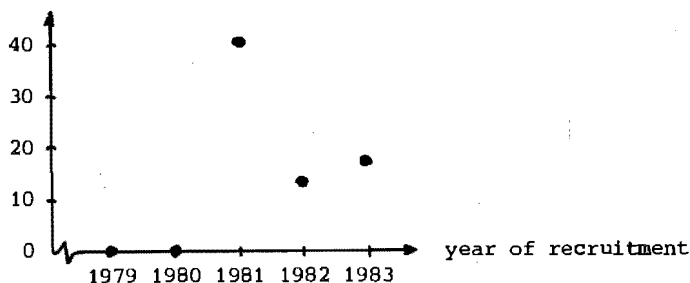
Figure 6.6. Necessary recruitment of volunteers in order to keep the
total strength constant, while using the promotion policy
of fig. 6.4 and the original recruitment policy of table
6.1.

| YEAR | GRADE | | | | | TOTAL |
	LT	CAP	MAJ	LT COL	COL+	
1979	318	466	467	220	85	1556
1980	168	546	516	260	88	1578
1981	191	547	480	263	82	1564
1982	271	516	458	250	61	1556
1983	313	502	451	234	55	1556
1984	374	459	459	213	51	1556

Table 6.4. Forecasted distribution of officers over the ranks, inclu-
ding the recruitment of volunteers as described in fig. 6.6.

Table 6.4 shows clearly that in the next two years the total number of
officers would be slightly more than is allowed with the alternative
policy. Moreover and worse, the distribution of officers over the
grades differs considerably from the actual distribution. This means
that the alternative career scheme which satisfies in the long run

does not give an appropriate distribution of officers over the ranks
in medium term. One reason for the irregular development of the dis-
tribution over the ranks is the actual distribution of grade seniori-
ties. Because of fluctuating recruitments in the past, this distri-
bution is very unbalanced (see table 6.5). Promotion mostly occurs at
a fixed grade seniority which results in heavily varying promotion
flows. A way to meet this problem in the future is by stopping to promote
the officers at a fixed grade seniority. By spreading the promotions
from a grade over a block of seniorities, for instance, over 3 years
(see fig. 6.7), the promotion flows would stabilize somewhat. The to-
tal percentage of officers who are promoted can remain the same but a
distinction in abilities can be made in this way.

GRADE SENIORITY		GRADE				
		LT	CAP	MAJ	LT COL	COL+
1	**	8	55	48	26	5
2	**	35	39	52	28	8
3	**	48	43	47	28	9
4	**	49	54	71	25	10
5	**	89	73	0	28	6
6	**	31	53	55	29	2
7	**	57	48	48	20	10
8	**	0	32	39	6	4
9	**	0	19	40	8	7
10	**	0	14	29	9	5
11	**	0	24	6	3	4
≥ 12	**	1	12	32	10	15

Table 6.5. Actual distribution over the grade seniorities for officers.

actual scheme   alternative scheme

grade age | 1 | 2 | 3 | 4 | 5 | 6 |▨| 8 | 9 | 10 | 11 | 12 | | 1 | 2 | 3 | 4 | 5 |▨▨▨| 9 | 10 | 11 | 12 |
                                ↓   ↓
             Promotions: 50%   Promotions:10% ↓ |
                                                                40%↓
                                                                    8%
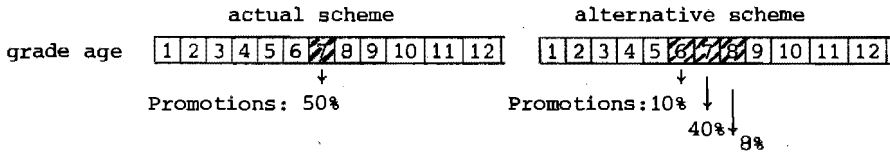
Figure 6.7. Left: example of an actual promotion scheme for some grade;
             50% of the officers with grade seniority 7 meets the
             promotion requirements and is promoted.

        Right: example of an alternative for the left scheme; pro-
             motions have been spread over the gread seniorities
             6,7 and 8. By promoting 10% of the officers with
             grade seniority 6, 40% of the officers with grade
             seniority 7 and 8% of the officers with grade se-
             niority 8, one would maintain the average time until
             promotion and the total fraction of promoted officers.

6.6. Short term planning

In short term planning one regards the number of conscripts and volun-
teers which is monthly needed in order to keep the Airforce continuous-
ly at full strength. Of course, short term planning is only of inter-
est for the group of officers as far as it concerns the recruitment
of volunteers in the grade "lieutenant". Further promotions cannot
occur for this category of officers.

For short term planning a special version of FORMASY has been devel-
oped in which promotions are not considered (the only possible flows
are turnover, retirement and recruitment). This program deals with
monthly figures so that necessary recruitments of volunteers and con-
scripts can be computed in detail. The same types of tables and his-
tograms as shown for the medium term and long term planning can be
obtained for the short term planning.

6.7. Detailed planning

Once the average career schemes for the various staff groups are known,
a detailed planning is necessary in order to determine whether manpower
availability and requirement are matched for each task group. As an
example we consider the officers of the task group "ground operations".
Medium term forecasts, assuming no recruitment , using the historical

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promotion scheme for this task group are given in table 6.6.

YEAR	GRADE					TOTAL
	LT	CAP	MAJ	LT COL	COL+	
1979	105	128	135	53	8	429
1980	80	135	137	62	7	421
1981	67	139	123	66	9	404
1982	32	163	107	63	8	373
1983	16	167	106	64	7	360
1984	8	156	107	58	8	337

Table 6.6. Medium term forecasts for the distribution over the ranks
of ground-operations officers, excluding recruitment and
using their historical career schemes.

The planning goal is to maintain, as much as possible, the actual dis-
tribution over the ranks in the near future. In order to attain this
goal, the following changes in the average promotion patterns are con-
sidered:

- let all promotions in the grade MAJ require 2 extra years, by the
  appropriate shift of the promotion fractions;
- accelerate all promotions in the grade CAP with 1 year by shifting
  the promotion fractions appropriately;
- let all promotions in the grade LT require 1 year extra.

The forecasted result of this operation corresponds with the desired
manpower distribution (apart from recruitment) as is shown in table
6.7.

	GRADE					
YEAR	LT	CAP	MAJ	LT COL	COL+	TOTAL
1979	105	128	135	53	8	429
1980	103	104	149	57	7	420
1981	79	120	140	56	9	404
1982	67	118	129	52	8	374
1983	31	136	127	57	7	358
1984	16	130	130	54	7	337

Table 6.7. Forecasts for officers of the task group "ground operations"
for the alternative career pattern, excl. recruitment.

The needed recruitment can easily be computed now, as was shown in
section 6.5.

A comparison of this alternative career scheme for the officers of a
task group with the proposed career scheme for the officers (cf. sec-
tion 6.5) shows very clearly that an "ideal" career pattern for the
total staff group is not always good for each task group. Especially,
if officers cannot be transferred to other task groups many problems
will arise (compare section 5.4).

6.8. Summary

In this case-study a survey has been given of the manpower planning
process within the Royal Netherlands Airforce. Also the usefulness of
the FORMASY system has been explained. Long term planning is based on
"ideal" grade and age structures in order to determine necessary re-
cruitment of regular staff avoiding irregular age distributions in the
future. Medium term planning deals in particular with extra recruit-
ment (i.e., apart from long term recruitment) in the next ten years,
partly needed because of the fluctuations in retirements. Furthermore,
alternative career schemes are studied. Short term planning regards
recruitment of volunteers on contract basis and conscripts and is

based on monthly figures. Furthermore, it has been described how a detailed planning has been worked out for a certain task group. Such excercises make it possible to compare the career opportunities for officers in different task groups and can help to notice possible discrepancies such that actions can be taken in time.

It has to be remarked that we have illustrated the manpower planning process by the development of alternative policies in order to adjust the evolution of the distribution of officers over the ranks to the given manpower requirement estimations. Notice, however, that matching of availability and requirement may also lead to changes of the requirements.

APPENDIX

In the appendix a summary is presented of an example of the
system for the medium term planning of the Royal Netherlands Airforce
(see section 6.5). Some results may differ from the results given in
section 6.5, since some transition fractions in the data-base have
been changed.

The notes at the end of this appendix give further explanations with
respect to the text.

The symbol → indicates the answers which have been typed in by the
user.

Here we used the english version of FORMASY.

→ RUN FORMASY [1]
‡RUNNING 0844

****

FORMASY IS AN INTERACTIVE COMPUTER PROGRAM FOR MANPOWER PLANNING,
DEVELOPED AT EINDHOVEN UNIVERSITY OF TECHNOLOGY

****

TYPE IN THE NAME OF THE DATA-BASE ?
‡?
→ OFFICERS. [2]

COMMENTS : [3]

TEST DATA 'OFFICERS', ROYAL NETHERLANDS AIRFORCE, 1979

TYPE IN THE LENGTH OF THE FORECASTING PERIOD ?
→ 5

TYPE IN THE CODES, PLEASE ?
→ HELP [4]

```
THE POSSIBLE CODES ARE :
    INPUTPRINT : PRINTING OF INPUT DATA
    EXTRAPRINT : PRINTING OF CAREER PROSECTS
    RECRU      : INPUT OF RECRUITMENT
    SUBTOT     : INPUT OF DESIRED SUBTOTALS IN TABLES 5)
     AFTER THE LAST CODE, TYPE IN ONE FIGURE ! 6)
→ INPUTPRINT
→ EXTRAPRINT
→ 4
```

PRINTING OF INPUT DATA 7)

```
NUMBER OF GRADES (FUNCTION GROUPS) =              5
NUMBER OF QUALIFICATION GROUPS =                 4
NUMBER OF TRAINING GROUPS =                      2
NUMBER OF GRADE SENIORITIES IN ALL CLASSES =    12
NUMBER OF CLASSES =                             14
NUMBER OF TRANSITIONS BETWEEN CLASSES =         26
```

****

NUMBERS OF THE CLASSES

NUMBER	GRADE		QUALIFICATION GROUP	TRAINING GROUP
1	1	LT	1	1
2	1	LT	2	2
3	2	CAP	1	1
4	2	CAP	2	2
5	3	MAJ	1	1
6	3	MAJ	2	2
7	3	MAJ	3	2

```
        8        3   MAJ           4                    2
        9        4 LTCOL           1                    1
       10        4 LTCOL           2                    2
       11        4 LTCOL           3                    2
       12        4 LTCOL           4                    2
       13        5  COL+           4                    2
       14        0                 0                    0  8)
```

****

TRANSITION PERCENTAGES FROM CLASS ... TO CLASS ...
                              FOR GRADE SENIORITY ...

```
              1                 2
```

```
     1,   3,  1:   0.0     1,  14,  1:   1.0
     1,   3,  2:   0.0     1,  14,  2:   1.0
     1,   3,  3:   0.0     1,  14,  3:   1.0
     1,   3,  4:   0.0     1,  14,  4:   1.0
     1,   3,  5:   0.0     1,  14,  5:   1.0
     1,   3,  6:   0.0     1,  14,  6:   1.0
     1,   3,  7:  99.0     1,  14,  7:   1.0
     1,   3,  8:  99.0     1,  14,  8:   1.0
     1,   3,  9:  99.0     1,  14,  9:   1.0
     1,   3,10:  99.0     1,  14,10:   1.0
     1,   3,11:  99.0     1,  14,11:   1.0
     1,   3,12:  99.0     1,  14,12:   1.0   9)
```
....

END OF INPUTPRINT

****

PRINTING OF CAREER PROSPECTS [10)]

TRANSITION 1

MIN. GRADE SENIORITY   = 7.0
MAX. GRADE SENIORITY   = 7.0
AVERAGE GRADE SENIORITY= 7.0

TRANSITION 2

MIN. GRADE SENIORITY   = 1.0
MAX. GRADE SENIORITY   = 7.0
AVERAGE GRADE SENIORITY= 4.0

PERCENTAGE OF ENTRANTS IN CLASS   1 WHO MAKE FOLLOWING TRANSITIONS :
                   PROMOTION   TURNOVER   STAYERS
AFTER 12 YEARS :   93.2   6.8   0.0
TOTAL   :   93.2   6.8   0.0

AVERAGE TIME SPENT IN CLASS   1 : 6.8

TRANSITION 3

MIN. GRADE SENIORITY   = 5.0
MAX. GRADE SENIORITY   = 5.0
AVERAGE GRADE SENIORITY= 5.0

TRANSITION 4

MIN. GRADE SENIORITY   = 1.0
MAX. GRADE SENIORITY   = 5.0
AVERAGE GRADE SENIORITY= 3.0

```
TRANSITION 25
---------------
MIN. GRADE SENIORITY   = 1.0
MAX. GRADE SENIORITY   = 5.0
AVERAGE GRADE SENIORITY= 2.8


PERCENTAGE OF ENTRANTS IN CLASS   12 WHO MAKE FOLLOWING TRANSITIONS :
                PROMOTION    TURNOVER      STAYERS
AFTER 12 YEARS :  93.3         6.7          0.0
TOTAL          :  93.3         6.7          0.0

AVERAGE TIME SPENT IN CLASS   12 : 4.5

TRANSITION 26
---------------
MIN. GRADE SENIORITY   = 1.0
MAX. GRADE SENIORITY   =12.0
AVERAGE GRADE SENIORITY=66.7


PERCENTAGE OF ENTRANTS IN CLASS   13 WHO MAKE FOLLOWING TRANSITIONS :
                TURNOVER      STAYERS
AFTER 12 YEARS :  16.6         83.4
TOTAL          : 100.0          0.0

AVERAGE TIME SPENT IN CLASS   13 :66.7



    DO YOU WANT TO CHANGE THE TRANSITION PERCENTAGES ?
+ NO


    TYPE IN THE ACTUAL RETIREMENT AGE AND THE RETIREMENT AGES
    FOR THE YEARS 1980 - 1984 ?
+ 55,55,55,55,55,55
```

DO YOU WANT THE MANPOWER DISTRIBUTION FORECAST ? TYPE IN: 0
DO YOU WANT THE MANPOWER DISTRIBUTION/ AGE FORECAST ? TYPE IN: 1
→ 0

MANPOWER DISTRIBUTION IN PLANNING PERIOD
....

YEAR *	LT	CAP	GRADE MAJ	LTCOL	COL+	*	TOTAL
1979 *	318	466	467	220	85	*	1556
1980 *	232	435	489	259	90	*	1505
1981 *	182	431	465	258	84	*	1420
1982 *	92	472	431	246	62	*	1303
1983 *	46	460	426	231	55	*	1218
1984 *	17	435	419	211	52	*	1134

****

WHICH OUTPUT DO YOU WANT (FIGURE, NO CODES) ?
→ HELP

TYPE IN :
        0 : NO FURTHER OUTPUT
        1 : TABLE OF NUMBERS IN QUALIFICATION GROUPS
        2 : TABLE OF NUMBERS IN TRAINING GROUPS
        3 : TABLE OF NUMBERS FOR THE GRADE SENIORITIES
        4 : FLOWS IN THE SYSTEM
        5 : STEADY-STATE DISTRIBUTION FOR LAST CHOSEN RECRUITMENT
        6 : STANDARD DEVIATIONS (UPPER BOUND)
        7 : STANDARD DEVIATIONS (EXACT)
        8 : COMPUTATION OF SALARY COSTS
        9 : HISTOGRAM OF THE MANPOWER DISTRIBUTION

QUALIFICATION GROUPS
_____

1

YEAR *	LT	CAP	GRADE MAJ	LTCOL	COL+	*	TOTAL
1979 *	224	266	194	4	0	*	688
1980 *	164	277	218	9	0	*	668
1981 *	133	282	209	12	0	*	636
1982 *	69	325	186	11	0	*	591
1983 *	38	323	177	18	0	*	556
1984 *	17	307	175	21	0	*	520

2

YEAR *	LT	CAP	GRADE MAJ	LTCOL	COL+	*	TOTAL
1979 *	94	200	220	168	0	*	682
1980 *	68	158	218	197	0	*	641
1981 *	49	149	196	200	0	*	594
1982 *	24	147	182	191	0	*	544
1983 *	7	137	183	171	0	*	498
1984 *	0	127	177	153	0	*	457

3

		LT	CAP	GRADE MAJ	LTCOL	COL+		TOTAL
1979	*	0	0	0	0	0	*	0
1980	*	0	0	16	0	0	*	16
1981	*	0	0	21	0	0	*	21
1982	*	0	0	25	0	0	*	25
1983	*	0	0	30	0	0	*	30
1984	*	0	0	34	0	0	*	34

4

		LT	CAP	GRADE MAJ	LTCOL	COL+		TOTAL
1979	*	0	0	53	48	85	*	186
1980	*	0	0	37	52	90	*	179
1981	*	0	0	39	46	84	*	169
1982	*	0	0	38	44	62	*	144
1983	*	0	0	36	43	55	*	134
1984	*	0	0	33	37	52	*	122

WHICH OUTPUT DO YOU WANT (FIGURE, NO CODES) ?
→ 3

FOR WHICH YEAR DO YOU WANT A TABLE (STOP BY 99) ?
→ 1984

```
     YEAR : 1984
     ---------------

     GR.SENIORITY    LT    CAP   MAJ LTCOL  COL+
     ----------------------------------------------
          1    **     0     28    45    25    12
          2    **     0     45    44    24     7
          3    **     0     84    32    28     7
          4    **     0     45    36    29     7
          5    **     0     76    90    49     8
          6    **     0     50    34    14     0
          7    **    17     32    29    11     0
          8    **     0     16    26    12     0
          9    **     0     20    36     6     0
         10    **     0     38     0     6     0
         11    **     0      0    13     5     0
         12    **     0      0    33     1    10   11)
     ----------------------------------------------


     FOR WHICH YEAR DO YOU WANT A TABLE (STOP BY 99) ?
  + 99


     WHICH OUTPUT DO YOU WANT (FIGURE, NO CODES) ?
  + 0



     HOW DO YOU WANT TO CONTINUE (CODES,NO FIGURES) ?
     HELP
```

```
     THE POSSIBLE CODES ARE :
         INPUTPRINT : PRINTING OF INPUT DATA
         EXTRAPRINT : PRINTING OF CAREER PROSPECTS
         SURVEY     : SURVEY OF CHANGED TRANSITION PERCENTAGES
         RECRU      : INPUT OF RECRUITMENT
         CHANGE     : CHANGE OF TRANSITION PERCENTAGES
         AGE        : FORECASTS OF THE GRADE/AGE DISTRIBUTIONS
         SUBTOT     : INPUT OF DESIRED SUBTOTALS IN TABLES
         PLANNING   : RECRUITMENT PLANNING
         DATABASE   : TRANSFORMATION OF CHANGED DATA TO NEW DATA-BASE
         STOP       : END OF PROGRAM
          AFTER THE LAST CODE, TYPE IN ONE FIGURE !
 → RECRU
 → CHANGE
 → 3


     TYPE IN THE NUMBER OF CLASSES WHERE RECRUITMENT IS ALLOWED ?  12)
 → 2

     TYPE IN FOR ALL CLASSES THE NUMBER AND ON THE NEXT LINE
     THE RECRUITMENT FOR THE  5 PLANNING YEARS ?
 → 1
 → 45,45,45,45,45
 → 2
 → 27,27,27,27,27
  *****************************************************************
     IN HOW MANY TRANSITIONS DO YOU WANT TO CHANGE PERCENTAGES ?  13)
 → 8
     TYPE IN ON SINGLE LINES THE NUMBERS OF THE TRANSITIONS ?
 → 1
 → 3
 → 5
 → 6
 → 8
 → 9
 → 10
 → 18
  ------------------------------------------------------------------
```

```
     HOW DO YOU WANT TO CHANGE IN TRANSITION  1 ?
→HELP


     TYPE IN :
               0 : CHANGE OF SINGLE PERCENTAGES
               1 : SHIFT OF THE AVERAGE TIME UNTIL TRANSITION
               2 : MULTIPLYING THE TRANSITION PERCENTAGES WITH A FACTOR
→1

     HOW MANY YEARS DO YOU WANT TO SHIFT THE PERCENTAGES ?
      + = LENGTHENING OF TIME UNTIL TRANSITION , - = SHORTENING OF TIME UNTIL
          TRANSITION
→-2
  WATCH THE STRUCTURE OF THE TRANSITION PERCENTAGES FOR THE GRADE SENIORITIES !!
  ----------------------------------------------------------------------
                                                                   14)


     HOW DO YOU WANT TO CHANGE IN TRANSITION  3 ?
→1

     HOW MANY YEARS DO YOU WANT TO SHIFT THE PERCENTAGES ?
      + = LENGTHENING OF TIME UNTIL TRANSITION , - = SHORTENING OF TIME UNTIL
          TRANSITION
→-2
  WATCH THE STRUCTURE OF THE TRANSITION PERCENTAGES FOR THE GRADE SENIORITIES !!
  ----------------------------------------------------------------------


     HOW DO YOU WANT TO CHANGE IN TRANSITION  5 ?
→1

     HOW MANY YEARS DO YOU WANT TO SHIFT THE PERCENTAGES ?
      + = LENGTHENING OF TIME UNTIL TRANSITION , - = SHORTENING OF TIME UNTIL
          TRANSITION
→-1
  WATCH THE STRUCTURE OF THE TRANSITION PERCENTAGES FOR THE GRADE SENIORITIES !!
  ----------------------------------------------------------------------
                                                                   15)
```

```
    HOW DO YOU WANT TO CHANGE IN TRANSITION 18 ?
→ 1

    HOW MANY YEARS DO YOU WANT TO SHIFT THE PERCENTAGES ?
    + = LENGTHENING OF TIME UNTIL TRANSITION , - = SHORTENING OF TIME UNTIL
        TRANSITION
→ -1
  WATCH THE STRUCTURE OF THE TRANSITION PERCENTAGES FOR THE GRADE SENIORITIES !!


    DO YOU WANT TO CHANGE THESE TRANSITION PERCENTAGES AGAIN ?
→ NO


    DO YOU WANT THE MANPOWER DISTRIBUTION FORECAST ? TYPE IN: 0
    DO YOU WANT THE MANPOWER DISTRIBUTION/ AGE FORECAST ?   TYPE IN: 1
→ 0

    TYPE IN THE AGE DISTRIBUTION OF RECRUITS (AGE, PERCENTAGE) ?

  CLASS   1:
→ 24, 6
→ 25, 9
→ 26,11
→ 27, 6
→ 28,13
→ 29, 6
→ 30,14
→ 31,11
→ 32, 4
→ 33, 2
```

```
→ 35, 3
→ 36, 1
→ 37, 1
→ 38, 1
→ 39, 3
→ 40, 1
→ 41, 2
→ 42, 2
→ 43, 3
→ 44, 1
  PERCENTAGE IS : 100
  AVERAGE RECRUITMENT AGE IS : 30.2

  CLASS   2:
→ 21, 3
→ 22,21
→ 23,24
→ 24,29
→ 25,16
→ 26, 4
→ 27, 2
→ 28, 1
  PERCENTAGE IS : 100
  AVERAGE RECRUITMENT AGE IS : 23.6
```

MANPOWER DISTRIBUTION IN PLANNING PERIOD
....

YEAR *	LT	CAP	GRADE MAJ	LTCOL	COL+	*	TOTAL
1979 *	318	466	467	220	85	*	1556
1980 *	167	529	529	262	90	*	1577
1981 *	190	532	492	266	84	*	1564
1982 *	231	503	468	253	62	*	1517
1983 *	257	489	460	239	55	*	1500
1984 *	300	448	467	215	53	*	1483

WHICH OUTPUT DO YOU WANT (FIGURE, NO CODES) ?
→ 2

TRAINING GROUPS

1

YEAR *	LT	CAP	GRADE MAJ	LTCOL	COL+	*	TOTAL
1979 *	224	266	194	4	0	*	688
1980 *	115	355	235	9	0	*	714
1981 *	129	368	218	12	0	*	727
1982 *	151	355	205	11	0	*	722
1983 *	177	320	199	18	0	*	714
1984 *	221	272	213	21	0	*	727

2

YEAR *	LT	CAP	GRADE MAJ	LTCOL	COL+	*	TOTAL
1979 *	94	200	273	216	85	*	868
1980 *	52	174	294	253	90	*	863
1981 *	61	164	274	253	84	*	836
1982 *	79	147	262	242	62	*	792
1983 *	79	169	261	221	55	*	785
1984 *	79	176	254	195	53	*	757

WHICH OUTPUT DO YOU WANT (FIGURE, NO CODES) ?
→ 4

FLOWS IN THE SYSTEM
••••••••••••••••••••

GRADE	* FLOW *		YEAR			
		1979	1980	1981	1982	1983
LT	RECR. IN	72	72	72	72	72
LT	PROM. IN	0	0	0	0	0
LT	TOT. IN	72	72	72	72	72
LT	PROM.OUT	219	47	29	43	25
LT	TURN.OUT	4	2	3	3	3
LT	RETI.OUT	0	0	0	0	0
LT	TOT.OUT	223	49	31	46	29
CAP	RECR. IN	0	0	0	0	0
CAP	PROM. IN	219	47	29	43	25
CAP	TOT. IN	219	47	29	43	25
CAP	PROM.OUT	149	35	45	46	57
CAP	TURN.OUT	7	7	7	6	7
CAP	RETI.OUT	0	2	6	4	3
CAP	TOT.OUT	156	44	58	56	66
MAJ	RECR. IN	0	0	0	0	0
MAJ	PROM. IN	149	35	45	46	57
MAJ	TOT. IN	149	35	45	46	57
MAJ	PROM.OUT	70	37	30	25	24
MAJ	TURN.OUT	9	10	9	9	9
MAJ	RETI.OUT	8	25	31	19	18
MAJ	TOT.OUT	87	72	69	53	51
LTCOL	RECR. IN	0	0	0	0	0
LTCOL	PROM. IN	70	37	30	25	24
LTCOL	TOT. IN	70	37	30	25	24

16)

```
LTCOL    PROM.OUT    16     9     9     8    13
LTCOL    TURN.OUT     3     4     4     3     3
LTCOL    RETI.OUT     8    21    30    28    31
LTCOL     TOT.OUT    28    34    42    39    47
-----------------------------------------------------
COL+     RECR. IN     0     0     0     0     0
COL+     PROM. IN    16     9     9     8    13
COL+      TOT. IN    16     9     9     8    13
.........................................
COL+     PROM.OUT     0     0     0     0     0
COL+     TURN.OUT     1     1     1     1     1
COL+     RETI.OUT    10    14    30    13    15
COL+      TOT.OUT    11    15    31    14    16
-----------------------------------------------------
```

WHICH OUTPUT DO YOU WANT (FIGURE, NO CODES) ?

→ 5

STEADY-STATE MANPOWER DISTRIBUTION FOR LAST CHOSEN RECRUITMENT
....

```
-----------------------------------------------------
YEAR : 2013
                      GRADE                       17)
          LT    CAP   MAJ LTCOL   COL+     TOTAL
-----------------------------------------------------
TOTAL:   300   486   486   237     95  **  1604
-----------------------------------------------------
```

NECESSARY RECRUITMENT TO MAINTAIN THE TOTAL NUMBER OF EMPLOYEES :
CLASS   1:   44
CLASS   2:   26

THE MANPOWER DISTRIBUTION WILL BE THEN :

			GRADE				
	LT	CAP	MAJ	LTCOL	COL+		TOTAL
TOTAL:	291	472	472	230	92	**	1557

WHICH OUTPUT DO YOU WANT (FIGURE, NO CODES) ?
→ 6

STANDARD DEVIATIONS OF THE FORECASTS (UPPER BOUND)
....

				GRADE		
YEAR	*	LT	CAP	MAJ	LTCOL	COL+
1980	*	1	4	8	5	2
1981	*	1	5	10	8	3
1982	*	2	6	11	9	4
1983	*	2	9	12	10	4
1984	*	2	9	13	11	5

WHICH OUTPUT DO YOU WANT (FIGURE, NO CODES) ?
→ 7

STANDARD DEVIATIONS OF THE FORECASTS (EXACT)
....

```
                      GRADE
  YEAR   *    LT    CAP    MAJ   LTCOL   COL+
  ---------------------------------------------
  1980   *    1     4      8     5       2
  1981   *    1     5      10    6       2
  1982   *    2     6      11    7       3
  1983   *    2     7      12    7       3
  1984   *    2     8      13    8       4
  ---------------------------------------------
```

     WHICH OUTPUT DO YOU WANT (FIGURE, NO CODES) ?
→ 8

     TYPE IN FOR THE 13 CLASSES (IN 1000-GUILDERS) :
     MINIMUM SALARY, PERIODIC INCREASE, MAX. NUMBER OF PERIODIC INCREASES :
→ 38,1.2, 7
→ 38,1.2, 7
→ 48,1.4,10
→ 48,1.4,10
→ 65,1.6, 8
→ 65,1.6, 8
→ 65,1.6, 8
→ 65,1.6, 8
→ 82,1.8, 6
→ 82,1.8, 6
→ 82,1.8, 6
→ 82,1.8, 6
→ 100,2.0, 6
                                                              18)
     TYPE IN THE YEARLY TREND IN PERCENTS (STOP BY 99)
→ 0

  SALARY COSTS IN MILLION GUILDERS
  ....
```

| YEAR * | LT | CAP | GRADE MAJ | LTCOL | COL+ | * | TOTAL |
|--------|-----|-----|-----|-------|------|---|-------|
| 1979 * | 13.45 | 25.11 | 33.47 | 19.29 | 9.35 | * | 100.67 |
| · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · · | | | | | | | |
| 1980 * | 6.66 | 27.05 | 37.14 | 22.78 | 9.76 | * | 103.38 |
| 1981 * | 7.49 | 27.54 | 34.69 | 23.08 | 9.07 | * | 101.87 |
| 1982 * | 9.10 | 26.36 | 33.05 | 22.05 | 6.56 | * | 97.11 |
| 1983 * | 10.17 | 25.87 | 32.71 | 20.85 | 5.86 | * | 95.46 |
| 1984 * | 12.02 | 23.88 | 33.22 | 18.85 | 5.55 | * | 93.53 |

    DO YOU WANT THE STANDARD DEVIATIONS ?
→ NO

    TYPE IN THE YEARLY TREND IN PERCENTS (STOP BY 99)
→ 99

    WHICH OUTPUT DO YOU WANT (FIGURE, NO CODES) ?
→ 9

    FOR WHICH YEAR DO YOU WANT A HISTOGRAM (STOP BY 99) ?
→ 1984

ONE FIGURE STANDS FOR  10 EMPLOYEES

YEAR  1984 :
---------------

```
-----A----A----A----A----A----A----A----A----A----A----A----A
```

```
    LT    1111111111111111111111111111111                              300
    LT    1111111111111111111111111111111                              300
   CAP    22222222222222222222222222222222222222222222                 448
   CAP    22222222222222222222222222222222222222222222                 448
   MAJ    3333333333333333333333333333333333333333333333               467
   MAJ    3333333333333333333333333333333333333333333333               467
 LTCOL    444444444444444444444                                        215
 LTCOL    444444444444444444444                                        215
  COL+    55555                                                         53
  COL+    55555                                                         53
```

```
    FOR WHICH YEAR DO YOU WANT A HISTOGRAM (STOP BY 99) ?
→ 99


    WHICH OUTPUT DO YOU WANT (FIGURE, NO CODES) ?
→ 0


    HOW DO YOU WANT TO CONTINUE (CODES,NO FIGURES) ?
→ SURVEY
→ AGE
→ DATABASE
→ PLANNING
→ 3
```

	1		3		5		6

```
1,  3, 1:   0.0     2,  4, 1:   0.0     3,  4, 1:   0.0     3,  5, 1:   0.0
1,  3, 2:   0.0     2,  4, 2:   0.0     3,  4, 2:   0.0     3,  5, 2:   0.0
1,  3, 3:   0.0     2,  4, 3: 98.0     3,  4, 3: 14.9     3,  5, 3:   0.0
1,  3, 4:   0.0     2,  4, 4: 98.0     3,  4, 4:   0.0     3,  5, 4:   0.0
1,  3, 5: 99.0     2,  4, 5: 98.0     3,  4, 5:   0.0     3,  5, 5:   0.0
1,  3, 6: 99.0     2,  4, 6: 98.0     3,  4, 6:   0.0     3,  5, 6:   0.0
1,  3, 7: 99.0     2,  4, 7: 98.0     3,  4, 7:   0.0     3,  5, 7:   0.0
1,  3, 8: 99.0     2,  4, 8: 98.0     3,  4, 8:   0.0     3,  5, 8:   0.0
1,  3, 9: 99.0     2,  4, 9: 98.0     3,  4, 9:   0.0     3,  5, 9: 99.0
1,  3,10: 99.0     2,  4,10: 98.0     3,  4,10:   0.0     3,  5,10: 99.0
1,  3,11: 99.0     2,  4,11: 98.0     3,  4,11:   0.0     3,  5,11: 99.0
1,  3,12: 99.0     2,  4,12: 98.0     3,  4,12:   0.0     3,  5,12: 99.0
```

....

	8		9		10		18

```
4,  6, 1:   0.0     4,  7, 1:   0.0     4,  8, 1:   0.0     8, 12, 1:   0.0
4,  6, 2:   0.0     4,  7, 2:   0.0     4,  8, 2:   0.0     8, 12, 2:   0.0
4,  6, 3:   0.0     4,  7, 3:   0.0     4,  8, 3:   0.0     8, 12, 3:   0.0
4,  6, 4:   0.0     4,  7, 4:   0.0     4,  8, 4:   0.0     8, 12, 4: 39.2
4,  6, 5:   0.0     4,  7, 5:   0.0     4,  8, 5: 24.5     8, 12, 5: 98.0
4,  6, 6: 71.9     4,  7, 6: 26.1     4,  8, 6:   0.0     8, 12, 6: 98.0
4,  6, 7: 71.9     4,  7, 7: 26.1     4,  8, 7:   0.0     8, 12, 7: 98.0
4,  6, 8: 71.9     4,  7, 8: 26.1     4,  8, 8:   0.0     8, 12, 8: 98.0
4,  6, 9: 71.9     4,  7, 9: 26.1     4,  8, 9:   0.0     8, 12, 9: 98.0
4,  6,10: 71.9     4,  7,10: 26.1     4,  8,10:   0.0     8, 12,10: 98.0
4,  6,11: 71.9     4,  7,11: 26.1     4,  8,11:   0.0     8, 12,11: 98.0
4,  6,12: 71.9     4,  7,12: 26.1     4,  8,12:   0.0     8, 12,12: 98.0
```

....

```
      TYPE IN THE DESIRED FIGURE :
      0 : YOU WANT THE AGE DISTRIBUTIONS FOR ALL GRADES INCLUDING RECRUITMENT
      N : YOU WANT THE AGE DISTRIBUTIONS FOR GRADE N
   →  0

      TYPE IN THE MINIMUM AND MAXIMUM AGE FOR THE
      AGE DISTRIBUTION YOU WANT TO SEE ?
   →  21,54
```

```
      -------------------------------------------------
      ACTUAL MANPOWER DISTRIBUTION : 1979
```

AGE	LT	CAP	GRADE MAJ	LTCOL	COL+		TOTAL
54 **	0	0	8	8	10	**	26
53 **	0	4	24	21	14	**	63
52 **	2	8	29	33	28	**	100
51 **	1	7	20	30	10	**	68
50 **	0	9	18	32	12	**	71
49 **	1	9	32	22	6	**	70
48 **	1	12	40	19	4	**	76
47 **	3	9	29	7	1	**	49
46 **	9	6	32	12	0	**	59
45 **	4	8	26	10	0	**	48
44 **	4	10	36	12	0	**	62
43 **	3	8	32	6	0	**	49
42 **	2	17	30	7	0	**	56
41 **	3	20	22	1	0	**	46
40 **	4	23	21	0	0	**	48
39 **	1	12	19	0	0	**	32
38 **	4	20	18	0	0	**	42
37 **	9	39	16	0	0	**	64
36 **	12	40	7	0	0	**	59
35 **	10	31	7	0	0	**	48
34 **	20	27	1	0	0	**	48

```
33 **    26   34    0    0    0  **   60
32 **    26   32    0    0    0  **   58
31 **    22   30    0    0    0  **   52
30 **    13   21    0    0    0  **   34
29 **    17   15    0    0    0  **   32
28 **    22   10    0    0    0  **   32
27 **    18    5    0    0    0  **   23
26 **    32    0    0    0    0  **   32
25 **    21    0    0    0    0  **   21
24 **    17    0    0    0    0  **   17
23 **    10    0    0    0    0  **   10
22 **     1    0    0    0    0  **    1
21 **     0    0    0    0    0  **    0
-----------------------------------------------
TOTAL:  318  466  467  220   85  **  1556
-----------------------------------------------
```

AVERAGE AGES OF MANPOWER

GRADE	AVERAGE AGE	DEVIATION
LT	31.5	6.2
CAP	37.4	6.3
MAJ	45.3	4.9
LTCOL	49.2	3.2
COL+	51.5	1.7

THE AVERAGE AGE OF TOTAL MANPOWER IS 41.0 YEARS

THE DEVIATION IS 8.5 YEARS

```
-----------------------------------------------------------------
YEAR : 1984
                              GRADE
AGE            LT    CAP    MAJ LTCOL   COL+        TOTAL
-----------------------------------------------------------------
    54 **      0      2     30    23     10   **      65
    53 **      0      2     34    28      6   **      70
    52 **      0      4     20    18      3   **      45
    51 **      0      9     20    19      5   **      53
    50 **      0      4     19    16      6   **      45
    49 **      0      6     24    21      7   **      58
    48 **      0      5     15    22      3   **      45
    47 **      2      7     18    18      8   **      53
    46 **      3      5     23    12      2   **      45
    45 **      4      7     28     8      1   **      48
    44 **      4      3     17     9      1   **      34
    43 **      5      8     22     8      1   **      44
    42 **      4     22     31     6      0   **      63
    41 **      4     22     31     2      0   **      59
    40 **      3     21     22     2      0   **      48
    39 **      4     27     16     1      0   **      48
    38 **      3     37     19     0      0   **      59
    37 **      3     36     18     1      0   **      58
    36 **      4     23     24     1      0   **      52
    35 **      9     14     17     0      0   **      40
    34 **     14     19     11     0      0   **      44
    33 **     16     24      6     0      0   **      46
    32 **     21     19      2     0      0   **      42
    31 **     22     30      0     0      0   **      52
    30 **     22     21      0     0      0   **      43
    29 **     21     21      0     0      0   **      42
    28 **     22     20      0     0      0   **      42
    27 **     20     14      0     0      0   **      34
    26 **     24     11      0     0      0   **      35
    25 **     25      6      0     0      0   **      31
    24 **     22      1      0     0      0   **      23
    23 **     13      0      0     0      0   **      13
    22 **      6      0      0     0      0   **       6
    21 **      1      0      0     0      0   **       1
-----------------------------------------------------------------
  TOTAL:     300    448    467   215     53   **    1483
-----------------------------------------------------------------
```

AVERAGE AGES OF MANPOWER

```
------------------------------------------------
    GRADE   !   AVERAGE   !  DEVIATION  !
            !   AGE       !             !
------------!-------------!-------------!
      LT    !    30.2     !     5.7     !
     CAP    !    36.3     !     6.5     !
     MAJ    !    44.4     !     6.1     !
    LTCOL   !    49.1     !     3.8     !
    COL+    !    50.0     !     3.0     !
------------!-------------!-------------!
------------------------------------------------
```

THE AVERAGE AGE OF TOTAL MANPOWER IS 40.0 YEARS

THE DEVIATION IS   8.9 YEARS

    TYPE IN THE DESIRED FIGURE :
   0: YOU WANT NO FIGURE OF THE AGE DISTRIBUTIONS
   N: YOU WANT THESE FIGURES WHERE N SUCCESSIVE AGES
      ARE TAKEN TOGETHER
→ 3

FIGURE OF THE ACTUAL MANPOWER : 1979

```
AGE    *
------------------------------------------------------------------
52-54 *2233333333333334444444444445555555555
49-51 *2222233333333333334444444444444444555555
46-48 *11122222233333333333333333333334444444445
43-45 *1122222333333333333333333333344444444
40-42 *11222222222222233333333333333344
37-39 *1112222222222222222233333333333
34-36 *111111112222222222222222222222333
31-33 *11111111111111112222222222222222222
28-30 *111111111122222222222
25-27 *111111111111112
22-24 *111111
21-21 *
------------------------------------------------------------------
1 FIGURE =   5 EMPLOYEES
------------------------------------------------------------------




YEAR : 1984
------------------------------------------------------------------




AGE    *
------------------------------------------------------------------
52-54 *23333333333333333334444444444444445555
49-51 *222233333333333333344444444444445555
46-48 *122233333333333344444444444444555
43-45 *1122223333333333333333444445
40-42 *11222222222222223333333333333333333344
37-39 *1122222222222222222222233333333333333
34-36 *1111122222222222223333333333
31-33 *111111111111122222222222222222233
28-30 *1111111111111122222222222222
25-27 *111111111111111222222
22-24 *11111111
21-21 *
------------------------------------------------------------------
1 FIGURE =   5 EMPLOYEES
------------------------------------------------------------------
```

```
        YOU CAN CHOOSE FROM TWO DATA-BASES ; TYPE IN:
        0 :   ACTUAL TRANSITION PERCENTAGES AND BASIC YEAR = 1979
        1 :   ACTUAL TRANSITION PERCENTAGES AND YEAR = 1984
  →  1


        TYPE IN THE NAME FOR THE NEW DATA-BASE ? 21)
  →  TEST.


     FLOW SCHEME FOR RECRUITS 22)
     ........................

     FROM    TO      AFTER ... YEARS
     GRADE  GRADE    1    2    3    4
     ------------------------------------
        1   *   1    98   96    0    0
        1   *   2     0    0   94   93
        1   *   3     0    0    0    0
        1   *   4     0    0    0    0
        1   *   5     0    0    0    0
        2   *   2    99   97   96   95
        2   *   3     0    0    0    0
        2   *   4     0    0    0    0
        2   *   5     0    0    0    0
        3   *   3    98   96   94   88
        3   *   4     0    0    0    5
        3   *   5     0    0    0    0
        4   *   4    99   97   96   84
        4   *   5     0    0    0   10
        5   *   5    98   97   96   94
     ------------------------------------


        DO YOU WANT TO CHANGE THE FLOW SCHEME FOR RECRUITS ?
  →  NO


        IN HOW MANY GRADES IS RECRUITMENT ALLOWED ?
  →  1
```

TYPE IN THE NUMBERS OF THESE GRADES AND ON THE NEXT LINE
THE MAXIMAL ALLOWED RECRUITMENT FOR THE 5 PLANNING YEARS ?
→ 1
→ 50,50,50,50,50

TYPE IN THE LOWER BOUND GRADE SIZES FOR THE 5 PLANNING YEARS ?
GRADE 1:
→ 170,200,250,300,350

TYPE IN HOW MANY YEARS BEFORE RECRUITMENT IS ALLOWED ?
→ 0

MANPOWER DISTRIBUTION IN PLANNING PERIOD INCL. RECRUITMENT
• •

YEAR *	LT	CAP	GRADE MAJ	LTCOL	COL+	*	TOTAL
1979 *	318	466	467	220	85	*	1556
1980 *	170	529	529	262	90	*	1580
1981 *	200	532	492	266	84	*	1574
1982 *	250	503	468	253	62	*	1536
1983 *	300	492	460	239	55	*	1546
1984 *	350	458	467	215	53	*	1543

RECRUITMENT IN PLANNING PERIOD
• •

YEAR *	LT	CAP	GRADE MAJ	LTCOL	COL+	*	TOTAL
1979 *	3	0	0	0	0	*	3
1980 *	7	0	0	0	0	*	7
1981 *	10	0	0	0	0	*	10
1982 *	27	0	0	0	0	*	27
1983 *	14	0	0	0	0	*	14

```
    DO YOU WANT RECRUITMENT PLANNING AGAIN ?
+ NO


    HOW DO YOU WANT TO CONTINUE (CODES,NO FIGURES) ?
+ STOP
    ************************************************************
```

THIS IS THE END OF THE INTERACTIVE COMPUTER PROGRAM

```
+++++++++ +++++++++  +++++++++   ++    ++   +++++++++  +++++++++  ++      ++
+      + +         +         +  + +  + +   +                  +   +    +
+        +         +         +   +  +  +   +                  +    +  +
++++++    +         + +++++++++  +   + +   +          +++++++++      ++
+         +         + +   +      +     +   +++++++++          +      +
+         +         + +    +     +     +   +         +        +      +
+         +         + +     +    +     +   +         +        +      +
+         +         + +      +   +     +   +         + +      +      +
++        +++++++++ +++    +++  +++   +++   +++ +++++++++      +++
```

#ET=28:47.7 PT=40.2 IO=4.4

Notes

1) By this command the user starts the processing of the computer program which is continuously stored on disk (background storage).

2) The data-base "OFFICERS" contains the necessary input data for the group "officers". Such data-bases are also stored on disk (background storage).

3) If such comments have been indicated on the data-base, then they are printed at this moment.

4) If the user does not know the answer, then he may type in "HELP" whereafter he receives the possible answers.

5) Sometimes, the user wants to lump some grades or function levels. In that case he may indicate which grades have to be taken together by the code "SUBTOT".

6) The figure serves as a delimiter for the codes.

7) This list follows from the code "INPUTPRINT". It gives some data recorded on the data-base.

8) The class "turnover" has to be indicated by (0,0,0).

9) The transition percentages for the transitions 3 - 26 have been deleted here.

10) This list follows from the code "EXTRAPRINT". The data with respect to the transitions 5 - 24 have been deleted here.

11) For the maximum grade seniority (here 12), the number of employees with this grade seniority indicates the number of employees with this grade seniority or more.

12) Because of the code "RECRU" (recruitment).

13) Because of the code "CHANGE" (changes of career policies).

14) Back-shift of the promotion percentages means that the first percentages of the transition are skipped.

15) The changes for the transitions 6,8,9 and 10 have been deleted here.

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16) The flows indicate for each grade the numbers of recruits, promotion into the grade, total inflow, promotions out of the grade, turnover, retirements and total outflow respectively.

17) In this year the steady-state distribution is obtained.

18) Such a trend may indicate for instance the inflation percentage or the yearly extra salary increase.

19) Because of the code "SURVEY" (transitions for which transition percentages have been changed).

20) Because of the code "AGE" (forecasts of the age distribution).

21) Because of the code "DATA BASE" (recording of changed data on a new data-base).

22) Because of the code "PLANNING" (recruitment planning).
    The flow scheme indicates for all grades the percentage of employees which is still in that grade and which has been promoted to higher grades for 1,2,3,.... years after entrance in that grade.

23) The "elapsed time" for this run has been about 28 minutes which was mainly caused by the large numbers of options which have been used for this example and by the number of users of the computer system. The "process time" has been about 40 seconds which was mainly caused by the computation of the exact standard deviations. The "input-output time" was about 4 seconds for the transport of data.

REFERENCES:

[1] R.L. Ackoff; A Concept of Corporate Planning. John Wiley, New York (1970).

[2] J.W. Barber (ed.); Industrial Training Handbook. Iliffe Books, London (1968).

[3] D.J. Bartholomew; Stochastic Models for Social Processes (2nd ed.). John Wiley, London (1973).

[4] D.J. Bartholomew; Errors of Prediction for Markov Chain Models. Journal of Royal Stat. Soc. 3 (1975), pp. 444-456.

[5] D.J. Bartholomew (ed.); Manpower Planning. Penguin Books, Harmondsworth (1976).

[6] D.J. Bartholomew/A.F. Forbes; Statistical Techniques for Manpower Planning. John Wiley, Chichester (1979).

[7] D.J. Bartholomew/R.F.A. Hopes/A.R. Smith; Manpower Planning in the Face of Uncertainty. Personnel Review 5 (1976), pp. 5-17.

[8] E. van der Beek; Prediction Errors in the Application of Markov Models for Manpower Planning (in Dutch). Memorandum COSOR 77-13, dept. of math., Eindhoven University of Technology (1977).

[9] E. van der Beek; Manpower Planning for the Public Works Office Using FORMASY (in Dutch). Manpower Planning Reports 7, Eindhoven University of Technology (1977).

[10] E. van der Beek/C.J. Verhoeven/K. de Waij; A Manpower Planning Method (in Dutch). Personeelbeleid 14 (1978), pp. 152-159.

[11] E. van der Beek/C.J. Verhoeven/J. Wessels; Some Applications of the Manpower Planning System FORMASY. Oper. Res. Verfahren 28 (1978), pp 19-32.

[12] A.M. Beth - Von der Warth/V. Steinecke; Personalaufwands-planung mit Hilfe eines Erweiterten Linearen Modells. Oper. Res. Spektrum 1 (1980), pp. 183-198.

220

[13]   P.M. Blau/W.R. Scott; Formal Organizations, A Comparative
         Approach. Routledge & Kegan Paul, London (1970).

[14]   D.L. Bosworth/G.J. Evans/R.M. Lindley; Mechanistic Manpower
         Models. in: Wabe [87], pp. 61-84.

[15]   C.H. Botter; Industry and Organization (in Dutch), Philips/
         Kluwer, NIVE, Eindhoven (1975).

[16]   A.M. Bowey; Labour Stability Curves and a Labour Stability
         Index. Br. Journal of Industrial Rel. 7 (1969),
         pp. 71-83.

[17]   A.M. Bowey; Corporate Manpower Planning. Management Decision
         15 (1977), pp. 421-496.

[18]   G.E.P. Box/G.M. Jenkins; Time Series Analysis Forecasting and
         Control. Holden-Day, San Francisco (1970).

[19]   R.G. Brown; Smoothing, Forecasting and Prediction of Discrete
         Time Series. Prentice Hall, Englewood Cliffs (1963).

[20]   D.T. Bryant/R.J. Niehaus (eds.); Manpower Planning and Orga-
         nization Design. NATO Conference Series II: Systems
         Science, Vol. 7. Plenum Press, New York (1978).

[21]   M.H. Cameron/J.E. Nash; On Forecasting the Manpower Require-
         ments of an Organization with Homogeneous Workloads.
         Journal of Royal Stat. Soc. A 137 (1974),
         pp. 584-595.

[22]   R.J. Casson; Re-evaluating Company Manpower Planning in the
         Light of Some Practical Experiences, in: Bryant/Nie-
         haus [20], pp. 545-559.

[23]   A. Charnes/W.W. Cooper/R.J. Niehaus (eds.); Management
         Science Approaches to Manpower Planning and Organi-
         zation Design. TIMS Studies in the Management Scien-
         ces. North-Holland, New York (1978).

[24]   D.J. Clough/C.C. Lewis/A.L. Oliver (eds.); Manpower Planning
         Models. North-Holland, New York (1977).

[25]   A.M. Mc Cosh/M.S. Scott Morton; Management Decision Support
        Systems. Macmillan Press, London (1978).

[26]   A. Crichton; Personnel Management in Context. Batsford,
        London (1968).

[27]   N.R. Draper/H. Smith; Applied Regression Analysis. John Wiley,
        New York (1966).

[28]   A.B. Drui; The Use of Regression Equations to Predict Man-
        power Requirements. Management Science 8 (1963),
        pp. 669-677.

[29]   R.C. Dudding/W.G. Piskor; A Computer Assisted Manpower Plan-
        ning Model. in: Bryant/Niehaus [20], pp. 331-339.

[30]   F.L.G. Esser; FORMASY, A System in Order to Forecast the
        Manpower Distribution and Necessary Recruitment.
        Master's Thesis, dept. of math., Eindhoven University
        of Technology (1975).

[31]   A. Etzioni; A Comparative Analysis of Complex Organizations.
        Free Press, New York (1968).

[32]   R.C. Fair; The Short Run Demand for Workers and Hours.
        North-Holland, Amsterdam (1969).

[33]   J. Gani; Formulae for Projecting Enrolments and Degrees
        Awarded in Universities. Journal of Royal Stat. Soc.
        A 126 (1963), pp. 400-409.

[34]   E.B. Geisler; Manpower Planning, An Emerging Staff Function.
        Amer. Management Ass. Bulletin 101 (1967).

[35]   A. Ghosh; A Note on Leontief Models with Non-homogeneous
        Production Functions. Metro Economica 10 (1960),
        pp. 14-20.

[36]   J. Gohl/H.J. Opelland; A Methodological Review of the Treat-
        ment of Individual Goals in Some Recent German Sys-
        tem Approaches towards Manpower Planning. in: Bryant/
        Niehaus [20], pp. 57-72.

[37]   S.M. Goldfeld/R.E. Quandt; Nonlinear Methods in Econometrics.
        North-Holland, Amsterdam (1972).

[38]   T.J. Gordon/O. Helmer; Report on a Long-range Forecasting
            Study. Rand Corporation Report no P-2982, Santa Mo-
            nica (1964).

[39]   R.C. Grinold; Interactive Design of a Manpower System.in:
            Bryant/Niehaus [20], pp. 307-318.

[40]   R.C. Grinold/K.T. Marshall; Manpower Planning Models.
            North-Holland, New York (1977).

[41]   J. Halpern; A Forecasting Technique with an Application to
            the Civil Service,in: Clough/Lewis/Oliver [24],
            pp. 219-225.

[42]   E. Harvey; Technology and the Structure of Organizations.
            Amer. Soc. Review 33 (1968), pp. 247-259.

[43]   W.R. Huisjes/E.H. Van Tuyll van Serooskerken/F.J. Wijbenga;
            Instruments for Manpower Planning (in Dutch).
            Informatie 19 (1977), pp. 734-741.

[44]   J.P. Ignizio; Goal Programming and Extensions. Lexington
            Books, Lexington (1976).

[45]   J.H. Jackson/C.P. Morgan; Optimization Theory, A Macro Pers-
            pective for Management. Prentice Hall, Englewood
            Cliffs (1978).

[46]   H. Kahalas/D.A. Gray; A Quantitative Model for Manpower
            Decision Making. Omega 4 (1976), pp. 685-697.

[47]   D. Katz/R.L. Kahn; The Social Psychology of Organizations.
            John Wiley, New York (1967).

[48]   P.G.W. Keen/M.S. Scott Morton; Decision Support Systems, An
            Organizational Perspective. Addison Wesley, Reading
            (1978).

[49]   J.H. Kessels; The Dynamical Behaviour of a Manpower System
            Master's Thesis, dept. of math., Eindhoven University
            of Technology (1974).

[50]   L.R. Klein; An Introduction to Econometrics. Prentice Hall,
            Englewood Cliffs (1962).

[51]   H. Koontz/C. O'Donnell; Essentials of Management. Mc Graw
                 Hill, New York (1974).

[52]   K.-F. Küching; Personalplanung und Unternehmungsforschung.
                 Gehlen Verlag, Baden-Baden (1973).

[53]   P.A. Lapp/I.W. Thompson; Supply and Demand for Engineering
                 Manpower Related to the University System in Ontario.
                 in: Clough/Lewis/Oliver [24], pp. 293-310.

[54]   J.R. Lawrence (ed.); Company Manpower Planning in Perspective.
                 Institute of Personnel Management, London (1975).

[55]   R. Likert; New Patterns of Management. Mc. Graw Hill,
                 New York (1961).

[56]   C.J. Margerison/N. Hunter (eds.); Management and Organization
                 Development, Bibliography (2nd ed.). MCB Publica-
                 tions, Bradford (1978).

[57]   F.H. Van Meeteren; Manpower Planning with the Use of FORMASY
                 at the Local Police Forces (in Dutch). Master's
                 Thesis, dept. of indust. engineering, Eindhoven
                 University of Technology (1978).

[58]   F.H. Van Meeteren; Application of FORMASY for the Police
                 Force of The Hague (in Dutch). Report Netherlands
                 Ministry of the Interior, The Hague (1979).

[59]   G.T. Milkovitch/A.J. Annoni/T.A. Mahony; The Use of the
                 Delphi Procedures in Manpower Forecasting. Manage-
                 ment Science 19 (1972), pp. 381-388.

[60]   J. Nash/A. Goddard; MANPLAN: a Flexible Computer Package for
                 Practical Manpower Planning. in: Bryant/Niehaus [20],
                 pp. 103-118.

[61]   D. Needham; Economic Analysis and Industrial Structure.
                 Holt, Rinehart and Winston, London (1972).

[62]   J.A.E.E. Van Nunen/J.Wessels; Forecasting and Recruitment in
                 Graded Manpower Systems. in: Bryant/Niehaus [20],
                 pp. 353-364.

[63]   H.L.W. Nuttle/J. Wijngaard; Planning Horizons for Manpower
         Planning in a Two-level Hierarchical System.Man-
         power Planning Reports 19, Eindhoven University of
         Technology (1979).

[64]   T. Parsons; Structure and Process in Modern Societies.
         Free Press, Glencoe (1960).

[65]   Project Group Organization Structure; The Strength of the
         Police Force (in Dutch). Report Netherlands Ministry
         of the Interior, The Hague (1979).

[66]   D.A. Pugh/D.J. Hickson/C.R. Hinings; An Empirical Taxonomy
         of Structures of Work Organizations. Adm. Science
         Quart. 14 (1969), pp. 115-126.

[67]   C.J. Purkiss; Manpower Planning, A Contribution of Concepts
         and Practice. Dissertation, University of Lancaster
         (1974).

[68]   J.A. Rowntree/P.A. Stewart; Estimating Manpower Needs II,
         Statistical Methods.in: A.R. Smith (ed.); Manpower
         Planning in the Civil Service.H.M.S.O no.3,
         London (1976), pp. 36-53.

[69]   L.R. Sayles/G. Strauss; Managing Human Resources. Prentice
         Hall, Englewood Cliffs (1977).

[70]   H. Schmidt/H. Hagenbruck/W. Sämann (eds.); Handbuch der Per-
         sonalplanung. Herder & Herder, Frankfurt/M (1975).

[71]   H.L. Seal; The Mathematics of a Population Composed of k
         Stationary Strata Each with Recruitment from the
         Stratum Below and Supported at the Lowest Level
         by a Uniform Number of Annual Entrants. Biometri-
         ka 33 (1945), pp. 226-230.

[72]   I.P. Sherlock; Manpower Planning as a Basis for Current
         Changes in Periods of Engagement in the Canadian
         Forces.in: Bryant/Niehaus [20], pp. 513-527.

[73]   H.Th.E.M. Siebelt/T. Taal/H. Van Wijk; Career Planning at the
         Netherlands Post, Telephone and Telegraph Organiza-
         tion (in Dutch). Intermediair 13 (1977).

[74]   H. Silcock; The Phenomenon of Labour Turnover. Journal of
                Royal Stat. Soc. A $\underline{117}$ (1954), pp. 429-440.

[75]   A.R. Smith (ed.); Models of Manpower Systems. English Uni-
                versity Press, London (1970).

[76]   B. Taylor/G.L. Lippitt (eds.); Management Development and
                Training Handbook. Mc. Graw Hill, Maidenhead (1975).

[77]   F.D. Tuggle; An Analysis of Employee Turnover. Behavioural
                Science $\underline{23}$ (1978), pp. 32-37.

[78]   G. Uebe/M.J. Beckmann/J. Fischer/E. Marnitz; Two Linear Pro-
                gramming Models of a Large German Federal Department.
                in: Bryant/Niehaus [20], pp. 307-318.

[79]   S. Vajda; The Stratified Semi-Stationary Population. Bio-
                metrika $\underline{34}$ (1947), pp. 243-254.

[80]   S. Vajda; Mathematics of Manpower Planning. Wiley-Inter-
                science, Chichester (1978).

[81]   S. Vajda; A Historical Survey. in A.R. Smith [75], pp. 7-10.

[82]   C.J. Verhoeven; FORMASY 2, User's Manual for an Interactive
                Manpower Planning System (in Dutch). Manpower Plan-
                ning Reports 5, Eindhoven University of Technology
                (1977).

[83]   C.J. Verhoeven; Eine Interaktive Personalplanungsmethode.
                submitted to: Oper. Res. Spektrum (forthcoming).

[84]   C.J. Verhoeven; Corporate Manpower Planning. Europ. Journal
                of Oper. Res. (forthcoming).

[85]   C.J. Verhoeven/J. Wijngaard; Application of the Manpower
                Planning System FORMASY at Philips Ltd. (in Dutch).
                Manpower Planning Reports 13, Eindhoven University
                of Technology (1978).

[86]   C.J. Verhoeven/J. Wessels/J. Wijngaard; Computer-aided De-
                sign of Manpower Policies. Manpower Planning Reports
                16, Eindhoven University of Technology (1979).

[87]   J.S. Wabe; Problems in Manpower Forecasting. Saxon House,
             Westmead (1974).

[88]   H. Wächter; Grundlagen der Langfristigen Personalplanung.
             Herne Verlag, Berlin (1974).

[89]   J. Wessels/J.A.E.E. Van Nunen; FORMASY, Forecasting and Re-
             cruitment in Manpower Systems. Statistica Neerlan-
             dica 30 (1976), pp. 173-193.

[90]   E.G.F. Van Winkel; ARIMA Processes, The Importance of Uni-
             variate Methods in Econometrics (in Dutch). Disser-
             tion, Free University, Amsterdam (1979).

[91]   J. Woodward; Management and Technology. H.M.S.O, London
             (1958).

[92]   J. Wijngaard; Markov Models for Manpower Planning, Some Re-
             marks and an Application on a Problem of Decreasing
             Growth. Manpower Planning Reports 11, Eindhoven Uni-
             versity of Technology (1978).

[93]   J. Wijngaard; Aggregation in Manpower Planning. Manpower
             Planning Reports 22, Eindhoven University of Tech-
             nology (1980).

[94]   A. Young/G. Almond; Predicting Distribution of Staff. Com-
             puter Journal 3 (1961), pp. 246-250.

[95]   A. Young/P.C.G. Vassiliou; A Non-linear Model on the Promo-
             tion of Staff. Journal of Royal Stat. Soc.. A 137
             (1974), pp. 584-595.

SAMENVATTING

Onder de term "personeelplanning" worden in de literatuur vele planningsactiviteiten met betrekking tot het personeel verstaan: korte, middelange of lange termijnplanning, planning voor individuen of voor groepen personeel, enz. Wij behandelen een aantal methoden voor middellange en lange termijn personeelplanning voor groepen personeel welke bruikbaar zijn voor groter organisaties.

In hoofdstuk 1 wordt personeelplanning dedefinieerd als een verzameling activiteiten die ten doel hebben het noodzakelijke aantal personen met de vereiste kwalificaties in de organisatie aanwezig te hebben, zodat de doelen van de organisatie worden verwezenlijkt en waarbij rekening wordt gehouden met de belangen van de individuele personeelsleden. Als activiteiten onderscheiden wij: wervingplanning, loopbaanplanning, opleiding- en vormingplanning en plaatsingplanning. De drie fasen van het personeelplanningsproces zijn: het voorspellen van de behoefte aan personeel, het voorspellen van de beschikbaarheid van personeel en de onderlinge afstemming van behoefte en beschikbaarheid. Een typologie van organisaties met betrekking tot personeelplanning is ontwikkeld. Hierin wordt aangegeven welke personeelplanningsactiviteiten voor verschillende typen organisaties belangrijk zijn.

In het tweede hoofdstuk wordt de eerste fase van het personeelplanningsproces behandeld: het voorspellen van de behoefte aan personeel. We onderscheiden statistische en subjectieve methoden voor het verkrijgen van deze voorspellingen. Ten aanzien van de statistische methoden kan weer een onderscheid worden gemaakt in de univariate extrapolatiemethoden en de multivariate methoden waarbij een relatie wordt ondersteld tussen personeelbehoefte en een aantal verklarende variabelen. Omdat de personeelbehoefte door vele factoren wordt beïnvloed, zijn algemene statistische methoden niet altijd bruikbaar. Het type organisatie en de personeelgroep waarvoor wordt gepland, zijn bepalend voor de toepasbaarheid van deze methoden.

Teneinde enig inzicht te verkrijgen in de wijze waarop de personeelbehoefte wordt voorspeld in praktijksituaties is een onderzoek gedaan in een aantal Nederlandse organisaties. Tenslotte wordt in dit hoofdstuk een procedureschets gegeven van personeelbehoeftebepaling.

In hoofdstuk 3 komt de tweede fase van het personeelplanningsproces aan de orde: het voorspellen van de beschikbaarheid van personeel. Een aantal wiskundige methoden worden gepresenteerd waarmee de ontwikkeling van de personeelbezetting kan worden voorspeld. Achtereenvolgens worden behandeld: Markov modellen, renewal modellen en optimaliseringsmodellen. De laatste twee typen modellen zijn geen zuivere voorspellingsmodellen maar combineren het voorspellen met het afstemmen van beschikbaarheid en behoefte. In dit hoofdstuk wordt aangegeven aan welke eisen de modellen moeten voldoen teneinde toepasbaar te zijn voor personeelplanning. Op grond hiervan, de gegeven definitie van personeelplanning en de gekozen indeling van het personeelplanningsproces hebben wij een Markov model gekozen als basis voor een personeelplanningssysteem.

Wij beschrijven in hoofdstuk 4 het op een Markov model gebaseerde personeelplanningssysteem FORMASY. Met behulp van dit interactieve computerprogramma kan men de ontwikkeling van een personeelbezetting voorspellen alsmede de gevolgen van een alternatief personeelbeleid. Teneinde de kloof tussen theoretische ontwikkeling en praktisch gebruik van het planningssysteem te verkleinen, is veel aandacht besteed aan de toepasbaarheid. FORMASY is zodanig opgezet dat het kan worden toegepast door personeelmanagers of leden van een personeel- of planningafdeling, dus door de deskundigen op personeelplanningsgebied.

Essentiële gegevens voor FORMASY zijn de huidige personeelbezetting ingedeeld in categoriën, de overgangsfracties voor iedere categorie en de toekomstige werving per categorie. De overgangsfracties kunnen daarbij gebaseerd zijn op historische gegevens, maar kunnen ook bepaald zijn op basis van een alternatief beleid. Als resultaat van FORMASY verkrijgt men de voorspelde bezetting per categorie, de leeftijdsverdelingen, verwachte salariskosten, stationaire verdelingen en diverse andere opties.

In hoofdstuk 5 komt de onderlinge afstemming van personeelbehoefte en -beschikbaarheid aan de orde. Het ontwikkelen van een alternatief beleid met betrekking tot werving, loopbaan, opleiding en vorming en plaatsing komt hierbij aan de orde en in het bijzonder de rol die een personeelplanningssysteem als FORMASY hierbij kan vervullen. Voorbeelden van toepassing van het planningssysteem worden gegeven.

Ingegaan wordt op het aggregatieniveau van personeelplanning, d.w.z. hoe moet het personeel worden verdeeld in groepen waarvoor planning relevant is. Belangrijke factoren voor deze verdeling zijn de lengte van de planninghorizon en de flexibiliteit met betrekking tot uitwisseling van personeel en functies.

Een andere belangrijke vraag die aan de orde komt, is: welke planninghorizon dient te worden gekozen? Bepalende factoren hiervoor zijn de onzekerheden ten aanzien van de voorspellingen en de mate van flexibiliteit van personeelbehoefte en -beschikbaarheid.

Tenslotte zijn in dit hoofdstuk in het kort een aantal organisatorische consequenties van de invoering van personeelplanningssystemen zoals FORMASY aangegeven.

In het zesde hoofdstuk behandelen wij een praktijkvoorbeeld van toepassing van het personeelplanningssysteem FORMASY. De organisatie waarop deze toepassing betrekking heeft is de Koninklijke Nederlandse Luchtmacht. Zowel de lange, middellange als de korte termijn personeelplanning komen aan de orde evenals de planning voor diverse dienstgroepen.

In de appendix, tenslotte, is een voorbeeld gegeven van verwerking van FORMASY op de B7700 computer van de Technische Hogeschool Eindhoven.

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CURRICULUM VITAE

De schrijver van dit proefschrift werd geboren op 28 juni 1953 te
Geertruidenberg. In 1970 behaalde hij het diploma H.B.S. - B aan het
Mgr. Frencken College te Oosterhout. Hij studeerde econometrie aan de
Katholieke Hogeschool te Tilburg en behaalde daar in 1976 het docto-
raal examen met specialisatie bedrijfseconometrie. Zijn afstudeer-
docenten waren Prof. dr. P.A. Verheyen en dr. J.Th.H.C. van Lieshout.
Tijdens de afstudeerperiode was hij tevens student-assistent.

Na zijn afstuderen kwam hij in augustus 1976 in dienst van de
Technische Hogeschool Eindhoven bij de onderafdeling der wiskunde en
werd hij te werk gesteld bij de interuniversitaire werkgroep "toepas-
singen van dynamische programmering" van de (onder-)afdelingen wiskunde
en bedrijfskunde van de Technische Hogeschool Eindhoven en het Inter-
universitair Instituut Bedrijfskunde te Delft.

Sinds augustus 1980 is hij werkzaam als adjunct-chef administratie
organisatie bij de Detam, bedrijfsvereniging voor detailhandel, ambach-
ten en huisvrouwen, te Utrecht.

STELLINGEN

behorende bij het proefschrift

INSTRUMENTS FOR CORPORATE MANPOWER PLANNING,
APPLICABILITY AND APPLICATIONS

door

C.J. Verhoeven

De oplossing van de overbezetting van top-rangen welke wordt aange-
geven in het voorbeeld in subsectie 5.3.1 van dit proefschrift, is
strijdig met de verwachte ontwikkelingen op de Nederlandse arbeids-
markt.

De flexibiliteit bij personeelplanning in een organisatie wordt aan-
zienlijk vergroot door het verhogen van het aandeel van personeel in
tijdelijke dienst in het totale personeelbestand en door het stimu-
leren van deeltijdarbeid.

Het is onrechtvaardig om de gevolgen van veranderingen op de arbeids-
markt en schaarste aan financiële middelen uitsluitend af te wentelen
op recente toetreders tot de arbeidsmarkt en de overige werknemers
te ontzien.

Het gevaar bestaat dat een inkrimping van het personeelbestand bij
de Nederlandse universiteiten en hogescholen in het kader van be-
zuinigingen zal leiden tot een vermindering van het aantal perso-
neelsleden in tijdelijke dienst, terwijl het aantal medewerkers in
vaste dienst niet of nauwelijks zal afnemen. Een gevolg hiervan is
een verkleining van de onderzoekcapaciteit terwijl de totale salaris-
last niet noodzakelijk zal afnemen.

Wanneer een werkgever de wet op het minimum loon ontduikt met meer
dan 20%, is het voor de betrokken werknemers financieel aantrekkelijk
om volledig arbeidsongeschikt te worden verklaard omdat de uitke-
ringen in het kader van de Ziektewet minimaal 80% van het wettelijke
minimum loon bedragen.

De techniek van kwadratische programmering wordt zelden toegepast in de econometrie. De methode is echter bijvoorbeeld geschikt voor het oplossen van portefeuille-selectieproblemen, onderzoek naar de structuur van een bedrijfstak (omvangsverdeling van ondernemingen) en het voorspellen van de macro-economische ontwikkeling van bedrijfstakken.

Lit. C.J. VERHOEVEN, Een algorithme voor het oplossen van kwadratische programmeringsproblemen met de mogelijkheid van gevoeligheidsanalyse gebaseerd op de simplexmethode,
deel 2 : Toepassingen van kwadratische programmering.
Katholieke Hogeschool Tilburg, juni 1976.

In het geval van perfecte negatieve correlatie tussen de rendementen van twee fondsen wordt het verband tussen de verwachte opbrengst van de portefeuille en de standaardafwijking grafisch weergegeven door twee lijnstukken. De efficiënte punten bevinden zich niet slechts op het bovenste lijnstuk, zoals ten onrechte is vermeld in Eygenhuysen (1977). Een correcte weergave is gegeven in Fama (1976).

Lit. H.G. EYGENHUYSEN, Risico en rendement van aandelenportefeuilles.
Stenfert Kroese, Leiden (1977), pp. 76-77.
E.F. FAMA, Foundations of finance.
Basic Books, New York (1976), pp. 220-222.

Indien het lokaal tarief voor telefoongesprekken (vast tarief ongeacht de gespreksduur) wordt afgeschaft, levert dit een bijdrage aan de verkleining van de wachttijd bij telefooncellen.

Het verdient aanbeveling aan degenen die geen militaire dienstplicht behoeven te vervullen, gedurende een bepaalde tijd een heffing op het inkomen op te leggen ten gunste van degenen die wel dienstplicht vervullen, teneinde een gelijke verdeling van lasten te verkrijgen.

Uit het oogpunt van rechtvaardigheid verdient het aanbeveling om aan wetenschappelijk personeel in tijdelijke dienst aan de Nederlandse universitaire instellingen, evenals dit gebeurt bij de Kort Verband Vrijwilligers in het leger, een premie toe te kennen bij de contractuele beëindiging van het dienstverband.

Eindhoven, 25 november 1980   C.J. Verhoeven