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ATS Manpower Planning in Practice: Introduction to a Qualitative and Quantitative Staffing Methodology

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Abstract

This document details the tactical perspective of the manpower staffing methodology in Air Traffic Service (ATS) organisations. It intends to give Manpower Planners (MPs), supervisors, controllers, senior management and staff members at all levels, detailed considerations on the day-to-day know-how of MP work. It clarifies qualitative and quantitative aspects of the staffing methodology in ATS organisations. By focusing on the day-to-day way of determining the number of controllers needed to perform the core task of an ATS organisation, this document may also foster the common understanding of broader and long-term MP considerations in the manning process. The ways of constructing a roster and improving it are also described. The advantages of shift scheduling software and their limitations are presented.

Keywords

Contingency planning	Individual rostering	Long-term planning	Manpower Planning
Refresher courses	Regulated breaks	Rostering	Scheduling software
Staffing	Team rostering	Time Management	Workload estimation

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EXECUTIVE SUMMARY

This document is part of the work of HUM.ET1.ST02, a Specialist Task (ST) within the European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) concerned with Air Traffic Controllers (ATCOs) Manpower Planning (MP) issues. The MP project concentrates on the development of professional Human Resources Management (HRM) methodology conforming to best practices and includes concepts, methods and tools for MP and staffing of Air Traffic Services (ATS).

Previous parts of the MP project dealt with an in-depth shortage analysis, which offered insights to general MP and manning processes (EATCHIP, 1998b) and the strategic point of view for MP (EATCHIP, 1998c). This document focuses on tactical approaches of the manpower staffing methodology in the day-to-day practice of MP work in ATS organisations.

By focusing on the day-to-day way of determining the number of controllers needed to perform the core task of the ATS organisation, i.e. the deliverance of ATS, this document may also foster an improved common understanding of broader MP considerations in manning processes.

By addressing a wide range of readers (including Manpower Planners (MPs), supervisors, controllers, senior management and staff members at all levels), it aims at enabling a common understanding of tactical MP and rostering.

Important fixed and flexible components or factors in any MP plan of ATS staff are introduced to clarify the staffing methodology in ATS organisations in a logical, step by step manner.

The underlying theme of this document is that the staffing challenge of MPs can be regarded as primarily qualitative rather than quantitative.

Chapter 1, “Introduction” describes the background, purpose and scope of the document.

Chapter 2, “An Analogy Between Tasks of the Controller and the Manpower Planner” draws an introductory analogy between the two jobs.

Chapter 3, “The Staffing Methodology” endeavours to clarify the methodology step by step.

Chapter 4, “The Art of Rostering” details the rostering parameters and suggests some ways to balance and improve a roster.

Chapter 5, “Automated Scheduling Software” presents the advantages of scheduling software for shift employees and discusses the limitations of such software.

Chapter 6, “Short-term to Medium-term Planning Considerations” outlines typical ad hoc (short-term) adjustments, different methods of workload estimation and summarises some of the warning signals for MPs.

Chapter 7, “Long-term Manpower Planning Considerations” describes how to cope with necessary adjustments of the staffing plans as well as how to improve the prediction of long-term staff shortages.

Chapter 8, “Summary” describes the main MP policy principles outlined in the document.

Annex A, “How to Calculate the Required Manpower” provides a simplified example as to how the quantitative (and the qualitative) requirements can be calculated.

Annex B, “How to Calculate Training Capacity” provides a typical example which illustrates the principles of training capacity calculation.

A list of references, glossary of terms used in the document, abbreviations and acronyms are provided.

1. INTRODUCTION

1.1 Background

This document is part of the work of HUM.ET1.ST02, a ST concerned with MP issues in ATS organisations. The MP project concentrates on the development of professional HRM methodology conforming to best practice (including concepts and tools) for MP and staffing of ATS organisations.

Objective number 6.4.1 of the Convergence and Implementation Programme (CIP) of the EATCHIP Work Programme (EWP) of the European Organisation for the Safety of Air Navigation (EUROCONTROL) calls for an “application of principles of the European Civil Aviation Conference (ECAC) MP programme”.

At its eighth meeting, the Human Resources Team (HRT) within EATCHIP established a Manpower Planning Study Group (MPSG) to be led by the HRT Chairman, which will submit a report on its work to HRT. The current document was put forward for consideration by the MPSG.

1.2 Preface

EATCHIP (1998a) dealt with ATCO manpower quantitative requirements in ECAC States. EATCHIP (1998b) questioned the benefits of an equilibrium in the adequate supply of ATCOs and examined some alternative models of MP. By focusing on in-depth shortage analysis, it offered some insights into general MP and manning processes.

EATCHIP (1998c) studied the strategic point of view for MP and management. The current document will focus on tactical approaches. It will concentrate on the qualitative and quantitative considerations concerning manpower staffing methodologies.

1.3 Purpose

The main purpose of this document is to clarify the staffing methodology in ATS organisations. It attempts to answer the question of “How”? by focusing on the day-to-day way of determining the number of controllers needed to perform the core task of the ATS organisation, i.e. the deliverance of ATS. This document may also foster improved common understanding of broader MP considerations and manning processes.

By describing in detail the staffing methodology, this document provides more transparency and awareness of the complex task of MPs. As a result, it may, on one hand, help to create a better common understanding between staff and management on the business requirements from an operational point of view, but on the other hand, enable an increase in management’s awareness

of staff workload and training needs. A higher level of awareness of the business requirements on MP may also assist in the process of developing and implementing adapted best practices in the staffing of positions and the scheduling of staff working hours that take in full account of safety, effectiveness and efficiency. One possible outcome may be reducing requests for roster changes.

This document is addressed not only to MPs and supervisors, but also to staff directly involved in air traffic operations, including ATCOs, planner controller, Flight Information Service (FIS) personnel, trainees, maintenance personnel (e.g. technical support), as well as staff in central services, administration, training and in senior management.

By addressing such a wide audience, it ambitiously aims at enabling a common understanding of the challenges in MP and rostering at all levels. It tries to explain what MP actually means and provides some qualitative and quantitative considerations to organisational and cost issues involved in the planning and rostering process.

1.4 Scope

MPs can be regarded as being primarily concerned with qualitative rather than quantitative staffing and rostering considerations.

This document, therefore presents a range of general MP qualitative and quantitative considerations to be given attention. In order to illustrate the planning process and to take into account all of the necessary steps involved, this document refers to an artificial base case where a mythical State has just separated itself from its origin. In this example it is assumed that the State of origin kept all ATS and the newly created State needs to establish a MP plan for ATS staff from scratch. By addressing the full range of MP thoughts to be taken into consideration, some useful, valid arguments may presumably also be derived by other States.

This document contains some of the more important constants and flexible components in any MP plan of ATS staff. It endeavours for once to clarify the staffing methodology in ATS organisations, step by step. First the general recipe, then the way of constructing a roster and improving it.

The advantages of scheduling software for shift employees and their limitations are also presented. Finally, the document contains some long-term considerations for MP.

2. AN ANALOGY BETWEEN TASKS OF THE CONTROLLER AND THE MANPOWER PLANNER

An interesting analogy exists between the tasks of ATCOs and the work of MPs in ATS organisations. MPs can actually adopt three important principles which are of major concern to any ATCO.

2.1 Safety

Just as ATCOs are concerned with avoiding conflicts between aircraft (a/c), the same applies for MPs. In preparing the weekly or monthly rostering, they wish to prevent any possible conflicts between different wishes and needs (e.g. operational and On-the-job Training (OJT) needs) from occurring.

2.2 Orderly

ATCOs usually do not like sudden changes in their controlled airspace or unexpected alterations in the scheduled flight under their jurisdiction.

MPs also wish to prevent abrupt modifications to their staff plan or shift roster. Although scheduled shift workers will ask for changes in their shifts for personal needs, one single change can cause tremendous ‘aftershocks’ and ramifications in the whole roster.

ATCOs and MPs both normally deal with the question “What is the change which will cause minimum further changes and disruptions”? The preferred answer can be “Stay at flight level” or “Keep your work schedules on backward rotation” (e.g. evening, day, morning, night, 3 days off).

Another important status quo target of MPs is to ensure stability in the training system. Changes in training, for example, can give rise to unpredictable production rates of new ATCOs.

2.3 Expeditious

ATCOs do their best to prevent wasteful extra flight mileage which can result in the inefficient use of fuel and time for the customers. Flight route length in terms of extra fuel is not a critical issue nowadays due to the low cost of fuel. However, this situation may change. ATCOs have no control over the efficiency of fuel consumption, but can make the a/c use more by poor routing. The average cost per kilometre of the en route services made available to users in the European airspace in 1997 was 0.53 European Currency Unit (ECU) (EUROCONTROL, 1997). Therefore, ATCOs are fully aware of what it means, when they instruct a pilot: “make one more orbit”.

MPs also aim to make the most efficient use of time of their most valuable resource, i.e. people. Ideally, they aim at granting ATCOs with “the minimum legal rest”, nothing more. In reality, this is not always achievable.

2.4 Other Similarities

The parallel between the Air Traffic Control (ATC) and MP work has additional aspects.

2.4.1 Future Conflicts

Both are preoccupied with possible future conflicts. For both it also applies that dealing only with current conflicts might be just too late.

2.4.2 Tacit Knowledge

It was never meant to be kept secret that experienced ATCOs in their day-to-day manner of ATC actually do not always calculate speed and distance of a/c and extrapolate figures. Experienced ATCOs not only recognise the a/c model but also have a vast additional knowledge e.g. regarding engine configuration (which a/c are powered by two or more jet engines), or possible differences in performance of the same a/c between different airlines. Based on this kind of previous knowledge, they are able to make informed decisions even faster and with more insight.

Experienced MPs also know that a certain controller colleague can, for example, usually handle 35 a/c per hour while another colleague is renowned for handling as many as 50 a/c. This kind of informal ‘tacit knowledge’ cannot necessarily be used on a daily basis by MPs or supervisors. However, under certain circumstances it might be found to be quite useful. For example, temporal use of such a ‘performing star’ might help at the end of a night duty, where traffic can rapidly build up to a level which imposes a significant workload in one sector thus delaying its division into smaller sectors.

Unfortunately, the supply of such gifted high performers is finite. One of the challenges is to avoid an over-utilisation of these highly talented ATCOs and thus burn out their physical or emotional capabilities. Operator capacity is to some extent inherently variable. Skilled MPs will also recognise their own limits.

Skilled ATCOs plan their workload. It is widely known how different individuals use different methods of handling traffic. All ATCOs follow standardised procedures and comply with regulations, conform to generally defined operating procedures, formulate standardised clearances to ensure a/c separation and communicate with pilots and other ATCOs. However, the fact that individual sectors differ in relation to each other in their complexity and intensity of the control task - combined with individual differences - will lead to the development of some individual working techniques.

MPs, by adopting different measures to cope, for example, with a sudden shortage also demonstrate their individual ways of handling the situation. Staff shortage can directly affect air traffic. An illustrative example of how a staff shortage can cause traffic delays occurred on 7 February 1998 between 1700-2000 at Zurich Area Control Centre (ACC)[1]. Information provided directly from Zurich ACC indicates that the staff shortage was caused by a high sickness rate. In addition, data from the Central Executive Unit of the Central Flow Management Unit (CFMU) indicates how, during that period of time, the rate of flights per hour was lowered from 50 (between 1700 and 1800) to 42 (between 1930 and 2100). Out of 157 regulated flights during this period of time 68 flights were delayed with a total of 706 minutes delay[2].

Finally, the logic behind the principle of descending an a/c “just in case” might be very similar to contingency plans of MPs, namely to minimise any uncontrolled or unassessed risk from occurring.

[1] EUROCONTROL Central Flow Management Unit (1998). *Air Traffic Flow Management Monthly Summary 01/02/98 to 28/02/98*. An internal report distributed among the Members of the ATM/CNS Consultation Group.
[2] CFMU daily report for Saturday 07 February 1998 (p. 2-8).

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3. THE STAFFING METHODOLOGY

So far ATC literature has shed little light on how, in practice, MPs can (or should) actually plan. This Chapter will concentrate in detail on the tactical perspective of the manpower staffing methodology. Although it is not achievable (in this introductory document) to examine all details, we shall endeavour to clarify the principles and the methodology step by step. First the general recipe, or method of staffing, then the way of constructing a roster and finally how to improve it.

3.1 The Method Adopted to Understand Staffing Methodology

Addressing the full range of MP thoughts that need to be taken into consideration in the planning process might help to understand some of the MP problems which exist in reality. It can also help to develop some useful, valid planning arguments. For this purpose a base case where a putative, hypothetical State named Atcania - which has just separated itself from its origin - is used. The State of origin kept all ATS and the newly created State needs to establish a MP plan for ATS staff from scratch.

The following Sub-chapters summarise some of the important fixed and variable components in a manpower plan. Ideas and concepts will be outlined showing how MPs can operate on an ongoing basis in order to arrive at smoothed, adjusted and flexible planning practices.

3.2 Staffing Factors

The principles outlined below are neither guidelines nor recommendations. These prevailing customs are merely MP reasoning, actions and / or MP fundamentals in ATS organisations, which were gathered by collating available experiences on the subjects.

The Purpose of Staffing Calculation

Usually, the main purpose of any staffing methodology in ATS organisations is to **determine the number of controllers needed to perform the core task of the organisation**, i.e. the deliverance of ATC services and the provision of a safe air traffic environment.

3.2.1 Analysis of Traffic Demands

The first step consists of a full scale evaluation of the traffic demand on the relevant airspace and the extent to which it should be used. Relevant questions in this respect are:

- How many a/c will use the given airspace subject to the jurisdiction of Atcania?
- What kind of flights can be expected?
- What will be the number of flights under Visual Flight Rules (VFR), Instrument Flight Rules (IFR), Operational Air Traffic (OAT), General Air Traffic (GAT) etc.?

3.2.2 Distribution of Traffic

The basic question to be answered in this respect is: **what is the expected distribution of traffic during different periods of time?**

Data provided should be as detailed and precise as possible (e.g. taking into account seasonal peaks, holiday periods, weekend traffic). Seasonal fluctuations normally refer to differences in traffic volume (e.g. between summer and winter). However, other seasonal factors can have an impact on manning and rostering. These include, for example, weather conditions (e.g. wind direction) and school holidays.

What is the expected demand during a single day and on an hourly basis (and / or on a 15 minute basis)? This determines the opening and closing times of working positions, taking into account the capacity of each sector, i.e. **Airspace Capacity** (see Glossary).

Sector / Position Opening

Opening and closing times of sectors / positions are normally determined by Operations (OPS) based on traffic volume and complexity in order to guarantee a safe and orderly traffic flow.

The Operational Requirements (ORs) defined are based on opening and closing of positions, i.e. establishing the number of positions required, their opening and closing times. Typical examples of planning basis are per day, per half a day, per shift, on hourly basis and / or on a 15 minutes basis.

In a large Flight Information Region (FIR) the geographic location of traffic at opposite ends of the FIR may mean that there is a need for sectorisation. Occasionally, the ORs for sectorisation are not established purely on density or complexity of traffic.

3.2.3 Airspace Organisation

With respect to airspace organisation, the question is: **how could the airspace be arranged in the most efficient fashion?**

Assuming there is a simple base case of one operational airport (in Atcania):

- What will be the areas of control around this airport?
- How many sectors are needed?
- Is an Upper Airspace Control Centre (UACC) necessary?
- Are there areas set aside for military use? In the past, military jets used to be the only a/c which regularly flew at high altitudes, nowadays civil a/c also use this airspace. In order to increase capacity, it would perhaps be easier to keep some traffic within the upper airspace (e.g. the 'free flight' concept).

Airspace Organisation

The organisation of the given airspace, its division into sectors, the number of control positions in these sectors, the opening / closing times of positions together with present and predicted traffic volume will all be important MP-related factors to be considered at this stage.

3.2.4 Technical Infrastructure

There are many technology-related questions to be asked at this stage, some of them are:

- What kind of technical co-ordination is required between the different units, e.g. six units, which include one UACC, four ACCs and one airport?
- To what extent should that co-ordination make use of new technologies?

(For further MP considerations related to technical infrastructure see also Sub-chapters 4.11 and 7.2.4).

3.3 Work Allocation Based on Operational Requirements (ORs)

The hours of operation of the above mentioned units and sectors are determined by the OR, i.e. how many controllers do MPs need to assign, at what positions and at what times.

3.3.1 Total Position Time

In order to keep the position open, what is the total number of hours required?

3.3.2 Seasonal Schedules

Based on the identified ORs and the traffic volume, distribution and growth expectations, what are the working schedules for weekdays / weekends, for summer / winter, or other seasonal peaks? What are the opening and closing times? The following sub-chapters outline some of the conditions MPs will normally take into consideration in calculating the number of controllers that should be available to be allocated (assigned) to the work.

3.3.2.1 Should One Plan for the Minimum, the Average, or the Peak Day?

Normally, the OR will not be based on traffic peaks, but upon average traffic. However, whether MPs plan for the minimum, the average or even the peak day demand depends partly on overtime practices and the organisational culture (see Sub-chapter 4.15). As a general rule, **the use of overtime should be limited to very special cases as an exception.** From a safety point of view, there are areas of risk related to the use of overtime on an ongoing basis as an integral part of the rostering.

Planning prudently for the peak day means that on some days ATCOs can leave their positions earlier than originally planned. Planning for the minimum day means that overtime payment will be necessary in order to keep the sectors open longer than foreseen during peak periods.

Eventually, regulations regarding the maximum working hours for any controller may become more widespread in the ECAC area. The general policy adopted with respect to overtime will be to plan for no overtime. For example, some States do not allow overtime except in some very special cases. Other States try to regulate this by forbidding overtime shortly before, or just after night shifts. The use of overtime will be drastically affected by such regulations.

3.3.2.2 Manning Positions

In manning a Controller Working Position (CWP) the basic questions are:

- Whether the position needs to be manned by an executive ATCO only or whether a planner and / or an Assistant Controller (AC) will be needed?
- How many hours a position is manned accordingly (e.g. with an executive ATCO and a planner or with an executive ATCO alone)?
- How many hours do the positions need to be operated?

For example, during night duty with significantly less traffic on screen in a given sector, an executive controller can sometimes work alone (see also Sub-chapter 4.10 on ‘Limited Ratings and Endorsements’).

There is evidence of an emerging tendency that in the future, an executive controller and a planner may be a combined operation. Currently this is not

often the case. Depending on traffic load or high levels of co-ordination with adjacent sectors or centres, an additional AC might be necessary. This third post by its nature, usually requires less manning hours than the first two.

Note: An ever increasing use of ACs may be a first indication that some re-sectorisation is needed. Although the situation is still manageable, it might indicate that the workload has produced an ever increasing number of periods where ATCOs need the assistance of an AC.

It should also be kept in mind that normally, in addition to controllers, FIS personnel and Flight Data Assistants (FDAs) are an integral part of the manning requirement of working positions.

3.4 Working Conditions and Other Constraints

3.4.1 Working Conditions

The basic question to be answered with respect to the statutory number of hours to be worked by an ATCO when scheduled on a roster is:

- **Based on the working conditions agreed with the unions, how many actual, effective hours of ATC could an ATCO deliver?**

Working Conditions and Other Constraints

In the normal course of business, MPs roster the staff to man the required positions, taking into account working conditions and other constraints.

MPs allocate manpower in a way which covers the OR, the necessary breaks and all legal constraints together with a certain surplus to cover staff on leave, sudden days off or sickness, while taking account of qualitative considerations.

There is always the need for MPs to gather (on an ongoing basis), data related to working conditions. For example, the average number of sick days (possibly on a monthly basis and perhaps also broken down by age and gender) could be of interest to MPs (see also EATCHIP, 1996a). Other useful data may include refresher training days required, expected periods of annual leave, average days spent on maternal (and / or paternal) leave, average days spent on special leave (e.g. compassionate leave). For training requirements and constraints see Sub-chapter 4.7.1.

3.5 Qualitative and Quantitative Considerations in Staffing

It should always be borne in mind that staffing methodology cannot (and should not) be based solely on staffing formulae and other numeric calculations. For example, there may always be some sectors where an ATS must be provided even if this is not fully cost-effective. Qualitative considerations are of as much importance as quantitative factors in MP.

It is therefore worth mentioning that most MPs regard MP (and in particular staffing) as being primarily a qualitative challenge. Some of these quality-related factors include:

- a decreased level of vigilance and decisiveness of operational staff during the seventh hour of a shift compared to the first one;
- deliberately planned shift overlapping and intentionally increased safety margins in the roster in order, for example, to prevent delays in neighbouring States and / or to cover short notice staff absences and / or to respect other supranational and international commitments (e.g. International Civil Aviation Organisation (ICAO));
- prolonged duration of breaks (e.g. longer breaks during a night shift are needed compared to day shifts);
- inclusion of meal breaks in the working hours;
- measures to avoid boredom which could contribute to the level of indecisiveness;
- social impacts resulting from split shifts on the same day (even if this would be a favourite solution and could be compensated by a bonus for the hours between the two working periods);
- MPs wish to accede to staff bidding on shift preferences (e.g. undesired night shift on 31st December);
- environmental measures (and pressures of non-governmental groups regarding, for example, reduced noise levels or reduced harmful aero-engine emissions such as nitrogen oxides (NO_x) and carbon dioxide (CO_2)) affecting the use of more effective departure / arrival procedures, flight patterns and / or number of flight per hour, per night;
- pressures from airlines to reduce ATC charges, flight time and fuel consumption;
- national labour legislations which may restrict the application of some theoretical manning calculations (e.g. regarding daily work on a display screen and its periodic interruptions by breaks);

- insufficient airspace capacity;
- technology constraints;
- 'tuned' and 'practical' numbers of staff and duties per day which are different in practice from theoretical calculations in order to meet quality considerations;
- reduced sleep-loss recovery and adequate sleep duration for the morning shift (e.g. not starting before 6am) in order to better plan the change between night shift and the following morning to allow for an adequate sleep duration;
- measures to avoid stress under conditions of high workload (see also Sub-chapters 6.2.2 and 6.2.3);
- measures to increase co-operativeness of staff with the introduction of more awkward shifts and unsocial hours (see also Sub-chapters 4.13.1 and 4.13.4);
- difficulty of older controllers to learn or cope with new systems;
- allowing overlap of duties in order to reduce some stress, accommodate traffic patterns or allow more rest time (see also Sub-chapter 4.9);
- rostering approaches which allow personnel to work in stable teams and avoid continuous changes within teams, resulting from individual rostering (see also Sub-chapter 4.2).

These qualitative considerations and others will be discussed in detail in the following chapters. At this point it is important to stress that due to those legitimate considerations (and others) there will inevitably always be some 'leakage of time' in the roster. However, the amount of time 'leaking away' will depend on the rostering practices applied.

It should also be stressed that MPs need (on a case by case basis) to estimate and subjectively judge whether a certain principally achievable quantitative gain or benefit is sufficiently balanced by qualitative gains / benefits, or whether these quantitative benefits can be achieved without impairing safety, staff morale or company culture.

Occasionally, for instance, a qualitative consideration (based on a 'pessimistic' scenario) to roster shift overlapping may well predominate quantitative arguments (based on an 'optimistic' or baseline probabilistic scenario).

As a rule of thumb and while studying Figure 1, some experienced MPs have noticed that qualitative considerations usually weigh about 60% in rostering decisions, while quantitative considerations weigh about 40%.

Figure 1 which is inspired by another conceptual model of Teamwork in Aviation[3] illustrates the way qualitative and quantitative considerations interact in constructing a balanced roster.

The Manpower Plan in Figure 1 takes into account not only the 'What' (quantitative considerations) but also the 'How' (qualitative considerations). Values shape an organisational culture (see also Sub-chapter 4.15). Combined with norms, management style and the organisational culture define qualitative considerations which can weigh some 60% in rostering decisions. At the same time, the mission of an ATS organisation combined with its safety and business strategy define ORs. These will present the quantitative considerations which can weigh some 40% in rostering decisions.

This kind of model can assist in increasing staff awareness in discussions on the way rosters are constructed. It enables a common language and common understanding of the complexity involved in MP.

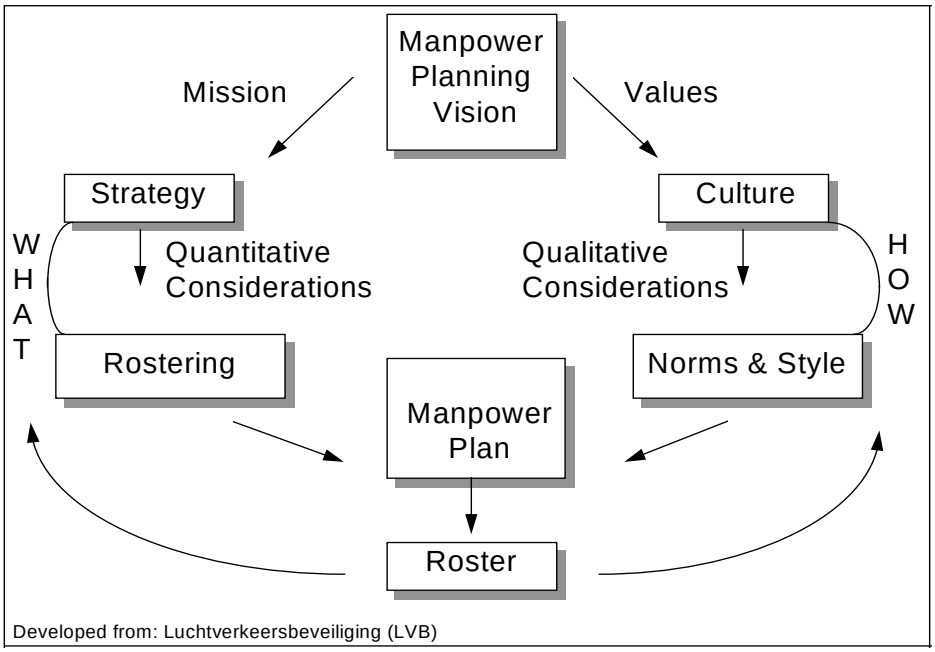
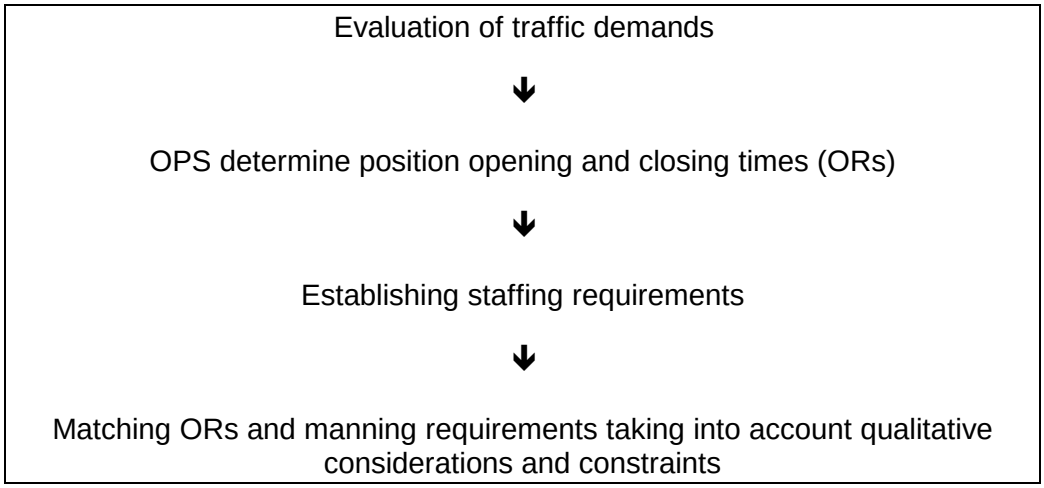


Figure 1: Qualitative and Quantitative Considerations in Rostering

[3] The model is developed by Coaching and Sparring at the Mega Group for the Dutch Luchtverkeersbeveiliging (LVB). We thank Mr. Stoové from LVB for the information on the model.

The following model summarises the matching process between the ORs and the manning requirements, taking into account time distributions of each step:



Safety margins and contingency planning are an integral part of any staffing method. For further consideration of these factors see Sub-chapter 4.9).

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4. THE ART OF ROSTERING

4.1 The Shift Roster Process

The list or plan showing duties, days off and leave for staff (i.e. the roster) is normally completed by MPs after a detailed consultation process with supervisors and the staff affected by that roster.

Rosters are the most obvious manifestation of tactical MP. It is also a manifestation of the rules and conditions which were agreed with the staff and their representatives. MPs can, within reasonable limits, close a position, cut one hour off the afternoon shift, increase staff on the night duty, add an extra position, change the limits of breaks and improve the balance over different periods of time (e.g. week, month).

In order to perceive roster issues in proportion, it is worthwhile first to mention that Missault and Niesing (1995) found that the given factors of working days per year and the OR which determine the number of duties to be performed per day are far more significant in achieving cost efficiency than the roster calculation itself.

Although rostering changes are widely considered as one of the most important tools of MPs to successfully cope with their task, Missault and Niesing (1995) concluded that a roster tool basically suggests only an optimal distribution of duties for any one day over a stable period of time.

This Chapter addresses the following questions:

- What are the pros and cons of individual rostering, team rostering, or an approach which combines both elements (e.g. staggered start and end times of duties, or by allowing individuals within a team to accumulate time during the summer season which is taken as additional leave during low traffic season)?

- What are the most efficient ways to develop shift rosters?

4.2 Individual or Team Rostering?

One of the major decisions MPs need to take is whether to apply individual or team rostering. The sequence of consecutive shifts and off-time can be assigned to a particular individual (i.e. individual rostering), or group of individuals (i.e. team rostering) as their usual work schedule (EATCHIP, 1996a).

4.2.1 Individual Rostering

The fact that there is no need for a systematic shift cycle to be followed permits more flexibility and leads to the perception that individual rostering is more efficient and cost-effective. Is it?

It is certainly more difficult to organise individual briefings. If more staff need to start working at the briefing time instead of the time required operationally, then the cost-effectiveness will partly diminish. For example, compulsory briefings can account for about half an hour (maximum) for each staff member in the roster[4].

By its nature, individual rosters facilitate responses to personal preferences of staff. However, this could quickly turn into a disadvantage for MPs if changes to the roster are too frequent.

Some of the days off (allocated to individually rostered ATCOs) can be used to reinforce a certain sector, or to increase the safety margin by using a stand-by duty especially for the early morning traffic, or for projects and receiving / delivering training.

4.2.2 Team Rostering

One could possibly save a few hours by adopting individual rostering techniques. However, team rostering allows more flexibility in coping with changes in start and end times of duties.

Moreover, by introducing staggered start and end times, one can compensate for some of the less desirable features in team rosters. If staggered begin and end times of duties are used in a team roster context, it becomes a hybrid composed from team and individual rosters. Working according to individual rostering exposes the whole MP system to “swap effects”, i.e. one person who changes his / her working schedule may affect a large number of staff. Experienced MPs know that this can easily turn into a major task to accommodate all (or even part of) individual preferences.

Team rosters can create and foster a team spirit. Its contribution to the motivation level of the team member can be extremely important and sometimes priceless. Accepting assistance from a colleague that you know you can rely on is not a sign of weakness, but a normal reaction to an overload in air traffic.

Team rosters enable better knowledge of colleagues both during and after work, if this is desired. Having a social life of colleagues working under individual rosters is more difficult.

Assuming that team rosters can normally improve communication between staff members, this could have a direct positive impact on safety.

[4] It should be mentioned that individual briefings using computer assisted methods could be a feasible solution.

In some FIRs there is simply too little traffic during the night, therefore it is impossible to have there strict team rostering for day and night shifts.

4.2.3 Individual, Team Rostering and Sickness-related Issues

It is not unusual to find a lower sickness rate among staff working under team schemes, than those under individual schemes due to 'social control' (although clearly this is not the case in at least one State in the ECAC area using individual rosters). In general, it seems that the sense of responsibility and caring for one's own team members can occasionally help to reduce the number of uncertified sick days.

Sick cases are safety-related issues. A workload can increase sickness whether under individual or team rostering and sick cases can also be related to future workload.

It is important to maintain a sense of respect in publishing a roster. In order to foster the acceptance of a roster, at a tactical level, an approach of give-and-take is recommended. If, for example, MPs need to maintain the flexibility to ask a staff member to cover the Saturday duty of another staff member who called in sick, they must give something in return. For example, if one day a sector is closed earlier the supervisor can send a person home. A give-and-take approach basically comes down to creating an atmosphere, an organisational culture of co-operation, where one party understands the operational and / or social needs of the other party and is willing to meet them. It is the sense of responsibility and the reputation of the ATS organisation on safety which brings MPs and staff together (see further discussion on organisational culture in Sub-chapter 4.15).

4.2.4 Individual, Team Rostering and OJT

It is well known that one of the most important factors of trainee success at OJT is the 'getting along' with colleagues. It could be easier for trainees to attune themselves with a well defined family spirit, as found in a team, than to be constantly changing combinations of colleagues whose social behaviour is less predictable.

The 'getting along' factor is deeply related to the whole philosophy of what is a 'properly conducted OJT'. Some will argue that properly trained OJT Instructors (OJTIs) should mean that 'face control' is not a factor. Many experienced people in the OJT domain believe that continuity of training is more important than team integration. Therefore, the student should start (at least) working with only one OJTI.

Teams can also develop rigid habits which make it difficult for newcomers to integrate, or they may adopt a sense of overestimation of their collective capability which might put safety at risk. On the other hand, less performing individuals are often "hidden" in a team which protects them from performance comparisons. Teams also tend to compete with each other - not always in the most collegial manner.

There is some evidence from training institutes that no matter on the type of rostering applied, team or individual, controllers tend to show teamwork behaviour, once the duty has started. They are used to working in teams, even if they are transferred to another team. However, this might depend to some extent on **how** the transfer was carried out.

4.2.5 Individual and Team Rostering - Summing-up and Conclusions

In summary, although individual rostering is probably considered as more cost-effective and hence more efficient, it is difficult to prove its real cost-benefit advantages. Team Rostering is generally applied, probably in response to socially driven preferences, provided that enough flexibility in the roster is allowed for transfer between teams and mixtures between shifts (see also Sub-chapter 4.13.3 on 'Shift Rotations').

As yet, there is no clear evidence of a significant relationship between individual or team rostering and sickness rates.

As far as OJT is concerned, continuity of training and work with one OJTI is probably more important than team integration.

Experience in many States has shown that strictly applied individual or team rostering schemes might face difficulties. Some kind of flexibility in various degrees is necessary (e.g. the application of half-teams). Therefore, it might well be that more 'hybrid' approaches (e.g. team rostering in principle, but individual start and end times of duties) are more efficient to cover the requirements. Hybrid forms and staggered duties lead to different start times of duties within teams. If part-time workers exist, they need to be treated differently anyway.

Once a specific rostering pattern is applied (e.g. individual rostering), staff dislike changes to another form (e.g. team rostering).

Whatever is chosen, individual or team, the roster should be published well in advance in order to allow predictability of social life.

Whether individual or team rostering is applied, the constraints (e.g. statutory number of weekly working days, or maximum consecutive shifts on three Sundays or minimum rest between shifts) remain, as do the number of duties required to cover the OR. The decision of which roster to use is largely dependent on other issues such as the real extent to which ORs are related to traffic and the real percentage of break time (see also Sub-chapter 4.13.2 for further discussion on real break time).

4.3 Establishing the Rostering Parameters

Before one is ready for rostering, there are a number of qualitative and quantitative questions to be answered:

- What is the official duration of the working week (e.g. 37.5 hours/week)?

- What is the working cycle pattern or shift ratio (e.g. 4/2, 4 days work, 2 days off)?
- What are the specific start and end times of shifts (including earliest and latest starts and ends)?
- What is the minimum number of ATCOs needed to cover the OR on a daily basis?
- What are the seasonal factors?
- What is the maximum number of consecutive days that an ATCO can work?
- What is the maximum number of days off during the rostering period?
- What is the maximum and minimum length for each morning, day, night and swing shift?
- What is the maximum length of time that may continuously be spent on the position by any one person?
- What is the duration of the break away from the position (see Sub-chapter 4.13.2)?
- What is the minimum break time within shifts?
- What is the maximum break time within shifts?
- What is the minimum recuperation time between shifts?
- What is the minimum number of weekends or Sundays off granted for staff (e.g. per year or per month)?
- Is there a limitation to the number of night duties in a year?
- Are there any restrictions on unusual start and end times of shifts?
- What is the average number of annual leave, special leave, public holidays and compensation days?
- What is the average number of sick leave days per year and per season?
- What is the expected number of days assigned to other associated duties or duties outside the Operational Room (OPSroom) (see Sub-chapter 4.4)?
- What is the average real time duration for handovers and briefings?
- What is the policy regarding the inclusion of supervisors in manning positions?

- Which members of staff have not yet checked out on all positions required and since when can they be taken into account for rostering (see also Sub-chapter 4.10)?

- How many days for refresher training are planned (see Sub-chapter 4.7)?

- What is the training period before and during implementation of new systems (required in order to learn to operate such systems)? Is this training period equal for all the staff, or different for more senior members of staff?

- What is the right balance between experienced ATCOs and less experienced ones on each shift?

- Who are the ATCOs able to handle the peak traffic?

- Were ATCOs, who work only one day a week in order to maintain their rating, assigned on a 'heavy' day?

- How many hours ATCOs are involved in simulation training and OJT?

Some of the factors mentioned above will be discussed in more detail in the following Sub-chapters.

4.4 Associated Duties

ATCOs need not only to perform the core task of ATC, but they are also required from time to time to carry out other associated duties closely related to the core business.

ATCOs core tasks usually consist of actively manning an operational position as an executive, planner or AC including coverage for breaks; to train *ab initio* trainees or to receive training. A controller will also have other associated duties, e.g. to participate in a project of evaluating a new Operational Display System (ODS), carry out managerial tasks etc.

While a lack of staff for duties such as drafting letters of agreement with adjacent centres, working on procedures or system development has rarely been seen as a sudden problem at an ATS organisation with seemingly perpetual labour shortage, the lack of ATCOs for duties at OJT, air space structuring, incident investigation and many other duties has had an impact on MP and the availability of staff for operational duties.

MPs need to establish what kind of staff are required for those associated duties. Among the duties outside the OPSroom, one could probably mention first the training. There will be no future generation of ATCOs without having fully licensed controllers spending a substantial number of hours as OJTIs. OJT typically takes place behind the position in the OPSroom. In addition training can take place outside the OPSroom in a classroom, simulators and / or by Computer-Based Training (CBT) exercises. ATCOs are involved at their

professional bodies or organisations. They also carry out many other duties which are not strictly operational. A legitimate question to be asked is, to what extent do these associated duties need to be carried out by licensed ATCOs or could they be done by other qualified personnel?

Would future contracts with ATCOs (and / or their social partners) perhaps specify the percentage of the ATC work to be performed out of the total working time (e.g. 60% will be in the OPSroom and 40% in other duties)? Would future contracts offer flexible part-time possibilities to ATCOs, or job sharing opportunities, while taking into account the minimum requirements to maintain their ratings (and their real competency)? These are related to broader HRM issues such as:

- How could organisational structure be used to achieve more flexibility in personnel staffing?
- What are the social impacts of poor flexibility and being short of staff?
- How can the ATS organisation plan to provide better manpower needs and also the necessary 'brainpower'?

4.5 Maintaining the Licence / Rating

ATCOs are obliged (in order to maintain their rating validation) to properly carry out their duties where they hold a valid rating, e.g. at least once every 30 days in some States or to work 20 shifts during the preceding 90 days of a calendar year or some longer period of time in other States. This will vary depending on the local or national administration regulation. MPs need to know who among their ATCOs run the risk of losing their licence due to these regulations, and who needs to re-validate their rating after spending a period of time in other duties outside the OPSroom. For example, controllers who already had a rating at an ACC and worked for a while at an aerodrome may need to re-validate their ratings before returning to the ACC.

Operational rules could be set regarding not only the minimum number of ATC hours needed in order to maintain a valid rating, but also concerning the traffic qualities and work circumstances (e.g. working at night).

Some controllers who spend most of their time in administrative tasks may need only, from time to time, some information sessions on current OPS issues without practice. When re-validation is required, it could be carried out in a relatively short time.

Other controllers who work in related management duties may require training to replace their colleagues in the control position at any time and under any traffic circumstances. The quality (and quantity) of training and practice for this requirement will be entirely different to that mentioned above.

MPs may have to examine ways to develop those differential rules regarding the different needs to maintain the active rating.

4.6 Medical Check-ups

While rostering, MPs also need to take into account that ATCOs are normally obliged to undertake a medical check-up at regular intervals in order to maintain their licence.

4.7 Refresher Training

ATCOs may also be obliged (again depending on local regulation) from time to time to undertake refresher training, e.g. on new equipment, emergency procedures and / or other unusual situations.

4.7.1 Training Requirements

MPs calculate the training requirements (receiving and providing training) separately from the ORs. Receiving and providing training, reasonably refers to training activities conducted outside the OPSroom and may also infer involvement in other related tasks.

While OJT itself is not supposed - in theory - to affect OR, in reality it does have an impact on OPS. In many instances, particularly in the early OJT stages, the capacity of the student will be less than the capacity of the fully qualified OJTI.

A sector may also be opened earlier than usual in order to enable OJT in this sector under low traffic conditions.

4.8 Early Retirement

MPs may need to know and take into account in their plans associated duties, training and licence-related deadlines, and also some personal data such as:

- eligibility for early retirement due to the number of years in service;
- number of years left until usual retirement;
- medical problems (people near the usual retirement age may have an increased risk of medical problems and therefore an increased risk of a loss of licence).

4.9 Contingency Planning and Safety Margins

Next to these planning activities, a contingency plan has to be foreseen, taking into account possible system failures and non-standard operations such as a/c alerts and emergencies.

For example, even if an assistant position is not required at a certain time of the shift, MPs may want to keep this position manned to accommodate longer

break periods or to use available time of a supervisor to man an operational position. Once a sector has been opened it is kept open for a certain time period. Fluctuations of traffic during the opening time do not necessarily influence the number of ATCOs needed in this sector, but will lead to a varied workload.

If significant seasonal fluctuations were identified, average opening periods may be shorter, but will not necessarily lead to a reduced number of staff required due to contingency measures.

It is often asked whether safety margins of staffing should be established by rounding calculations up, or rounding down. One could round down if it would fit the roster (in working days and hours), if not one should round up. The number of staff should fit the roster arrangement applied. In fact, staffing margins should already be part of the planning. If staff are not available, a sector is closed and the traffic is limited.

Contingency planning may also refer to the provision of a safe air traffic environment:

- during industrial and / or professional disputes;
- on January 1st 2000 (and afterwards). Since MPs have a direct interest in whether, for example, ATCOs will be named as defendants before a court in the case of accidents or incidents related to the year 2000 computer bug[5].

Safety margins are not only quantitative, but also involve some qualitative considerations. For example, when ATCOs are exposed to a heavy traffic load during a night shift, some additional relief can be considered in order to increase the safety margins and to counterbalance subsequent daytime sleepiness.

MPs cannot rely on a roster which is stretched to its limits, where the whole manning procedure hangs precariously in the balance. The result of such arithmetic-oriented planning is likely to prove disappointing to the MPs.

4.10 Limited Ratings and Endorsements

Consoles at the position may include an executive controller (or a 'radar controller'), a planner controller and (even) an AC. All are supposed to be fully licensed. In practice, some States have adopted the policy to employ staff with limited ratings and endorsements for licences. For example, a new ATCO who checked out on one position, but still has to obtain during a statutory period (e.g. a nine month probation period) ratings on other positions may already

[5] For further reading on the year 2000 computer bug in aviation, see also Yates, C. (1998). The millennium time bomb, *Jane's Airport Review, 10 (3),* 01.04.1998, p 25; Garrett, P. (1998). The millennium bug, *Orient Aviation, 5 (4),* 01.03.1998, p 14-15; Sheppard, I. (1998). Year 2000, *Flight International*, 9-15 September 1998, p 57-60.

work at that position in contingency cases. One should bear in mind that this temporal solution is not optimal, due to the fact that while performing this operational duty, this individual is not being trained for the other positions. Beside this, the temporary solution often has an awkward habit of becoming permanent.

Limited endorsement could be a perfectly legitimate policy, for example, one State in the ECAC area issues endorsements only to one sector. In other cases, the endorsement procedure could be to be rated first on lower traffic sectors and only after a longer period of gaining experience to obtain a rating on higher traffic sectors. However, if the goal is to have fully qualified licensed ATCOs, there is a risk in the temporary use of limited endorsement ATCOs. One could be left (over a long period of time) with having only limited ratings and endorsements staff.

MP for ATCOs depends on ratings and endorsements, since these are the indications of what a person potentially can deliver. However, for MPs aiming at a flexible and efficient roster, who already have appropriately qualified staff available for duties, it is also important to consider what a person can actually deliver.

4.11 Technological Impacts on Rostering

Thanks to automated systems such as the Activation message (ACT), a system can automatically indicate to the next sector inbound flights. The neighbouring sector knows of incoming traffic by automatisation and regulations. This development enables a restructuring of the working station, e.g. to reduce the number of positions from three to just one. Obviously such a development has important implications to MPs in their rostering work.

The spread of Global Positioning System (GPS) technology has some conflicting consequences on MP. On the one hand, this technology will enable controllers to have more accurate information on a/c positions. It may even reduce the dependency on reports from radio operators in the case of transatlantic flights (e.g. the radio operators who work from Ireland for Shanwick Oceanic Control, based at Prestwick) and save some 20-30 minutes in communication time per flight. On the other hand, it enables ATCOs to handle more traffic, to fit more a/c into the same airspace by reducing the minimum separation. It still remains to be seen how these different influences will affect the number of ATCOs.

Past experience has shown that some of the major new technologies which were introduced during the last three decades (e.g. the transition from a procedural system to a radar control) did not reduce the number of staff. On the contrary, the number of staff required to handle these technologies increased (at least during the long transition period).

The same probably applies for the ever increasing popularity of the ‘free flight’ concept. It is too early to say if this will affect the present number of ATCOs, and whether this number will increase or decrease.

Isolated reforms usually do not work as expected in the beginning because of the way working conditions and other labour-market rigidities reinforce one another.

4.11.1 Training and Technology

Training technology is continuously progressing, offering new prospects (e.g. more and more CBT and simulator training) to the Training Manager, since it may improve the quality of operational training and allow for the development of alternate solutions to OJT. This fact is important for MPs, since it may change OJT time and may change the total time for becoming qualified as a fully licensed ATCO. It may also require additional staff to run and maintain these technologies.

In this context, the aspect of age and training for new systems should be borne in mind. In today's society, the use of multimedia computers is more and more general and thus increases the likelihood of acceptance of modern training, and operational tools by older ATCO staff. However, older ATCOs may still face difficulties in learning new systems. In the cases where the older staff may experience difficulty MP and human resource development planning can take account of this reality by scheduling individuals for other duties, or early retirement schemes.

4.12 What is a Well Balanced Roster?

4.12.1 Age

After a first rostering was achieved, Atcania’s MPs have breathed a sigh of relief, but not a deep one. Experienced MPs will make sure that their rostering contains a well balanced age distribution as far as possible. A combination of a senior ATCO with a senior pilot at the end of a night duty in circumstances of increasing morning traffic might be a recipe for a potential recorded incident. A shift populated only by very young ATCOs is also undesirable. A balanced range of age groups will probably better serve the purpose. A good age distribution would typically include some experienced ATCOs with some less experienced ones.

4.12.2 Level of Experience

MPs will be well advised to try to provide also a good mixture of different levels of experience and age groups in their rosters. They should usually try to provide a considerable level of rotation to prevent boredom or stress setting in. Goodwill and grace for the more senior ATCOs is always appreciated. A burn-out of the youngster or the ‘star’ performer is dangerous. Exhaustion can increase sickness cases. Experienced MPs know that a close follow-up on unseasonable increases in sick leave could indicate that a newly appointed supervisor has not yet found the right balance in this respect or has neglected some other important aspects in managing his / her human resources.

4.12.3 OJT

In principle, all available, sufficiently experienced, qualified and socially competent controllers should theoretically be capable of assisting in the OJT efforts. These controllers will need to have relevant experience and should receive instructions in the conduct of OJT. Experienced MPs will take into consideration in a balanced roster the fact that not every experienced controller will be eligible to act as an OJTI. Wrong attitudes or lack of social skills explain why not every controller may be the best choice for acting as an OJTI. See Chapter 7 in EATCHIP (1995), for selection and training of OJT coaches.

4.13 Improving the Roster

Having established the minimum number of staff needed for operating ATC positions and the number of staff essential for associated duties, one could start deducing how many 'spare' ATCOs (i.e. above the required minimum) are available on a certain day. Staff capable of being used in other functions can be monitored on a regular basis.

4.13.1 Minimising the Balancing Losses

ATS organisations (and airports in particular) operate within a dynamic environment. The actual number of staff needed to 'run' the roster will almost always be higher than the minimum that was calculated theoretically due to inevitable 'balancing losses' (Missault and Niesing, 1995).

Balancing losses are a result of overlaps and redundancies which lead to what MPs call a 'leakage' of time, and cannot be recuperated. Balancing losses occur due to a combination of practical habits and legal constraints. Such losses are influenced by agreed working conditions and labour laws, varying between States. The following list gives a few examples of factors which impact balancing losses:

- an informal rule of minimum shift length (e.g. 4 hours);
- the roster cycle (e.g. a cycle of 4/2 providing 122 days off which is the closest to a standard number of 104 days off, but still higher);
- maximum shift length (e.g. 10 hours);
- average weekly working time (e.g. 37h30);
- number of officially allowed hours of sleep during a night duty;
- minimum time between consecutive shifts;
- maximum working days (e.g. 6);
- maximum consecutive Sundays to be worked;

- unacceptable starting time of a shift (e.g. 02h45 am);
- fixed start and / or end times of shifts (not allowing for staggered duties);
- group or team briefings instead of individual briefings;
- number of night shifts;
- size of the team;
- number of positions.

MPs aim at minimising the balancing losses and thus the number of staff needed in a roster. In collecting operational loss data, much can be learned from financial banks which pioneered work on risk management. One of their lessons is that to manage risks effectively, organisations need to separate those who monitor risks from those who take them.

Some balancing losses are inevitable or even necessary and justified. However, ways to determine the losses and monitoring them should be found. It is well recognised that these ways will vary to a great extent between States.

4.13.2 Regulated Breaks

Regulations usually define duration of duties, including standby duty, breaks and rest days. The purpose of limiting periods of operational duty and providing relief or recuperation breaks is to avoid acute fatigue effects, stress, health problems (such as circadian rhythm disruption), other chronic effects of night work, or incidences of sleep difficulty. A 12 hour shift which lacks appropriate shift breaks and which involves monitoring tasks in front of a radar screen can result in difficulties in coping with work-related problems.

In most States controllers are allowed to take about 22% of their duty time as a break (one hour for meal and two breaks of 20 minutes out of a 7h30 working day, or other arrangements). Depending on national legislation they are also not supposed to perform more than 2 consecutive hours in front of a Visual Display Unit (VDU), or radar screen under normal conditions.

The effective break assignment and its duration should be determined by the supervisor, depending on traffic (volume and type) and available staff, and not by the roster, otherwise operational flexibility can be lost. The effective time for breaks can be assumed to be 22% of the working time, although in reality, higher break proportions are not unusual.

MPs need to estimate (on a yearly basis) the average number of hours required for breaks, annual leave, sick leave, days off (depending on the roster cycle), public holidays, receiving and / or providing training, days participating in projects, guild and / or union activities etc. A detailed example of how to calculate all these manning factors in order to arrive at the required

manpower is given in Missault and Niesing (1995). For a concrete example, see also Annex A.

MPs not only provide sufficient break periods and relief controllers but also bear in mind some important qualitative related considerations. As part of the management they ensure that adapted rest areas (including tobacco-smoke free zones), refreshment and eating facilities are available to any shift **within** the premises (when relaxation and refreshment are considered as working time).

MPs are also involved in 'fatigue management'. In this respect, they may provide supervisors with the opportunity to allow for the so called 'strategic naps' (see Glossary) during night shifts as a means of improving alertness and anchoring circadian rhythms.

MPs are also aware that active relaxation (e.g. listening to classical music through personal headphones) was found to be significantly more effective among controllers than passive relaxation (e.g. reading magazines during a 10 minute rest cycle) (Kastner et al., 1998).

4.13.3 Shift Rotations

From the point of view of shift rotations, a slow rotation rate is favoured in order to facilitate the adaptation to the rotation. There is evidence that due to the circadian rhythm, a forward rotation (i.e. first morning, then afternoon, then night) is favourable compared to a backward rotation (Stokes and Kirsten, 1994). Due to social factors (i.e. the roster is not attractive to staff), a strict forward rotation is often not applied since staff prefer to 'block' work- and rest time. Staff prefer, for example, to start the cycle with an afternoon shift, then morning, then night. Weekly rotation, (i.e. rotating hours change once per week) is generally considered difficult to cope with.

Recent discussion at the 37th Annual Conference of the International Federation of Air Traffic Controllers' Association (IFATCA) revealed that there is no consensus yet on all recent medical findings related to rotating shifts. (The representative of) "New Zealand stated that backward rotating rosters were his MA's (Member Association) preferred option and research confirmed this. Standing Committee (SC4) stated that medical evidence suggested that forward rotating rosters were preferred" (Cooper et al., 1998, p. 8-9).

While it was clear that consecutive night shifts are not recommended, some medical evidence confirmed that a minimum of 16 hours off after a midnight shift is recommended, another study recommended 24 hours.

Some more research work is probably required in this field. It was suggested that some ratio between medical requirements and social preferences (e.g. 70% / 30%) is needed.

4.13.4 Social Life

ATCOs like any other human beings, normally wish to have a high degree of long-term predictability of the roster they are supposed to work in order to plan their time after working hours. For example, ATCOs (like other persons) also want time to enjoy holidays together with their children who happen to have school breaks during peak traffic periods.

Rosters, therefore, should be published at least one month in advance. By the nature of their job and due to the necessity of working odd hours, ATCOs suffer from disruption of social interactions. Overly complicated schedules can make it difficult to plan ahead and enjoy any form of social life.

In addition, changing teams will also break up the shift cycle. The team rostering system does allow one to predict what one will be working, for example, on New Year's Eve one full year in advance.

4.14 Social Dialogue

MPs will be well advised to discuss with their staff proposed major changes to rostering and working practices. The acceptability, for example, of a previously clarified and agreed way of using new software is not only better than an imposed one, but is normally a prerequisite for success. As the former US president, Lyndon Johnson is supposed to have said: "Don't ask me to be on the landing if I'm not in on the take-off". Cultural aspects as management of staff communication and measures to maintain and / or improve staff morale are crucial to an ATS organisation's performance.

In general, it is recommended to jointly determine long-lasting working practices with the shift workers themselves, since they could be found to be the real Subject Matter Experts (SMEs) on this issue.

Discussion and consultation with staff is necessary, but at the end of the day MPs are supposed to take decisions, even unpopular ones. Besides, trying to be nice to everyone usually ends up in pleasing nobody.

4.15 Organisational Culture

Sub-chapter 3.3.2.1 mentioned that the use of overtime should be limited to very special cases as an exception. There is a real risk in using overtime on an ongoing basis as a permanent, integral part of the rostering. The safety effects which are affiliated with such a practice are yet not fully understood. Apart from the unknown safety risks, a procedure of a long-term planning, which is based on regular use of overtime is an undesirable management practice, which might have implications on the health of staff.

Sub-chapter 3.3.2.1 explained how the use of overtime can be drastically affected by regulations forbidding this practice at certain shift constellations. This in turn may create a new challenge in organisations where overtime has

already become inherent in the organisational 'reward culture' (see EATCHIP, 1998b).

Having said that, it is recognised that in the day-to-day practice in many ATS organisations, the use of overtime is sometimes inevitable.

Efforts should be taken to reduce the occurrence of such instances to the absolute minimum. There is also evidence that in some cases, over the years, staff may have perceived the inevitable use of overtime as being an 'integral' part of their income. When a new software or a calculation method is introduced, these perceptions should be taken into account and handled with great sensitivity.

Planning results are subject to 'good will' and culture of organisation. The 'best balance' of the give-and-take culture (see Sub-chapter 4.2.3) should be sought. The use of scheduling software (see Chapter 5) and / or its introduction should be part of the give-and-take culture and not an imposed administrative decision.

Overtime payments or pay increases are only a few examples of the overall management-staff relationship. Arriving at efficient solutions in HRM requires first understanding the essence of the give-and-take culture. Staff members are human beings with social and private needs. One sided imposition of new measures affecting overtime practices should be avoided. Otherwise industrial relations which have seemed so far to be cruising smoothly, will suddenly witness how the water is growing choppier. Staff morale is crucial to an ATS organisation's performance.

Future arrangements between management and staff may include (after open talks between all parties involved) specific related issues, e.g.

- seasonal schedules to ensure better coverage of ORs during busy periods of the year;
- a new emphasis on profitability and the use of performance-related pay or stock options;
- the percentage of shares which can be given to staff;
- who can check out trainees, only fully qualified ATCOs, or independent board;
- the percentage of time spent on other associated duties;
- group bonus based on, for example, the avoidance of disturbances, or handling more traffic than a pre-defined and commonly agreed seasonal benchmark, etc.

4.15.1 Sickness

Issues related to sickness and 'social control' can be culturally dependent and sometimes open to different interpretations. This can be illustrated by an **exceptional** example in an ATS organisation outside the ECAC area. Six (of eight) ATCOs, who booked off their shift on 25 March 1998 at a major international airport, after calling in sick were ordered by the local Labour Relations Board to report back to work. The Board determined in an emergency meeting later that night the ATCOs were engaged in an 'unlawful strike'. The ruling was made since the staffing problem coincided with a twelve-hour radar power outage on the same day, which cut air traffic by 50% and delayed flights for hours. Since that airport is a major hub, the problem caused ripple delays at airports all across that continent.

A spokesman for the ATS provider said that although the company was aware of (labour) 'activity', the delays were caused solely by the power delivery problem connected with the radar system. A representative of the local ATC Association said the ATCOs were legitimately sick. He added that it is not unusual for this many people to call in sick since many people had been working long hours, double shifts and they were worn down.

The important lesson from this exceptional example is to realise how difficult it might become to distinguish between different interpretations of uncertified sick cases.

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5. AUTOMATED SCHEDULING SOFTWARE

If the MP scenario so far was not complex enough, it is further complicated by the fact that the opening and closing times of sectors will eventually vary from day to day. The flow of traffic is usually not steady or continuous. There are peak and low traffic periods within each sector, which can occur at widely differing times. Obviously, planning shifts of ATS staff is a highly complex task of accommodating all constraints, regulations, parameters and preferences.

In practice, the EUROCONTROL Task Force on Shift Rosters found that some ACCs which used individual rostering experienced thousands of ad hoc duty changes per year on staff request. It is easy to imagine the enormous effort required to manually calculate the effects of all those wishes and then manually re-optimise the roster.

Sophisticated automated scheduling tools can assist in optimising the coverage of all duties and absences within the statutory number of working hours. Scheduling software usually aims at proposing a correspondence between the staffing requirements and the number of ATS staff scheduled for operational and other associated duties.

5.1 Advantages of Automated Scheduling Tools

Some of the typical features of currently available shift scheduling tools are:

- calculate the optimal and / or minimum number of shifts needed every day;
- increase efficiency by rapidly producing cost optimised shift cycles (e.g. on a daily or hourly basis);
- increase flexibility in harmonising staffing levels (e.g. ATCOs staffing requirements) of different duration, seasonal variations and frequencies of low and peak periods of traffic volume;
- match fluctuations in the supply of staff, with different shift cycles (e.g. works 3 days, rests 2 days) and different ORs (e.g. opening and closing hours);
- investigate opportunities to take advantage of seasonal fluctuations in workload and traffic distribution;
- minimise balancing losses (see Sub-chapter 4.13.1);
- provide a sector customised tool to deal with local particularities;
- reduce break time as a result of reduced overlaps;
- increase break time to cope with peaks;

- provide reasonably balanced rosters which take account of all implemented criteria for balancing shifts with regard to skill mix, OJTIs needed etc. on a certain working position;

- provide a managerial tool to cope with over / understaffing situations and overtime payments;

- provide an administrative tool (e.g. to credit hours worked or to debit leave);

- provide a planning tool for MPs to calculate the costs of different scheduling scenarios (often many States collect data regarding landing fees, airport charges and their corresponding income, but rarely on en route real costs);

- provide an assistance planning tool to modify shifts in response to requests for temporarily changing shift cycle sequences, (e.g. staggered shifts, or scheduling on a quarter-hour basis);

- assure compliance with legal requirements (e.g. breaks incorporated in collective agreements on working conditions);

- provide the possibility to accommodate personal requests of staff (e.g. to be granted a specific shift or special leave);

- accommodate complex shift patterns and team rostering with personal requests (e.g. for annual leave);

- assist in changing and editing planned shifts (e.g. due to sick leave, personal requests of staff);

- provide the possibility to rapidly re-balance a published shift caused by operational changes and reassigning the scheduled staff;

- assist in producing statistical reports, e.g. on costs, service quality, meeting daily staffing requirements, reducing overtime payments, reports on staff availability, tracking circumstances which led to overtime, and of course, rostering plans to be published by various graphical means;

- assist in avoidance of controller's loss of rating due to insufficient number of operational hours;

- provide a sense of fairness to staff which is necessary whenever employees compete for a limited number of available preferred shifts (e.g. distributing morning shifts equally among controllers, equal treatment in overtime or night scheduling, responding to special shift preferences, solving conflicting leave requests between ATCOs, or simply enabling employees interaction with their preferred shifts);

- help to maximise recuperation periods of ATCOs between shift blocks;

- interface to wage systems possibly to calculate shift allowances, overtime payments etc.

In summary, such software can efficiently:

- reduce planning time;
- recognise general constraints and parameters;
- calculate the specific minimum legal rest;
- provide warnings on violation of constraints or legal requirements;
- highlight warnings on undercoverage of staffing requirements, or indicate the impact of granting annual leave.

5.2 The Limitations of Automated Scheduling Tools

Scheduling software is an assistance tool to an expert planner who already possesses the full knowledge and understanding of all circumstances, rules, regulations and policies to be applied. Such tools should not be the sole or the final means of planning. Ideally, this kind of software should allow shift data to be easily retrieved and modified. MPs should be able to input special constraints or re-balance shifts, based on their own good qualitative judgement, even if it is not the most beneficial shift cycle or the most efficient one. The final establishment of work scheduling should be left to the informed human being.

Sub-chapter 5.1 mentioned the advantages of scheduling software. However, MPs may have a wider scope of qualitative considerations in implementing (or not) what the software suggested. They should be able to override warnings, to lengthen or shorten shifts under extraordinary circumstances and after the staff concerned have been consulted, to move schedules backward or forward and to review specific shift preferences if they consider these necessary. A human judgement should always be favoured.

MPs normally know better than any software when:

- a permanent application of ‘minimum legal rest’ starts to affect stress;
- a specific shift pattern affects fatigue;
- some level of staff overlap helps to reduce stress;
- a certain shortage of staff starts to increase stress;
- breaking up a specific team affects motivation.

MPs also know better than any software:

- specific histories of sleep disorder among staff;
- nightbird or morning lark type individuals and their preferred schedules;
- the periods when specific members of their staff do not like to take leave, or wish to come late or go early for personal reasons.

Precisely for this reason MPs are part of the **human** resources management process and activity. For the time being, humans can still respond better to the needs of other humans than a machine.

Using the best software and the best planning practice still does not guarantee an absolutely cost-effective roster. ATCOs can be healthier than expected in any average sick leave calculations, traffic can be lower than originally planned, a sector can be closed earlier than foreseen. Therefore, it is almost unavoidable that during some hours in any particular day, more ATCOs will be present on duty than necessary.

6. SHORT-TERM TO MEDIUM-TERM PLANNING CONSIDERATIONS

6.1 Ad hoc (Short-term) Adjustments

It is likely that after preparing the roster, the traffic volume or other conditions have changed. EATCHIP (1998b) mentioned some of the commonly used MP short-term means to cope with a shortage e.g.:

- to postpone refresher training courses;
- to reassign ATCOs from other areas;
- to increase supervisor's time handling air traffic;
- to use any available staff, even with limited ratings and endorsements;
- to tighten annual leave schedules;
- to cancel participation in associated duties outside the OPSroom;
- to increase work scheduling (i.e. overtime);
- to temporarily raise ATCOs' pay for overtime.

6.1.1 A Typical Short-term Adjustment

A minor MP short-term adjustment will typically require (in the following order) to:

1. Set up new operational constraints based on traffic volume and complexity, by calculating Load Threshold Value (LTV) (see Sub-chapter 6.2.1).
2. Establish the new ORs and to choose the relevant input parameters for the rostering (e.g. acceptable starting time of shifts, or their cycles).
3. Establish the minimum number of duties per day as for example, suggested by the software in use.
4. Use the best common sense and experience to refine the minimum number of duties per day. This can be carried out, for example, by shortening unnecessarily long or overlapping duties, or shifting few hours of a particular duty to another without adding hours.
5. Calculate the effective number of staff needed to cover the duties in the roster taking into account all leave, days to be spent on projects, days off and other known absences. Some of the days off can be recuperated for operational work (e.g. an ATCO working in another team).

6. Establish the safety margins and contingencies regarding additional staff and prepare the adjusted roster.

6.2 Medium-term Staff Planning

Part of the day-to-day tasks of MPs are to monitor changes and predict trends. In their medium-term planning, some of the activities MPs are expected to carry out are:

1. Estimate the future number of positions and opening hours based on traffic increase forecasts.

2. Re-define (together with other experts) future ORs by lengthening the sector opening, or creating a new sector or by using more assistant ATCOs time, and only afterwards calculate the number of *ab initio* trainees which will still be needed to recruit and train.

3. Adapt the rosters constantly, whenever the ORs are adjusted.

In the medium-term, MPs can propose:

- a revalidation of ATCOs ratings when serving in administrative positions;
- a better allocation of future ATCOs within the ATS system;
- a dramatic increase of intakes into training;
- a review of the demographic balance sheet in the light of revised operational demands and new training success rates (EATCHIP, 1998b).

As EATCHIP (1998b) indicated, one of the most common adjustments to prove medium-term changes in traffic volume or complexity is re-sectorising.

It is important to mention that horizontal **and vertical** re-sectorising are not the only means of compensating for changing requirements nor the most cost-effective measures. It could be worthwhile to consider other alternatives, such as better integration of individual sequencing systems and procedures, which are typically concentrated nowadays around individual airports, or implementation of systems which speed up a/c movements on the ground by using object-oriented technologies.

6.2.1 When is Re-sectorising Needed?

If the traffic in at least one of the existing sectors exceeds what is "reasonably acceptable", then it is about time to create a new sector. Reasonably acceptable is defined by the LTV, (see Glossary), which - depending on sector size and complexity - will normally vary between 50-70 units.

It should be mentioned that there is evidence for the fact that re-sectorisation has in several instances already reached its limits and other measures need to be taken to overcome the situation.

6.2.2 Controller Workload

The issue of controller workload is directly related to MP day-to-day considerations and therefore will be addressed below.

In order to correctly estimate the workload, it is necessary to gather data on the geographical area size, its sub-areas and the throughput of traffic in each sub-sector.

Threshold values of workload should naturally be co-ordinated between the requirements of OPS staff and MP. However, in practice, MPs cannot take into account the workload factor, because the demand depends on the sector organisation. Ideally, the workload should not be solely dictated by the OPSroom, but rather be co-ordinated with regard to opening and closing hours. In reality, this is not always the case. For example, at the end of a night duty when traffic builds up, although the morning shift starts at a fixed time (e.g. 07h00), sectors are opened as necessary (as soon as the morning shift is there). The data from OPS indicate when a sector should be opened, when it should be closed and what the expected throughput is. Afterwards, it is up to MPs to identify which executive ATCOs will work in the sectors and at what times.

6.2.3 Workload Estimation

Workload can easily change like a rubber band, as a function of traffic flow. When traffic builds up in the early hours of the morning, for example, with the arrival of transatlantic flights, workload can increase from a level of, say, 60% on one ATCO up to 95% (see Sub-chapter 6.2.3.1). The transatlantic effect is predominantly on the UK, Ireland and some neighbouring States. There is also a build-up of routine intercity traffic at the same time.

It is tricky to establish the exact level of controller workload. Different approaches are in use in different States[6].

[6] For further reading see also Hendy, K. C., Hamilton, K. M. and Landry, L. S. (1993). Measuring subjective workload: when is one scale better than many? *Human Factors, 35(4),* 579-601.

6.2.3.1 Fast-time Modelling

One could use Fast-time Modelling techniques based on models of controller workload with varying degrees of sophistication, e.g. covering different tasks, or cognitive and visual search functions. Basically Fast Time Modelling is used to build up a function, on a sector by sector basis, relating number of a/c to workload. Then, some workload threshold is used to define the **Controller Capacity** (see Glossary).

For example, it could be the traffic level at which controllers are directly occupied 70% of their time. The 70% corresponds to 42 minutes measured working time in one hour, leaving 18 minutes for general recuperation or other tasks, while the number of a/c generating the workload for the sector during the peak hour stands for the sector capacity. The 70% value is in use in the EUROCONTROL Airspace Model (EAM) which is explained below.

Other States establish a function with a scatter distribution which provides maximum and minimum data, presented in high-low charts. Then workload is defined in terms of a maximum percentage of time, where the average workload is at a certain level (e.g. 80%), or a smaller percentage of time, where the peak can reach a higher figure (e.g. 95%).

6.2.3.2 EUROCONTROL Airspace Model (EAM)

Extensive work was carried out within DED.4 at EUROCONTROL to develop the ATC Capacity Analyzer (CAPAN) and its simulation engine, the EAM. This is a critical event model which (during a simulation) treats a number of defined events in the life-cycle of a simulated flight, e.g., entry into the first simulated sector, conflict search and resolution, etc. On completion of the simulation, an analysis package examines the resulting profiles of each a/c and determines the defined number of tasks that were required of the ATCOs to process the flight. As each task has a defined execution time and working position(s), it is possible to determine the amount of work required to handle a given traffic sample (EUROCONTROL, 1997).

Although the CAPAN has already been used for many control centres, the methodology and thresholds used are neither a standard nor the only way for workload estimation. According to its developers, the methodology and thresholds are probably best described as working hypotheses, based on empirical experiments, used in evaluating current operations. DED.4 conducts those studies upon specific request by the States concerned as a service. The deliverable is a sector capacity value which the State can use. How to derive that figure is considered as the developers domain, as long as the controllers from the centre accept the method and values employed.

Other ATS organisations associate a workload with each a/c as a function of characteristics of its flight, e.g. climbing / descending level, a/c type, speed, etc.

6.2.3.3 "*Quantile* Excision Procedure"

A similar method from the air traffic capacity planning field applies a "*quantile* excision procedure". A typical peak hour (i.e. the 5% *quantile* peak hour, which is actually a value above which 5% of the traffic movements occur) is arrived at empirically on the basis of extensive data analysis of a/c movement data. Then, the 'outliner' values are identified. The hours with the highest load values (i.e. peak loads above the 5% *quantile* of hourly load) are excluded since they are untypical. The load estimation is then based on the remaining 95% of normal operating hours. For the same area, different criteria (of traffic movements) may lead to select a different *quantile* (Weigelt, 1994).

6.2.3.4 Workload Estimation - Conclusions

Workload estimation is quite a complex task when one adds the qualitative facts that traffic mix can be a stressor or a relief, depending on the context, to the quantitative traffic volumes and traffic type. ATCOs differ in their personal problems, age and health background (e.g. cardiovascular differences), which could affect their stress and perceived workload levels. In addition, there is some early evidence that tower controllers display significantly higher heart rates and blood pressure increases than their colleagues in ACCs.

In most cases, the workload estimation is then revalidated by expert controller opinions, or a combination of consulting the union and expert controller assessment of the traffic conditions as, for example, being realistic.

The workload threshold in practice usually varies between one and eighty a/c. The problem arises when the workload is always at the 80 a/c level, or when it increases to 85. As mentioned above, the MPs do not take into account the maximum workload. They have to plan according to ORs, i.e. the number of sectors and the length of time each sector is open.

Some words of caution are necessary regarding threshold values and workload figures. One should never forget that the words "figure" and "fictitious" come from the same Latin root. For every number estimated or statistical basis that can be appropriately used, another can be wrongly used or abused. In other various working environments, employers, employees and unions frequently interpret statistics to suit their purposes. In other cases, statistics are distorted through sheer ignorance. This emphasises again the importance of a social dialogue (see Sub-chapter 4.14).

6.2.4 Manpower Movements Between Sectors

Another commonly used measure of MPs is to regulate the number of ATCOs by moving manpower between sectors. An ACC will usually have several sectors, each having its own specific environment and peculiarities, each requiring a specific ATCO rating. If there are permanently 'spare' ATCOs in one sector they could be re-trained to work in another sector. However, this can be considered only as a medium-term measure, since re-training in each sector could take between 2-6 months.

6.2.5 The Spread of Regional Airports

The MP problem related to the ever increasing use of regional airports can be best illustrated by comparing it with liquids which find their own level and reach the same height in combined containers. In 1647, Pascal proved that the pressure applied to an enclosed fluid is transmitted equally in all directions and to all parts of the enclosing vessel. This became known as Pascal's law.

For all intents and purposes, the airspace between a major hub and its small regional airports is pretty much like an enclosed vessel. From the MP point of view, the increasing popularity of regional airports can only increase the number of ATCOs needed to the same level as that found in a neighbouring (busier) hub or ACC.

6.2.6 Warning Signals

6.2.6.1 Leave Carry-overs

An accumulation of remaining annual leave days, or the necessity to carry over leave days (for service reasons) into following years could indicate to MPs an emerging manpower need. Leave carry-overs should therefore be closely monitored.

6.2.6.2 Refresher Training Delays

Depending on the importance of the planned subject for refresher training, it will normally be carried out every one or two years.

A delay in planned refresher training days may serve as a first indication to MPs on an emerging shortage. MPs should monitor such occurrences.

Refresher training planning may be impacted on by licensing provisions. This reality will almost certainly call for annual competency checking, which may require refresher training before each check.

6.2.6.3 Long Breaks

Supervisors have the authority to change breaks to accommodate changes in ORs. If the number of available ATCOs is greater than the minimum number of ATCOs required, the supervisor may consider granting a longer break than previously foreseen, and thus increasing time leakage. Experienced MPs may monitor events of this kind. It could be a first indication of an emerging surplus of ATCOs. Under-utilisation of staff is, in principle, not only costly but could also indicate an immediate MP mistake.

Table 1 summarises some examples (but certainly not all) of the warning signals for MPs mentioned in this document, their possible indication and some examples of suggested courses of action. Nevertheless, it might help to handle the symptoms and arrive at suitable actions in a structured way.

Table 1: When the MP situation is perhaps still manageable, but the alarm bells are ringing (a non-exhaustive list)

Symptom	**Diagnosis and Indications**	**Possible Action**
Reduced supply of trained staff	Changes in the selection tools in use, or training schemes.	A new test battery, better selection of instructors, reduced training time and its simplification.
An ever increasing use of ACs	The workload has required more and more periods where ATCOs needed some relief, which was provided by the ACs.	Re-sectorisation may be needed.
An unseasonable increase of the average number of days spent on sick leave, or an increased use of special leave	Dissatisfaction of staff; a newly appointed supervisor has not yet found the right balance or has neglected some other important managerial aspects.	A training course for the supervisor may be needed.
Leave carry - overs or accumulation of remaining annual leave days	An emerging shortage.	Using overtime, group bonus, or reassignment of ATCOs from other areas; increasing supervisor's time handling air traffic.
Longer breaks than previously foreseen	The available number of ATCOs is greater than the minimum number of ATCOs required. There is an under-utilisation of staff. A first indication of an emerging surplus of ATCOs or an immediate MP mistake.	Using flexible time schemes; conducting refresher training earlier than foreseen.

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7. LONG-TERM MANPOWER PLANNING CONSIDERATIONS

Due to the dynamic nature of the air traffic environment, MP is straining to keep up with dizzying, rapid changes. This Chapter deals with long-term planning tools available to MPs which help cope with these changes.

7.1 Long-term Activities

A clear presentation of a strategic manpower plan is necessary to clarify the personnel needs within a certain time frame, normally a five year period (see also EATCHIP, 1998c).

On a day-to-day basis MPs have to deal with three layers: those who come into the system ('in-flow'), those who go through it ('through-flow') and those who leave it ('out-flow'). The first and the last layers are (or at least should be) to some extent more predictable (see also Sub-chapter 7.2). The second layer is more exposed to sudden changes. ATCOs can have a change in their career, lose their licence due to medical reasons, or due to a lack of minimum operational hours, be tempted to take an early retirement due to changes in working conditions, resign, or die.

From the present number of personnel, the loss of staff can be expressed in terms of retirements, invalidity, change of career, loss of licence, death, etc.

7.1.1 *Ab Initio* Intakes

Taking all the above into account and the possible changes in air space structure and re-sectorisation to cope with increases in traffic, the number of new controllers who will be needed can be derived. The forecast of the number of ATCOs needed will usually also include other duties, for which a controller background is deemed necessary, as pointed out earlier.

Obviously, MPs need to carefully take into account figures of expected retirements, traffic growth forecasts and staff changes, in order to know how many *ab initio* trainee controllers will be needed to counterbalance these losses. (See also Sub-chapters 5.4.1 and 5.5.1 in EATCHIP, 1998d).

MPs may ask another perfectly legitimate question of whether cost-benefit considerations lead to the conclusion that contracting out the whole service of recruitment, selection (and even training) will not be cheaper and faster than conducting the whole service in-house.

Assuming that a decision was taken to conduct recruitment, selection and training in-house and knowing the average success rates for both institutional training and OJT, MPs can - through deduction - arrive at a reasonable assumption regarding the number of trainees who should be trained. From these figures (and knowing the success rate at different stages of selection and training), they can deduce how many should be interviewed, how many

should be invited to take the cognitive tests, and how many should enter training.

MPs need to constantly follow up on any changes in the selection tools (in use) and keep track of possible effects on the supply of trained staff.

Ideally, the MP purpose will perhaps be better served if MPs were also involved in pre-training forecasts, e.g. how many candidates should be interviewed in order to achieve the figure of *ab initios* which later will provide an adequate supply of people into OJT. In practice, however, in many States, MPs have a say only down to the training level (and no input in the selection stage).

7.1.2 Training Capacity

Attention should be paid to training capacity, i.e. the number of places at the training institute and, even more important, to the capacity in OJT. OJT is widely known as being the bottleneck in training. In general, in calculating training capacity one takes into account the

- maximum OJT capacity per annum;
- national ATC academy capacity;
- success rate at the different stages of training;
- the rate in which trainees may filter from the training academy.

Annex B "How to Calculate Training Capacity" provides an example of how to calculate OJT capacity.

7.1.3 Leave Policy

Although it is nowadays clearly not the case, it would be interesting to consider a policy where supervisors can determine, for example, up to 20% of the annual leave days of their staff. Such flexibility in the MP system will not necessarily meet with strong enthusiasm from the staff and / or social partners, but might one day be part of a future collective bargain on working conditions.

7.1.4 Group Bonus

Another element of future agreement on working conditions, which can assist MP flexibility is to offer ATCOs a temporal group bonus instead of increasing overtime payments. This bonus could be based on increased capacity after consultation with staff and ensuring traffic safety levels.

In one State in the ECAC area 25% of ATCOs' income originates from "group bonus for no disturbances to air traffic" (see also Sub-chapter 4.15).

A bonus could be perfectly justified, based on the assumption that a considerable amount of money can be saved, which would otherwise have been paid on overtime in order to compensate for staff shortages.

It would probably be better to consider a flexible bonus based on sectors (or teams). On the sector level, the traffic flow and the efforts spent in handling the traffic are probably more easily measurable than other alternatives.

Flexible bonuses can successfully cope with situations where individual ATCOs are not evaluated on the basis of their performance, or when "service quality" is not rewarded, and / or when an "averaging down" of talent occurs.

7.1.5 Administrative Incentives

An additional MP measure can be a non-financial, administrative incentive to take some of the annual leave during periods of low traffic (e.g. winter). Seasonal peaks for MPs can be created not only by traffic demands, but also during the school holidays, when many staff members wish (at the same time) to have some days off, e.g. at the February half-term holiday, or at the Easter holiday.

Examples for administrative incentives can be to permit more carry-over of leave from one year to another, only if it is taken, for example, during pre-specified low traffic seasons, without according additional days leave; or setting priorities according to the schooling calendar. In some States (e.g. Sweden) where staff are entitled to take four weeks leave in summer, traffic is restricted.

Although seasonal fluctuations could lead to a shorter average working week in winter than in summer and subsequently to a lower number of staff required, it is not necessarily always the case. A smoothly, well planned on-time manpower plan may foresee some documentation work and training on new equipment during the low season.

7.1.6 ATC Diploma

MPs who struggle to fill their open vacancies may consider the idea of awarding fully qualified ATCOs with some kind of aviation related, semi-academic diploma, or a certificate of technical qualification acknowledging the efforts spent during long ATC training. This measure may attract suitable young applicants, who would otherwise have pursued another career more academically recognised.

Licence is a recognition of specific qualifications. But some young potential candidates may nowadays also prefer the additional semi-academic recognition. It could be worthwhile to award academic certificates after theoretical training to acknowledge the achievements in training. This could help students who fail in subsequent training stages.

In some States there are already equivalent ATC diplomas of *École Polytéchnique* or universities.

7.1.7 Affirmative Action Policy

MPs face a special challenge in States where affirmative action policies require the fulfilment of certain quota for female controllers. For example, in Sweden 50% of ATCOs should be females, in Greece 40%. The difficulty arises in team rostering when a female ATCO, for example, is entitled to two hours per working day special break for a long period of time after the delivery of a child.

In order to plan more precisely, MPs may be interested to know whether female ATCOs will (on average) have more sick leave days than their male colleagues. MPs may also wish to know whether female ATCOs tend on average to use more maternity leave rights than their male colleagues use paternity leave rights.

An increased need for detailed planning in this respect can be expected. In November 1997, the European Court of Justice gave encouragement to supporters of affirmative action across the European Union by upholding a German law that favours women in public-sector promotions. It can be assumed that this tendency will increase.

Future similar affirmative action policies regarding disabled persons (see Glossary) may also affect MP in ATS organisations.

7.1.8 Future Possible Changes in Service

As private (and perhaps to a lesser extent State-owned) ATS organisations will aim at increasing their competitiveness, a combination of novelty, choice, service and value will be required. The idea of making differential ATS is possibly a novelty as a commercial proposition, but not new for ATS users as a practice (e.g. flights which are defined as “State flight” - or misused as such - are not subject to CFMU regulations).

The future may witness more and more cases of an unaccommodated demand. Ensuring that all the growth in air traffic can be accommodated safely is likely to have one obvious consequence - delays. One day, as a result of these delays, some airlines may be willing to substantially raise their charges in return for some sort of priority, e.g. in the approach or perhaps one day even en route, provided the charge calculation is based on sound economical principles.

Differential ATS does not mean that low paying airlines will have to be shunted out of the way to allow the high payers through. Furthermore, it does not mean that low payers will enjoy a less safe environment than today. Safety of a/c must never be compromised. What it actually means is that ATS will unavoidably become like any other commodity or service. A slot (see Glossary) is already a tradable commodity. As much as toll highways and differential health services faced strong social and professional objection initially, preparing the background (and the infrastructure) for serving, for example, different airlines at different runways will undoubtedly meet with some resistance in the beginning.

In any event, perhaps one day, airlines, who are prepared to pay premium charges may be provided with a special fast track, while the others will have to queue, as it is now. In this event, MPs will also have to prepare their human resources in advance for such a differential service.

7.1.9 Business Impacts

MP decisions have a substantial impact on the business results of their ATS organisations. Their decisions can result in a reduction of revenues from en route charges, or in different levels of route charges or in more traffic being spread out to quiet airports.

The significance of changes imposed by MPs is hard to exaggerate. For example, a MP decision not to increase the number of staff, but to maintain the current level, although a regional airport has just been expanded, will have direct effects on the business results of that organisation. Awareness of these considerations and business oriented thinking is nowadays required from MPs as from other members of the organisation.

In any event, preparing any reduction in staff, introducing any change in working conditions (e.g. breaks) or practices (e.g. rostering software), MPs will be well advised first to consult with the social partners (or professional staff associations) representing the staff.

Personnel costs represent a very high part of the overall ATS organisation costs. Direct costs of personnel are estimated to be sometimes around 70%, in some States even 90% of the overall costs. In most cases it is between 50-60% with an average figure of about 56% of the overall costs. The effects, for example, of new schemes of early retirements (and other effects) on the total personnel costs should be investigated beforehand[7].

7.1.10 Better Control of ATCO Loss

If MPs were now to build their staff reserves from scratch they would probably hold less ATCOs in life time employment and more in short-term flexible contracts. However, it is recognised that some corporate cultures require that reform should be implemented under the condition of no staff being made redundant.

Beside enhancing the reward system (e.g. increasing salaries of staff), ‘poaching’, (a potential drain of qualified staff to other national or supranational ATS organisations) or early retirement of staff or loss of licence of senior controllers can be prevented by some enhanced HRM measures such as:

- ensuring the existence of appropriate career development opportunities;

[7] See also OECD (1998). *Maintaining Prosperity in an Ageing Society*, an OECD Study Report, April 1998, and Blöndal, S. and Scarpetta, S. (1998). Retire Early, Stay at Work?, *OECD Observe,* June/July 1998.

- avoiding burn-out of ATCOs;
- providing an appropriate task allocation;
- offering development programmes for identified staff for migration to other jobs or tasks;
- providing job enlargement and / or enrichment;
- ensuring high team involvement and / or good team spirit;
- keeping good company / organisational culture;
- keeping working conditions competitive;
- sharing some portion of the gains or revenues with staff.

These issues will be tackled in depth in other deliverables within the EATCHIP Human Resources Work Programme.

7.2 Long-term Prediction of Staff Shortage

A model for control and MP decision making in ATS organisations can include a multi-variable approach of forecasting staff shortage and, at a later stage, running a comparison between regions or States.

It is trickier to spot the need for changes in staffing levels when the traffic volume is rising rapidly. For MPs the reasons for staff shortage and / or surplus may be classified into two categories: those problems (or reasons) they can do something about (e.g. limited endorsement policy), and those they have to live with (e.g. statutory number of working hours).

The following (non-exhaustive) list shows possible examples of factors which can explain differences in prediction accuracy of controller supply. Parameters (or factors) involved in forecasting the shortages of controllers may be shown to fall into four groups:

1. initial conditions,
2. policy variables,
3. demography and
4. resources.

These factors are discussed in Sub-chapters 7.2.1-7.2.4.

Each one of the factors mentioned below in Sub-chapters 7.2.1-7.2.4 should be weighted by SMEs (e.g. experts in human behaviour, traffic patterns, flow and sector regulations) regarding the extent to which they have an impact on

staff availability and human performance at a later stage. Each factor can explain differences in predicted shortages, based on actual differences in a given State. Each one of these factors can then be weighted while using optimisation algorithms.

For example, for each factor, MPs can indicate on a scale of '0' to '100' to what extent this factor was important in their forecast of manpower supply. A '0' score implies no relevance. A '100' score implies that this factor alone would forecast the whole shortage of controllers.

A table can then be constructed to show the contribution each selected factor made to the difference between shortages of controllers in different States (e.g. in percentages).

Initial conditions matter in the sense that, other things being equal, the shortage of a given ATS organisation tends to increase by X %. For example, being dependent on a 'stop-start' recruitment approach (as an unchangeable initial condition and / or policy) may be found to subtract roughly 0.6 percentage points from a State's accuracy of forecasting ATCOs shortages.

7.2.1 Initial Conditions

Factors (or parameters) to be considered in this group might include:

- peak traffic figure in the past 12 months for the sectors and positions;
- present and future traffic volumes, including revised operational demands;
- complexity of regional traffic characteristics;
- statutory number of working hours;
- number of annual leave days and any additional days granted for age or travelling and any special leave days;
- number of public holidays;
- expected number of days for military service, court appearance, or elections;
- expected number of days for professional activities in unions, staff committees, IFATCA etc.;
- expected number of days for participation in simulations, tests, working groups and *ab initio* training (other than OJT in the OPSroom);
- government restraint measures (e.g. hiring freezes, downsizing or reducing overtime);

- staff unionisation level which can affect the frequency and duration of any strikes;
- selection ratios and validity of selection tools;
- training capacity and success rate in training;
- flexibility of the training institute to re-use a lost seat;
- number of seats at the training academy and seat time on radar displays available to OJT as a potential (delay-causing) bottleneck;
- enhanced success rate for OJT due to pre-recruitment preparation courses[8];
- constraints due to the necessity to allow ATCOs to work at least the minimum number of hours in order to keep their rating.

7.2.2 Policy Variables

- checkout policy;
- 'stop-start' approach in recruitment and recruitment seasons (e.g. when all potential candidates are already at the university);
- the business strategy of the ATS organisation due to the fact that it is fully / partially privatised, or corporatized as a non-profit organisation[9];
- contingency planning policy;
- threshold of acceptance on traffic delays;
- retirement policy (e.g. fixed or flexible retirement);
- contingency losses policy;
- structured workload policy;
- limited ratings and endorsements policy;
- offshore recruitment and 'poaching' policies;
- maternity and paternity leave policies;

[8] Candidates in the modern job market are taking more and more courses to prepare themselves not only for selection tests, but also for the training and the job itself. These initiatives may reduce the OJT time needed.

[9] Privatisation is playing a crucial role, too, because many of the ATS organisations are, or were until recently, state-owned. Preparing for privatisation has meant shaking up the companies (including for example, hiring younger, less experienced, or non-ATCO managers) to make the private companies more attractive to investors.

- equal employment policy or legislation;
- policy (or practice) regarding supervisors handling traffic;
- policy regarding volume of deputy-supervisor, officer-in-confidence and training officer tasks handling traffic;
- team / individual rostering policy;
- policy of transfers to other sectors, transfers to tasks other than control;
- policy of relocating less successful trainees;
- relocation compensation policy;
- reward and bonus systems;
- promotion policy;
- productivity / gainsharing policy;
- policy regarding number of days devoted to staff development;
- policy on frequency of refresher and other training courses;
- staff development and career development policies.

7.2.3 Demographical Parameters

- staff age pyramid (e.g. of current controllers);
- retirement age;
- age of recruits and minimum educational requirements, mandatory military or civil service affecting this age;
- life expectancy in a given State, which can affect the period of time the organisation will enjoy the services of staff, which it has invested in.

7.2.4 Resources: Infrastructure and Equipment Capacity

- airport, ACC and declared sector capacities (including safety buffers);
- technological innovations (i.e. current level of equipment and impact of any future data processing system improvements on capacity);
- procurement regulations which may limit the business flexibility;
- GPSs which may affect the number of ATCOs needed (see Sub-chapter 4.11).

8. SUMMARY

8.1 Main Principles of Manpower Staffing Management

The following summarises some main MP principles outlined in the document.

There is no such thing as 'the' best way of staffing. In staffing, the process of considering qualitative factors is just as important as the quantitative result.

Planning is an ongoing dynamic process. Flexible planning, which is continuously smoothed and adjusted to the supply and demand of staff is a key to MP success.

The task of MPs in ATS organisations is basically to find the balance between OR and staffing levels. However, anyone who ever experienced the daily task of MPs coping with "swap effects", sudden staff shortages due to sickness, or staff requirements in related duties and projects, while at the same time being concerned with dozens of qualitative factors may find this simplistic definition unimpressive.

MPs, like ATCOs, are concerned with identifying and avoiding potential conflicts between different wishes and needs at all organisational levels. Thus, MP is a process where planning activities need to be co-ordinated at (and between) managerial, supervisory and staff levels.

After publishing a long planned roster MPs are not usually in favour of sudden changes to the shift rosters for understandable reasons. However, they recognise that their staff would from time to time have some personal needs which will require shift changes. Since one single change can induce a high number of other changes, MPs will normally seek the change which will cause minimum further effects.

MPs have an interest in ensuring the stability of the training system, in order to enable a smooth predictable production rate of new controllers.

MPs possess some informal 'tacit knowledge' (e.g. about the capability of individual controllers to handle different volume of traffic). They will use this information only under certain circumstances in order not to over utilise and burn out the highly talented ATCOs. Skilled MPs also recognise their own limits.

Data from the OPS indicates when a sector should be opened and closed and what the expected throughput is. Afterwards, it is up to MPs to identify which executive ATCOs and planner controllers will work and at what time. Therefore, MPs always create contingency plans. They normally base their manning on average traffic and not peak levels.

MPs regularly monitor phenomena such as:

- an increased use of ACs as an indication for a coming re-sectorization;
- an increase of available staff or longer breaks as indicators of an emerging surplus and for purposes of using the staff in other functions;
- development of technological innovations which could have an impact on staffing levels;
- absenteeism and an unseasonal increase in sick leave which could be related to a newly appointed supervisor, for example. This is also useful for monitoring who is about to lose a licence due to medical reasons;
- an accumulation of remaining annual leave days and a postponement of refresher and / or other important training courses;
- a lack of control staff for further development either in other careers or in projects where their input is urgently needed.

Team and individual rostering each have advantages and disadvantages. The decision on which roster to prefer can depend on qualitative considerations and indirectly related operational issues.

Efforts can be made to provide non-ATCOs to carry out associated duties, which do not require a fully qualified licensed controller.

MPs aim to make the most efficient use of staff time. Ideally, they would aim at according ATCOs with “the minimum legal rest”, nothing more. In reality, this is not always achievable. There is a dangerous limit to the extent of which ATCO breaks can be reduced but there will always be situations where longer than necessary breaks will be given and / or balancing losses will occur. An ‘efficient’ software tool will propose a schedule where the minimum possible breaks are granted and balancing losses are reduced to a certain minimum.

Efficient MPs would be attentive enough not to immediately accept any proposed ‘ideal’ automated schedule without bringing more qualitative considerations as discussed into the equation in order to derive a balanced situation. They will co-ordinate their plans across all organisational levels involved and will consult and involve staff and / or representatives in the case of changes in shift cycles, time management or work allocation principles and seek a common understanding and support.

In summary, staffing is not only about time management, formulae and numeric calculations, but rather more about human judgements concerning the quality of service MPs provide the ATS organisation with.

MP as an organisational unit is part of the overall HRM. MP is not an isolated function occupied with rostering and shift cycles. It is rather an important part of a bigger, coherent and integrated HRM system, which includes recruitment, selection, training, human resources development and retirement planning functions.

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ANNEX A: HOW TO CALCULATE THE REQUIRED MANPOWER

The Minimum Number of ATCOs Required

Sub-chapter 3.4.1 mentioned that the controller working conditions and the OR will determine the number of controllers needed to operate the sectors. The total position time per year divided by the **effective** hours per ATCO per year gives the minimum number of ATCOs actually needed (see Formula 1).

Formula 1: The minimum number of ATCOs required

$$\frac{\text{Total Position Time / year}}{\text{Effective hours per ATCO / year}} = \text{Minimum number of ATCOs required}$$

This formula indicates a simple way of calculating the number of ATCOs needed. It can lead to the **minimum** number of ATCOs needed without taking into account e.g. safety margins. The challenge to MPs resulting from this approach is to cope with staff shortages in OPS, training and projects.

The Maximum Number of ATCOs Required

Formula 2 shown below, is more 'advanced' since it takes into account the roster cycle and other roster-related factors, leading to the **maximum** number of ATCOs needed (Missault and Niesing, 1995). The challenge to MPs resulting from this approach is how to plan and allocate operational staff to other related duties outside OPS in times of staff surplus in OPS. The task of MPs is to find the right balance between the two results.

Formula 2: The maximum number of ATCOs required

$$\frac{\text{N° of duties per day X 365}}{\text{Effective working days per ATCO / year}} = \text{Maximum number of ATCOs required}$$

Examples of Manning Requirements Calculation

As already mentioned before, the basis for the MP (on a sector level) is the occupation time of the positions in any given sector based on the opening and closing time of the positions. These times are derived from the amount of traffic to be processed in that sector, which are called the ORs.

The example in Table 2 is based on three sub-sectors, East, South and West Sector, each with Executive and Planning Controller positions, except for the West Sector, which has an AC position in addition for certain times of the day.

The abbreviation of the position column is to be read as East Planning Controller (EPC), East Executive Controller (EEC) and so on.

Table 2: Example of sectors manning according to operational requirements

Position	**Opening and closing time of sectors**	**Hours**	**Position occupation during the day**	**Staff**	**Hours**
EPC	06h45 - 22h00	15h15	00h00 - 06h45	2	13h30
EEC	06h45 - 22h00	15h15	06h45 - 07h30	4	03h00
WPC	00h00 - 24h00	24h00	07h30 - 12h00	7	31h30
WEC	00h00 - 24h00	24h00	12h00 - 14h00	6	12h00
WAC	07h30 - 12h00	04h30	14h00 - 15h00	4	04h00
	15h00 - 21h00	06h00	15h00 - 21h00	7	42h00
SPC	07h30 - 14h00	06h30	21h00 - 22h00	4	04h00
	15h00 - 21h00	06h00	22h00 - 23h59	2	04h00
SEC	07h30 - 14h00	06h30			
	15h00 - 21h00	06h00			
		114h00			**114h00**

Calculation Following Formula 1

The Manning Factor calculation following Formula 1 could look like the following example in Table 3:

Table 3: Example of the Manning Factor calculation

	Days in year		365
A	Hours in year 365x24		**8760**
	Standard working day (in hours)		07h30
	Breaks per day (in hours)		01h30
B	Effective hours/day		**06h00**
	Days in year		365
	Days off	104	
	Average annual leave	29	
	Average sickness	8	
	Public holidays	10	
	Training, etc.	10	
			161
C	Effective days per year		**204**
D	Effective hours per year (**BxC**)		**1224**
	Manning Factor (**A÷D**)		**7.16** (for 24 hours)

According to Formula 1, the minimum number of staff needed in this example will be 8760/1224 = 7.16 (for 24 hours operations).

For any other number of hours the sector is in operation, e.g. 15.25 hours, the number of controllers would be:

7.16 x 15.25/24 = **4.55**

Consequently, applying these manning factors on the OR example (3rd column in Table 2), the total number of controllers needed to run the sector on a yearly basis would be **34**.

Looking at the OR, it is easy to derive that at least **21** duties (from the 5th column in Table 2, for the night 2 + 1 for breaks, for the morning 7 + 2 for breaks and for the afternoon 7 + 2 for breaks) are necessary to occupy the positions during the times foreseen.

Calculation Following Formula 2

Formula 2 takes into account the duty roster cycle, in which the controllers are working. In the following example it is assumed that a 4/2 cycle is applied, i.e. four days on, two days off. The number of working days per year controllers are available for work can be calculated as follows:

Days in a year		365
Days off in cycle	122	
Average annual leave	29	
Average sickness	8	
Public holidays	10	
Training, etc.	10	
Total non-working days	179	179
Total effective working days		**186**

The total number of controllers needed to run the sector (24 hours operations) on a yearly basis would according to Formula 2 be:

21 duties x 365/186 = 41.21, say **42** controllers.

All parameters used in the calculations will of course differ from one ATS organisation to another, depending on the legal context of the State in which they are applied and the related working conditions and regulations. Furthermore, other parameters, typical to a specific ATS organisation and perhaps even typical for different parts of one organisation, may have to be added. Thus, the manning calculation will produce different results throughout the ECAC area.

Assumptions and Constraints

Both calculation methods assume that all elements of the calculation are evenly spread over the year, like the leave and sickness days. It is also assumed that the regulatory number of weekly working hours will be accommodated in the rosters, independent from the roster cycle in use.

These assumptions prove to be wrong in practice. The following are likely to be amongst the reasons for that:

- There will be time leakage because duties cannot be fitted into a roster in a way that adheres to working conditions / regulations and, at the same time, the regular number of working hours requirement is met.

- The effective time for breaks is assumed to be 100% accommodated (e.g. exactly 22% of the working time), although breaks are rarely spread evenly and more are needed in a night shift than during the day.

- Leave, sickness and other staff absence are not evenly spread across a whole year as one can see from staff absences calculated on a weekly / monthly basis.

Consequently, the time leakage has to be dealt with by having additional staff. The Multiplication Factor calculation (Formula 1) establishes the absolute minimum number of staff, required in order to operate a smooth running roster for any given OR. The Manning Calculation method (Formula 2) establishes a maximum number of staff. The challenge will be for MP (and the whole HRM system of an ATS organisation) to allocate and use the staff resources efficiently in times of surplus in OPS. The true number of staff needed will be in between the minimum and the maximum. However, from experience, it tends to lean in the direction of the maximum figure.

Therefore balancing losses (i.e. higher number of hours than the theoretical calculation) are inevitable to some extent due to

- working conditions (e.g. to schedule staff according to an average weekly working time even if on a particular day this number of hours is not operationally required);

- breaks;

- briefing balancing losses (e.g. in team rosters).

It will be a challenge to get a grip on the time leaking phenomena, possibly by using more sophisticated time management and work allocation systems, in order to increase staff effectiveness on the one hand, whilst on the other hand reducing the staff overhead needed to cover for the time leakage.

MP for other Staff Duties Categories

The controller figures, calculated to cover the ORs may form the MP basis for a whole unit, consisting of operational, engineering systems and administrative support staff.

Two important items have to be mentioned in this respect:

1. The way in which controller activities outside the OPSroom such as participation in *ab initio* training (other than OJT), projects, and / or simulation exercises, etc. are calculated (see Sub-chapter 4.4).

One could argue that a provision for this purpose can be made in the calculation method itself, by extending the average number of days which were foreseen for training etc., with the number of days perceived to be necessary for this purpose, based on past experience. The drawback of this argument is that controllers are normally rostered for ATC duties, but when needed outside the OPSroom, they cannot be released due to personnel constraints, thus possibly increasing time leakage.

The best way to prevent this time leakage is to add controller posts, in addition to the controller posts purely needed for ATC for this specific purpose. As those ATCOs have to be kept operational, they can function as a kind of buffer, to relieve controller constraints in the OPSroom, providing this does not interfere with their other work.

2. The way in which other functions in an operational environment are filled with staff having a controller background. It should be borne in mind that this alternative offers possibilities to controllers for career advancement. Consequently, this possibility should be reflected in the MP.

Based on this an OPS Input / Output plan can be made up, reflecting the numbers of control staff **and** the number of other staff for which a controller background is deemed a necessity, as shown in Table 4. In Table 4 'ETS' stands for Early Termination of Service, 'CS' for Control Staff and 'OS' stands for Other Staff. In some ATS organisations, controllers may even choose early retirement within a specific time frame, so this factor could be taken into account as well. Setting availability against requirements, indicates the field of actions MP has to exploit.

Entering the above data into a Unit's overall staffing plan consolidates the staffing figures required (and available for a whole Unit) and using this data from individual Units, the staffing figures can then be further consolidated into the overall Business Plan of the ATS organisation.

If such a procedure would have been adopted, (in a standardised way), perhaps even more refined in the division of controllers into Aerodrome Control Tower (TWR), Approach Control (APP) and ACC with the attributes Procedural or Radar, this would enable the deliverance of more precise information on controller manpower quantitative requirements throughout the ECAC area.

Table 5 presents an example of staff levels in a five year plan in budgetary posts. All the figures mentioned in Tables 4 and 5 are hypothetical and no reference or interpretation can be made to any specific State.

Table 4: OPS input / output plan

		1	9	9	7		1	9	9	8		1	9	9	9		2	0	0	0		2	0	0	1		2	0	0	2		2	0	0	3
AVAILABLE:		I	II	III	IV		I	II	III	IV		I	II	III	IV		I	II	III	IV		I	II	III	IV		I	II	III	IV		I	II	III	IV
Control staff (55)		158	159	163	163		163	166	166	164		169	161	161	159		162	160	166	165		170	166	172	168		161	168	168	166		171	166	174	172
Control staff (56)		158	159	163	163		163	166	166	164		169	161	161	161		163	162	168	167		174	173	180	177		173	177	175	173		176	175	183	181
Other staff/Contr. bckgrnd		31	31	31	31		31	31	31	31		30	30	30	30		30	30	30	30		30	30	30	30		30	30	30	30		30	30	30	30
Total present (55)		189	190	194	194		194	197	197	195		199	191	191	189		192	190	196	195		200	196	202	198		191	198	198	196		201	196	204	202
Total present (56)		189	190	194	194		194	197	197	195		199	191	191	191		193	192	198	197		204	203	210	207		203	207	205	203		206	205	213	211
Output AI *)		4	6	3	1		5	0	0	5		0	0	0	6		0	7	0	7		0	8	0	0		8	0	0	8		0	8	0	0
ETS 55 (norm)		-2	-2	-3	-1		-2	-2	-1	0		-8	-4	-2	-3		-2	-1	-1	-2		-4	-2	-4	-7		-1	0	-2	-3		-5	0	-2	-3
ETS 56 (±)		-2	-2	-3	-1		-2	-2	-1	0		-8	-3	0	-4		-1	-1	-1	0		-1	-1	-3	-4		-4	-2	-2	-5		-1	0	-2	-3
Retirement other staff		0	0	0	0		0	0	0	-1		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0
Intake / Resign / Death CS		-1	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0
Invalidity/transfer CS		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0
Intake / Resign / Death OS		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0
Invalidity/transfer OS		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0		0	0	0	0
Total Control staff ETS = 55		159	163	163	163		166	164	165	169		161	157	159	162		160	166	165	170		166	172	168	161		168	168	166	171		166	174	172	169
Total control staff ETS ± 56		159	163	163	163		166	164	165	169		161	158	161	163		162	168	167	174		173	180	177	173		177	175	173	176		175	183	181	178
Total other staff		31	31	31	31		31	31	31	30		30	30	30	30		30	30	30	30		30	30	30	30		30	30	30	30		30	30	30	30
REQUIRED:	MUT					MUT					MUT					MUT					MUT					MUT					MUT				
Centre Superv.		8					8					8					8					8					8					8			
Sectors A		62				8	70					70					70					70					70					70			
Sectors B		55					55					55					55					55					55					55			
Sectors C		42					42					42				8	50					50					50					50			
Mgt.Support		4					4					4					4					4					4					4			
Curr. Ops		6					6					6					6					6					6					6			
Syst.Pl.& Impl		4					4					4					4					4					4					4			
Training		15					15					15					15					15					15					15			
Projects		2					2					2					2					2					2					2			
Total req.:		198					206					206					214					214					214					214			
Temp.demand																																			
Bal.ETS = 55		-8	-4	-4	-4		-9	-11	-10	-6		-14	-18	-16	-13		-23	-17	-18	-13		-17	-11	-15	-22		-15	-15	-17	-12		-17	-9	-11	-14
Bal. ETS +/- 65		-8	-4	-4	-4		-9	-11	-10	-6		-14	-17	-14	-12		-21	-15	-16	-9		-10	-3	-6	-10		-6	-8	-10	-7		-8	0	-2	-5
Bal. Other Staff		0	0	0	0		0	0	0	-1		-1	-1	-1	-1		-1	-1	-1	-1		-1	-1	-1	-1		-1	-1	-1	-1		-1	-1	-1	-1

* Taken into account after full qualification

Table 5: 5 year plan staff levels in budgetary posts

	Available 1997	Required 1997	+ / -	Required 1998	+ / -	Required 1999	+ / -	Required 2000	+ / -	Required 2001	+ / -	Required 2002	+ / -	Required 2003
HoD Office	3	3		3		3		3		3		3		3
Ab-Initio	72	72		72		72		72		72		72		72
Reserve	12	12		12		12		12		12		12		12
Curr. Ops	8	8		8		8		8		8		8		8
Centre SV	8	8		8		8		8		8		8		8
Sectors A	60	62	8	70		70		70		70		70		70
Sectors B	50	55		55		55		55		55		55		55
Sectors C	40	42		42		42	8	50		50		50		50
Flow Cell	5	5		5		5		5		5		5		5
FDA	50	50	-2	48	-2	46	-2	44	-2	42	-2	40	-2	38
Syst. Impl.	7	7		7		7		7		7		7		7
Training	20	20		20		20		20		20		20		20
Mgt. Supp.	5	5		5		5		5		5		5		5
Projects		2		2		2		2		2		2		2
Sub Total OPS	**340**	**349**		**355**		**353**		**359**		**357**		**355**		**353**
Directorate	5	5		5		5		5		5		5		5
Engineering	120	120		120		120		120		120		120		120
Supp. Service	40	40		40		40		40		40		40		40
Total	**505**	**514**		**520**		**518**		**524**		**522**		**520**		**518**
OPS balance		-9		-6		2		-6		2		2		2
DIR balance		0		0		0		0		0		0		0
ENG balance		0		0		0		0		0		0		0
Supp. S balance		0		0		0		0		0		0		0

ANNEX B: HOW TO CALCULATE TRAINING CAPACITY

Sub-chapter 7.1.2 explained the principles of training capacity calculation. Below a typical example is provided.

If, for example, the maximum OJT capacity is, say, 32 per annum and the national ATC academy capacity is 4 intakes per year with 12 *ab initio* trainee controllers each, this means 144 *ab initios* over a period of 3 years. However, one should bear in mind the relevant success rate at the different stages of training (e.g. during general introduction, the theoretical training, simulation or radar training). If the overall success rate in training before OJT is, say, 67%, from those 144 trainees only 96 will enter OJT over a period of three years.

There is no problem as long as the trainees graduate from the training academy at a maximum rate of 16 per six months, or 32 per annum. In order to fill the capacity in OJT this would mean starting e.g. with 3 intakes of 12 trainees each. According to a sudden increasing failure rate at early stages in the academy, one could regulate and adjust the required number of subsequent intakes to meet, but not cross the threshold of 32 undergoing OJT per annum. Table 6 illustrates the way academy and OJT capacity can be calculated.

Table 6: Academy and OJT Capacity

Constraints	**Academy's Production Rate**	**OJT Capacity**
Intakes p/a	3	
Ab initios per intake	12	
Academy capacity p/a	48	
Academy capacity per 3 years	144	
Success rate	67%	
Expected trainees at OJT per 3 years	144 X .67 = 96	
Expected trainees at OJT p/a	**32**	**32**

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GLOSSARY

For the purposes of this document the following definitions shall apply:

***Ab initio* Trainee Controllers**: Selected individuals, with no previous relevant qualifications, who are given basic instruction and training to enable them to obtain theoretical qualifications. Normally the *ab initio* phase ends after institutional training before entering into OJT.

Airspace Capacity: The number of aircraft that can be fitted into ATC sectors, keeping in mind aircraft separation and safety standards, area navigation direct routings and other factors (EATCHIP, 1996b).

Air Traffic: All aircraft in flight or operating on the manoeuvring area of an aerodrome (ICAO Doc 9569 Definitions).

Air Traffic Service (ATS): A generic term meaning variously, flight information service, alerting service, air traffic advisory service, ATC service (area control service, approach control service or aerodrome control service). (ICAO Doc 9569 Definitions).

Area Control Centre (ACC): A unit established to provide ATC service to controlled flights in control areas under its jurisdiction.

Breaks: The time in a shift when an individual or group of individuals is not at the workplace. This includes lunch breaks, rest breaks, relief breaks, and all other forms of workplace release from work for recuperation purposes.

Controller Capacity: The number of a/c that can be handled by a controller within a certain period of time for a given sector size, i.e. the maximum workload of controllers (EATCHIP, 1996b).

Delay: The period between the CFMU departure and the first take-off time requested by an operator.

Disabled Person: Somebody with a physical or mental impairment that substantially limits one or more major life activities (Americans with Disabilities Act (ADA), 1990).

Equipment Capacity: The maximum number of flights that can be handled by an ATC system, e.g. the limited number of Mode C (or the future Mode S) identification (and flight level) codes that can be allocated at any time for a given sector size.

Human Resources Management (HRM): The conscious and specific direction of effort towards the quality of the workforce in the short and long term. It involves all processes and activities aimed at managing the human resources of an organisation: MP, recruitment, training and development and career management.

Job: A group of a certain number of core tasks, direct support tasks and indirect support tasks which require a certain level of abilities, knowledge and skills.

Licence: An ATC licence indicates a controller's qualifications and includes a record of his competence at a particular unit together with his medical classification.

Load Threshold Value (LTV): The sustained hourly rate of entry of new units into a sector. These are added to the units which are left over from the previous hour.

Manpower: The total supply of individuals available and qualified for service.

Model: A description or analogy of a real or hypothetical situation, usually formal and simplified, which is used to develop understanding.

Night Duty: A period of not less than four hours between 22h00 and 07h00 next morning[10].

Off Time: The hours a particular individual or group of individuals are not normally required to be at the workplace (Tepas and Monk, 1987).

On-the-Job Training (OJT): The integration in practice of previously acquired job related routines and skills under the supervision of a qualified coach in a live traffic situation (EATCHIP, 1995).

The training enables student controllers to checkout as operational controllers at a specific operational unit.

Operational Controller: The holder of a certified qualification which permits the individual to control air traffic at a specific operational unit.

Operational Requirements (ORs): Instructions which define the opening and closing times of the sectors necessary to guarantee a safe and orderly traffic flow. They are determined by the traffic volume, distribution and complexity.

Operational Staff: The staff working in the operational environment of ATS comprising ATCOs, flight data assistants, flow managers, operations room supervisors and ATS support staff.

Rest Time: Any period which is not working time (Council Directive (CD), 1993).

Rostering: The allocation of human resources in order to ensure service for the scheduled working hours in accordance with legal and local procedures.

[10] Cooper, M.G. (1997). The Regulation of Air Traffic Controllers' Working Hours, In: The Royal Aeronautical Society, *Fatigue and Duty Limitations - An International Review*, 16 September 1997, London: The Royal Aeronautical Society, p. 2.5.

Schedule: The sequence of consecutive shifts and off time assigned to a particular individual or group of individuals as their usual work schedule (Tepas and Monk, 1987).

Shift: The time of day on a given day that an individual or a group of individuals are scheduled to be at the workplace (Tepas and Monk, 1987).

Shift Break: Time within a shift when work is not required, usually a time period of less than 1 hour in duration. This includes lunch breaks, rest breaks, relief breaks, and all other forms of workplace release from work (Tepas and Monk, 1987).

Shift Roster / Shift Schedule: The sequence of consecutive shifts and off time assigned to a particular individual or group of individuals as their usual work schedule.

Slot: A permission for a particular airline to land an a/c, or have that a/c take off, at a particular time, i.e. an access right (Flight International, 28.1-3.2.98).

Standby Duty: A period during which, by prior arrangement, controllers are required to be available to report at their workplace with the intention of providing an ATC service[11].

Strategic Naps: A short period of sleep taken at specific times during a night shift. It can vary from a maximum of 20 minutes nap in the early night to a maximum of 50 minutes late in the night (Cooper et al., 1998).

Task: A piece of work, performed by an individual or individuals, which has a definite beginning and end, and results in a product or a service.

Team: A team in ATS is a group of two or more persons who interact dynamically and interdependently with assigned specific roles, functions and responsibilities.

Teamwork: Group effort applied to work.

Training: The planned systematic development of the knowledge, understanding, skill, attitude and behaviour pattern required by an individual in order to perform adequately a given task or job.

Working Time: Any period during which the workers are working, at the employer's disposal and carrying out their duties, in accordance with national laws and / or practice (after CD, 1993).

[11] After: Cooper, M.G. (1997). The Regulation of Air Traffic Controllers' Working Hours, In: The Royal Aeronautical Society, *Fatigue and Duty Limitations - An International Review*, 16 September 1997, London: The Royal Aeronautical Society, p. 2.8.

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ABBREVIATIONS AND ACRONYMS

For the purposes of this document the following abbreviations and acronyms shall apply:

a/c	Aircraft
AC	Assistant Controller
ACC	Area Control Centre
ACT	Activation message
APP	Approach Control
ATC	Air Traffic Control
ATCO	Air Traffic Controller / Air Traffic Control Officer
ATS	Air Traffic Services
CAPAN	Capacity Analyzer
CBT	Computer-Based Training
CFMU	Central Flow Management Unit
CIP	Convergence and Implementation Programme
CWP	Controller Working Position
DED	Directorate EATCHIP Development
EAM	EUROCONTROL Airspace Model
EATCHIP	European Air Traffic Control Harmonisation and Integration Programme
ECAC	European Civil Aviation Conference
ECU	European Currency Unit
ET	Executive Task
EUROCONTROL	European Organisation for the Safety of Air Navigation
EWP	EATCHIP Work Programme
FDA	Flight Data Assistant

FIR	Flight Information Region
FIS	Flight Information Service
GAT	General Air Traffic
GPS	Global Positioning System
HRM	Human Resources Management
HRT	Human Resources Team
HUM	Human Resources Domain
ICAO	International Civil Aviation Organisation
IFATCA	International Federation of Air Traffic Controllers' Associations
IFR	Instrument Flight Rules
LTV	Load Threshold Value
MA	Member Association
MP	Manpower Planning
MPs	Manpower Planners
MPSG	Manpower Planning Study Group
OAT	Operational Air Traffic
ODS	Operational Display System
OJT	On-the-Job-Training
OJTI	On-the-Job-Training Instructor
OPS	Operations
OPSroom	Operational Room
OR	Operational Requirement
REP	Report
SC	Standing Committee
SDOE	Senior Director Operations and EATCHIP
SME	Subject Matter Experts

ST	Specialist Task
STB	Short Term Benefits (Task Force)
TWR	Aerodrome Control Tower
UACC	Upper Airspace Control Centre
VDU	Visual Display Unit
VFR	Visual Flight Rules

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