EUROPEAN ORGANISATION FOR THE SAFETY OF AIR NAVIGATION

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Heuristic Modelling and Policies in ATCO Manpower Shortage or Surplus Management

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Abstract

This document gives Manpower Planning (MP) managers, and specialists responsible for implementing, administering or providing MP services detailed considerations on one main question: should staffing initiatives meet or exceed authorised staffing levels? It presents a few shortage / surplus management models, including their advantages and disadvantages. It intends to encourage discussion and trigger thinking rather than establish guidelines as regards the desired models. However, some general policy principles in view of choosing a model are suggested together with operational ways and MP means to cope with a shortage.

Keywords

Delays	Manpower planning	Models	Overtime
Shortage	Staffing	Surplus	Traffic growth

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EXECUTIVE SUMMARY

This document is part of the work of HUM.ET1.ST03, a Specialist Task (ST) within the European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) concerned with Air Traffic Controller (ATCO) Manpower Planning (MP) issues. The MP project concentrates on the development of professional Human Resources Management (HRM) methodology conforming to Best Practices including concepts and tools for MP and staffing of Air Traffic Services (ATS) staff.

This document forms part of Phase II “Development and Definition of Alternative Models: Heuristic Modelling and Policies in Manpower Shortage / Surplus Management” of the project “An Integrated Human Resources Planning and Decision Making Approach and Methodology in Air Traffic Control (ATC)”.

It intends to give MP managers, and specialists responsible for implementing, administering or providing MP services detailed considerations on one main question: should staffing initiatives meet or exceed authorised staffing levels?

It presents a few models (including their advantages and disadvantages) among possibly many others. It intends to encourage discussion and trigger thinking rather than establish guidelines as regards the desired models.

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

Chapter 2, “Air Transport Delays”, briefly reminds some of the reasons for delays to air transport and their costs, before addressing their possible link to ATCO shortages.

Chapter 3, “Alternative Models” questions the benefits of different planning targets such as, for example, surplus or equilibrium in the adequate supply of ATCOs. It considers broad MP issues of better management of ATCO loss, time management, relationships between MP and traffic growth, task allocation and financing of training capacity increases.

Chapter 4, “Summary” describes the main MP principles outlined in the different models. In addition, some general policy principles as regards choosing a model are suggested together with operational ways and MP means to cope with a shortage.

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

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1. INTRODUCTION

1.1 Background

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 led by the HRT Chairman.

This document is part of the work of HUM.ET1.ST03, a ST concerned with ATCO MP issues which was put forward for consideration by the MPSG. 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 staff.

1.2 Main Question

Recent research (EATCHIP, 1998a) indicates that some States in the ECAC area succeeded in sustaining an equilibrium in the adequate supply of ATCOs during the period 1993-1997. In other words, when measuring the real shortages of ATCOs by comparing the past planned figures with the actual figures, some States had neither a significant shortage nor a surplus of ATCOs.

Furthermore, one could consider a ‘deviation factor’ (i.e. the deviation from a predicted shortage or surplus as represented by an average of deviation from past predictions) as being even more important than the real shortage. The reason for this is that an ATS organisation may be capable of successfully coping with a small deviation from its own prediction (whether it be a prediction of surplus or shortage) as long as that deviation is kept in reasonable dimensions. However, an ATCO shortage of 10% which is known in advance may be easier to cope with than a sudden unpredicted shortage of 7%. It may be achieved, for example, by adopting temporary overtime or annual leave policies.

EATCHIP (1998a) also indicates that a considerable number of European States succeeded in keeping this deviation to less than $\pm$3%. Some of these even managed to yield an average deviation from their own prediction, over a period of five years, of less than $\pm$1%.

It should also be borne in mind that a deviation may be due to not taking account of associated duties outside the Operations Room (OPSroom) (e.g. ATCOs serving as training instructors). However, an advanced MP system

should provide the means to include these functions and should also be able to forecast these ATCO associated activities. Such a MP system will not only keep track of the total number of ATCOs wherever needed, but also will take into account the significant difference in time required for career development between ATCOs in the OPSroom and those outside.

Assuming that a low and stable real shortage rate or a low and stable deviation from prediction rate are manageable, one could examine the benefits of an equilibrium in an adequate supply of ATCOs. Should staffing initiatives meet or exceed authorised staffing levels?

1.3 Purpose

This document intends to draw the attention of Manpower Planners (MPs) to some critical issues in the MP process. It questions the benefits of an equilibrium in the adequate supply of ATCOs and some alternative models of MP.

The reason for focusing in this phase on in-depth micro-view shortage analysis is that it offers insights to (higher-level) macro-view MP and fosters a better understanding of the manning processes.

1.4 Scope

This document goes beyond the widely accepted aspiration to eliminate any shortage of ATCOs.

It presents a few models among possibly many others. It intends to encourage discussion and trigger thinking rather than establish fixed positions as regards the desired models. Occasionally, it is not the answers which enlighten but the questions themselves.

2. AIR TRANSPORT DELAYS

Before analysing shortages and their possible link to delays, it is necessary to briefly mention some of the reasons for delays to air transport and their costs.

Some of the reasons for a **primary** delay can be attributed to

- **non ATC-related causes** such as seasonal increase in traffic, lack of airspace capacity, 'penalised departure airports', airport restrictions, gate limitations at destination airport, adverse weather, damaged runway, blocking of runway, technical and aircraft (a/c) equipment, late de-iceing, late release of a/c from maintenance, lack of planned standby a/c for technical reasons, a/c damage, late crew boarding, lack of valid visa for crew, late check-in of passengers, extraordinary request for security check, baggage processing, late preparation in warehouse of cargo or its documentation, late acceptance of mail, industrial disputes affecting ramp handling (e.g. late delivery of a/c cleaning service, or catering), and flight operations, or

- **ATC-related causes** such as sickness / staff shortage, staff on strike, dense traffic flow, low visibility procedures, ATC en route, ATC ground, late arrival of a/c from previous sector, Air Traffic Flow Management (ATFM) regulations, ATC-related technical problems (e.g. computer failure or radar processing failure).

It should be borne in mind that non ATC-related delays (because of the potential of missed slots) contribute under some circumstances to recorded ATC delays (Central Office for Delay Analysis (CODA), 1997).

There are also reactionary, or **secondary** delays resulting from the late arrival of inbound a/c due to any one or more of the primary causes.

The last data available from summer 1997 (peak season) have shown year on year increases in delay. The number of flights delayed by more than 5 minutes increased in July 1997 by 7%, and the total for the year amount of delay imposed increased by 1% to 2,762,202 minutes (CODA, 1997).

Analysis of delay causes shows that the most significant direct delay cause in July 1997 (and previously) was due to ATC en route at 22.4% (CODA, 1997). According to data from the Association of European Airlines (AEA) ATC en route and ATC ground accounted for some 70% of the delay causes in 1996 in some European airports (CODA, 1997).

There is no data available about the portion of staff shortage cause among the ATC-related causes, but it is realistic to assume that it is significant.

The average cost per minute ground delay is 18.5 European Currency Unit (ECU) and the average cost per minute airborne delay is 32.3 ECU (Dalichampt et al., 1997).

3. ALTERNATIVE MODELS

3.1 Model I: Temporary Shortage is Undesirable

A common sense approach will first lead to the conclusion that a shortage of trained, able staff, whether large or small, is a bad thing. A shortage complicates MP in any organisation.

3.1.1 The Consequences of a Shortage

One of the consequences of a shortage is the inability of a part of the Air Traffic Management (ATM) system to provide the capacity needed to satisfy a given demand. The result can be expressed as increases in

- what is known as the **'average cost of ATC per nautical mile flown'**;
- actual (and recorded) ground and airborne delays;
- inefficient flying (e.g. extra flight mileage);
- reduced revenues from route charges.

In addition, a reduced number of flights at a given time and place means more flights at another time or place which might lead to more environmental constraints or flight penalties to the airlines. It also indirectly affects landing fees, ground services and other network effects (e.g. traffic flows in neighbouring Area Control Centres (ACCs)).

In a shortage operational environment ATCOs may also experience unusual (higher than normal) levels of stress. It is accepted that the ATCO's job produces high task stress. Organisational understaffing is usually an additional stressor, i.e. an important source of occupational stress. Any unnecessary, additional sources of stress are known to have a negative impact on the human performance (Costa, 1996).

High levels of shortage or surplus can also indirectly cause distortions in calculating route charges for airlines. More and more 'private' ATS organisations (whether corporatized or partially privatised) are forced to discount their route charges instead of increasing their profits[1]. How could one calculate an expected volume of traffic to be handled when the supply of manpower is not stable? This is also contrary to the airlines' wish for a stable environment.

[1] This may not be convergent for totally privatised ATS organisations.

In a shortage operational environment, ATS organisations are inevitably uncertain about the level of future traffic that can be handled within their airspace. It is difficult to conduct refresher training or to plan career advancement and participation of staff in projects. This may lead to the postponement of refresher training courses or to the imposition of a moratorium on annual leave. It can also lead to a situation where staff are unable to obtain more flexibility from the schedule and will affect the social life of staff. In addition to this, sectors may also need to be grouped or even closed.

3.1.2 Re-sectorizing

Traditionally, capacity gains have been achieved by dividing airspace into smaller and smaller control sectors to offset increases in workload generated by ATCOs shortage or additional flights. Re-sectorizing is the universal panacea of the day. However, this technique has reached its useful limit in some of the busier European airspace areas because it generated additional coordination workload. The limitations to the volume of air-ground radio communications messages eliminate the benefit of reducing the sector size (EATCHIP, 1997; see also EATCHIP, 1998b).

3.1.3 Other Solutions to Shortage

Other creative solutions may have to be found to cope with a shortage. Temporary delegation of ATC responsibilities across national Flight Information Regions (FIRs) to address particular traffic confluence or congestion problems at particular times are widespread as shortage increases (EATCHIP, 1997).

In a shortage operational environment there are not enough staff for other associated duties outside the OPSroom (e.g. training, projects, participation in the International Federation of Air Traffic Controllers' Associations (IFATCA) meetings etc.).

The solution is not necessarily the creation of new posts. There is a need for some flexibility within the system, e.g. fully licensed ATCOs who are in administrative positions may under exceptional circumstances be recalled to service, provided their rating is still valid or revalidation can be quickly obtained.

MP aims at a higher degree of ‘liquidity’ or freedom in shifting ATCOs between functions outside and inside the OPSroom. However, in reality both are linked. Just as too many ATCOs inside the OPSroom causes a surplus, so too few ATCOs outside the OPSroom can cause a shortage. Perhaps, MPs should focus on a more broadly defined index which includes both? Such an index would currently show a strong rise in shortage in many ECAC States relative to current statistics measuring shortage solely in the OPSroom.

A shortage can be temporal, e.g. as a result of an unexpected wave of early retirement (see years 1994-1995 in Figure 1).

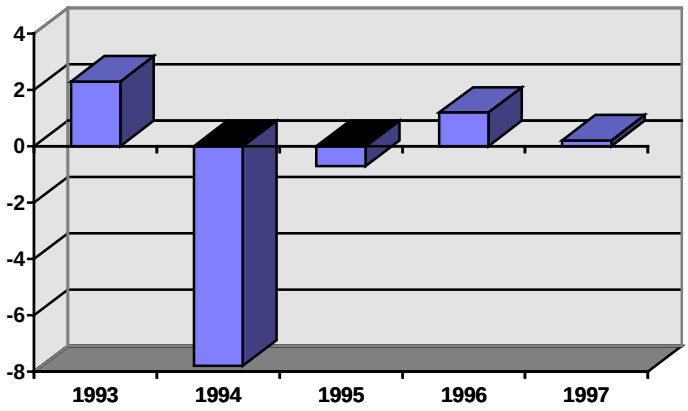

Figure 1: A temporary shortage (in %)

In conclusion, Model (I), “Temporary shortage is undesirable” has implications on many organisational levels, e.g. on the strategic business plan, the training programs, the reward systems, the working conditions and regulations, the task allocation and the performance review.

Hypothesis: Any shortage of trained, able staff complicates any MP system and therefore is undesirable. A temporary shortage has operational and staffing distortional consequences.

3.2 Model II: Chronic Shortage Can Become Uncontrollable

A temporary effect vis-à-vis a more chronic or cumulative effect can also be considered as an alternative. However, a shortage can also become almost an uncontrollable situation (see Figure 2). After several years of double-digit shortage, it is questionable how a chronic, large shortage can be managed and recovered.

A chronic shortage has significant external effects. An ATS organisation should, for example, in such a case be prepared to accept a ban on all night flights between midnight and 6am as its price for allowing an accumulated shortage.

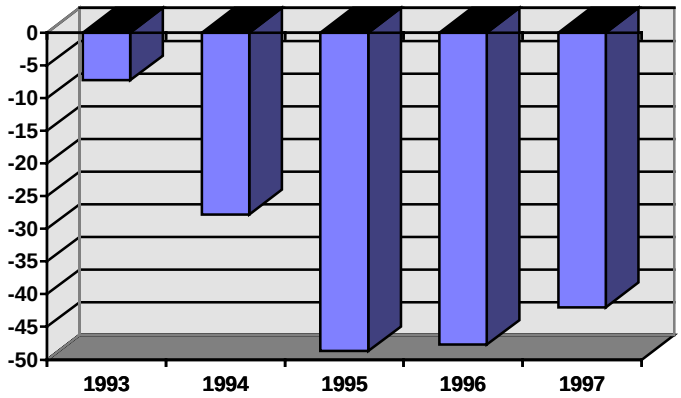

Figure 2: A chronic shortage (in %)

A chronic shortage causes not only delays of air traffic but can also jeopardize airport plans for additional terminals, increasing the airport's capacity by millions of passengers a year or plans for additional runways and further development.

3.2.1 A Chronic Shortage as a Symptom of Lack of Planning

A chronic shortage is not inevitable and / or sudden. A chronic shortage situation may indicate a total lack of any sort of planning or power of directing plans. In a chronic deviation situation, one does not have to be a cynic to disbelieve any forecasts. This situation suggests a lack of strategic direction and the break down of any planning.

Does a better allocation within the system of future ATCOs save money? For example, since delays produced by ACCs can be reduced at lower costs than those produced by airports (Dalichampt et al., 1997) should one perhaps consider tackling a chronic shortage first at the tower?

A chronic, large shortage can become uncontrollable. It may reflect a total lack of any sort of planning.

3.3 Model III: A Small Shortage Can 'Grease the Wheels' of the ATS Organisation

Because of the uncertainties and distortions which were mentioned in Models (I) and (II), almost everyone agrees that low deviation (surplus or shortage) is better than high deviation.

But how low should deviation go? This model will argue that a small amount of it may not be a bad thing and could even be beneficial. For example, some shortage helps 'grease the wheels' of the ATS organisation and may increase its efficiency. A low level of organisational stress can serve as a constructive, healthy motivational factor, although this must be within controllable parameters to avoid compromising safety.

In the current situation, where a considerable number of European States have a small deviation, the validity of this argument can be increasingly important for decision makers. If it is correct, then the pursuit of extremely low levels of deviation may be misguided (see also Figure 3).

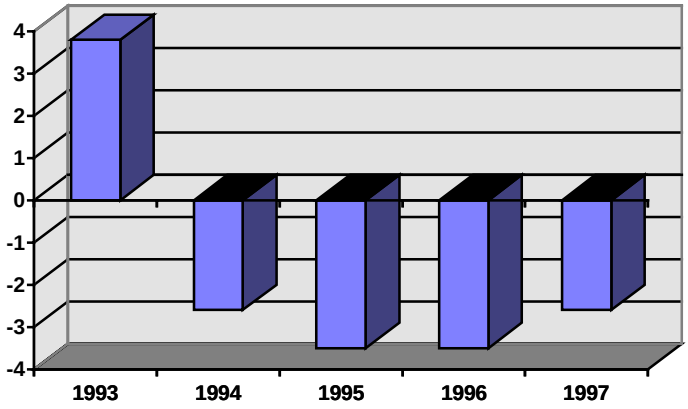

Figure 3: A small shortage (in %)

Smith et al. (1972) in a survey of over 600 individuals reported that the majority of ATCOs actually enjoyed the fast pace and high demands of their work. In another study, Smith (1973) reported that among 800 ATCOs the challenging nature of the work itself was regarded as a positive feature of the job.

However, there are also some negative effects of a small shortage. It affects the working conditions, the roster management, the human performance and the long-term strategic options.

Hypothesis: A low level shortage which creates a healthy organisational stress can serve as a constructive motivational factor. It can 'grease the wheels' of the ATS organisation.

3.4 Model IV: The Net Benefits of the 'Wheel-greasing' Argument are Small

One should be cautious in not overdoing and taking the 'grease' effect too far. The concept of low shortage as organisational 'grease' can become the focus of controversy. What are the short-term results of cutting a deviation (e.g. a shortage)? Probably an increase in overtime payments (for other consequences see also Sub-chapter 4.2).

3.4.1 Toward Better Time Management and Expertise in Task Allocation

When an ATS organisation has a small amount of shortage, it can adjust itself to changing rostering needs by raising ATCOs' pay for overtime. If ATCOs (or their union) were reluctant to do this, their average cost would be higher (as measured per employee per route charges) and hence the ATS organisation would theoretically enjoy fewer route charges revenues.

The wheel-greasing argument depends largely on illusions. ATCOs usually like to see their nominal wages rise (e.g. by means of overtime payment which was caused by a shortage), giving them the illusion that their circumstances are improving, even though in real terms (stress / health-adjusted or inflation-adjusted) they may be no better off. Having to work overtime may also affect the possibility of benefiting from other career opportunities or leisure activities.

When according more time to staff to balance against overtime, one risks ever increasing the shortage. When paying off, staff become accustomed to the additional financial reward.

3.4.1.1 Overtime

Different definitions and national / regional nuances in regard to overtime exist. For the purpose of this document, overtime means, in a very broad sense, the time during which a person works at a job in addition to the regular (statutory) working hours. However, it is recognised that in some States it refers to the time worked in addition to scheduled hours. In some States national regulations require an approval from the home staff committee for each overtime case. There is, however, consensus that in any event, overtime should not usually be common practice or subject in long-term planning. It is normally used as a short-term tool, e.g. to cover manning needs resulting from staff sickness.

3.4.2 Varied Effects of Shortage

A shortage may affect ATS organisations in a number of ways. These may be contradictory. On one hand it could grease the system as outlined above, even reducing delays in traffic. On the other hand it could subject decisions made by ATCOs working addition hours to much the same uncertainty that affects their decisions as regards On-the-Job Training (OJT) success rates. ATS organisations would then be more likely to misjudge how much intakes to

training should rise. Not to mention that ATCOs are stretched to capacity. An incorrect choice may cause harm which outweighs the benefits of greasing the ATC system wheel.

This situation can strengthen the position of staff and weaken the position of management. It might have a positive impact on the human performance output but a negative one on the strategic options of the organisation. This calls for a strategic management decision as to what is the long-term perspective of the “best” solution.

In order to separate the negative effects from the positive ‘grease’, one should look at specific procedures of working conditions at each ATS organisation. There are also important cultural differences in

a) the acceptable level of stress;

b) the evaluation procedures of OJT success.

However, this model argues that the costs of shortage are likely to show up at substantial levels of deviation (e.g. shortage of above 5.5%) as ATS organisations will, for example, misjudge the loss of route charges which will result from the shortage. The beneficial ‘grease’ impact will probably occur at more manageable levels of shortage (e.g. below 5.5%) as ATS organisations alter working conditions. After all, a temporary moratorium on annual leave cannot last for ever as a permanent solution (see also Figure 4).

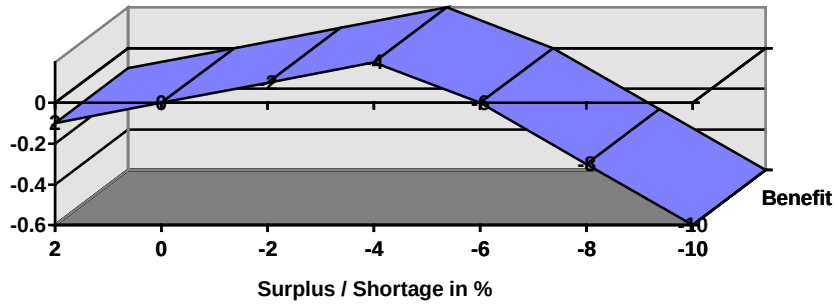

Figure 4: Net benefits of a small shortage

In addition, as time passes and the ATS organisation adapts to the new low-deviation environment, the advantages of ‘greasing the wheel’ may be diminishing.

The benefits of ‘grease’ may be modest, and may be present only when deviation is below about 5.5% shortage. In contrast, the costs of deviation rise quickly with a higher level of deviation. Combining the two effects implies that

while a tiny amount of deviation may indeed have benefits, the net effect may be trivial and begins to diminish once deviation exceeds, say 4%.

Another reason for the decrease in benefit of the 'grease' argument is the accumulative costs of overtime payments.

In summary, the greasing effect is short-term. This approach is not strategically managed but enjoys benefits at a low level of shortage.

The original idea was that a bit of shortage is good for the ATS organisation. The suggestion that the benefits may be smaller than first believed will be music to the ears of the ever-vigilant anti-shortage hawks.

Hypothesis: The positive effect of the low shortage can turn into an obstacle if overtime payments for ATCOs become the dominant factor in evaluating OJT success.

The benefits of the low shortage also diminish when the costs of overtime payments rise, and when route charges are lost as a result of the shortage.

3.5 Model V: A Stop / Go Approach in Recruitment and Training is Unlikely to Help

This Sub-chapter supports the wish to avoid the damage caused by a stop / go approach in recruitment, selection and training. A temporary surplus should not necessarily lead to a 'stop' in recruitment activities and a small temporary shortage does not necessarily end up in massive intakes into training. However, none of this will produce quick results.

3.5.1 When Recruitment Switches Off

It is widely recognised that the subsystems of recruitment, selection and training of *ab initio* trainee controllers cannot be easily switched off and on. The attractions of an ATCO career in the labour market will be adversely affected by a break in continuity. A test battery needs maintenance on an ongoing basis. Selecting and training competent personnel for selection boards and trainers are time consuming and costly (see for extensive discussion EATCHIP, 1998c).

Figure 5 shows that half of the time, only half of the capacity in training and recruitment is fully used. Furthermore, there is no real saving due to the fixed costs in both systems (e.g. renting of an ATC academy, leasing costs of simulators, maintenance and upkeep of selection tools).

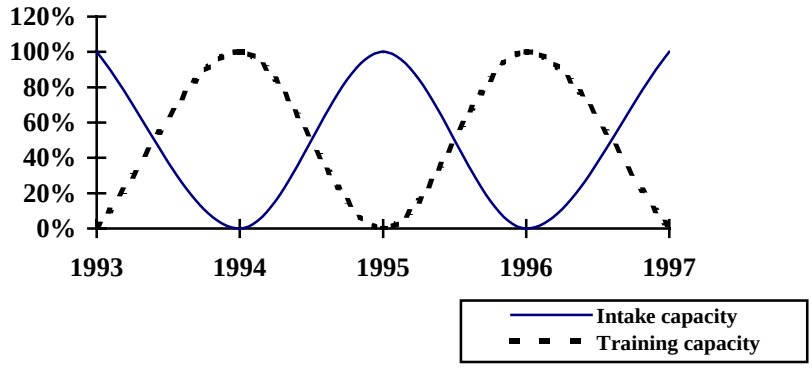

Figure 5: A stop / go approach

A stop / go approach can also cause an uneven age distribution, backlogs in OJT and possibly a lengthening of training time due to "catch-ups" in recruitment. A stop / go approach has no positive impacts on any existing lack of resources in the overall system.

Hypothesis: Recruitment, selection and training cannot be easily switched off and on. Therefore, a stop / go approach is unlikely to provide a solution.

3.6 Model VI: Equilibrium

What are the results of a situation with zero deviation (i.e. equilibrium)? Perhaps any fluctuation, even a small one, is difficult for MPs? Perhaps the beginning of an accumulative surplus might lead to a stop / go approach in recruitment and training (see also Model V)? Perhaps unnecessarily higher levels of stress are caused by the lack of familiar stressors? Or perhaps false expectations for the enduring equilibrium of an adequate supply of ATCOs?

In any event, this model stands for an unintentional surplus or shortage, i.e. relative equilibrium. However, a perfect equilibrium may exist in natural sciences or Newton's Cradle (Figure 6), but only rarely in human sciences or in dynamic systems.

Figure 6: Equilibrium

In the ATC environment it will be more realistic to discuss a relative equilibrium situation (as demonstrated in Figure 7).

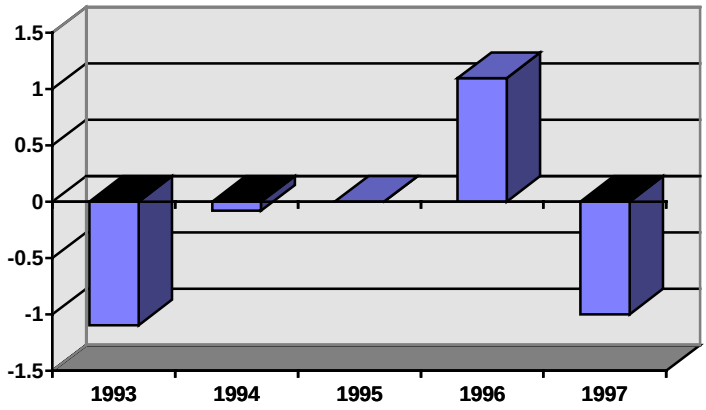

Figure 7: A model of relative equilibrium

A relative equilibrium seems to be an ideal situation. However, the current model argues that in an equilibrium (i.e. neither surplus nor shortage), illusions and other behavioural factors may cause substantial and permanent damage. As mentioned above, false expectations that the MP has finally found the right formula and no corrections are needed, might develop. In a relative equilibrium situation, the trick will be to prevent MPs from becoming over confident with a diminished sensitivity to risk. One should avoid painting a rosier picture than necessary or ceasing to monitor potential risks on an ongoing basis.

One should not only aim to be better prepared for sudden shortages, but to get a better grip on everyday and long-term MP. Planning as an ongoing dynamic process should be adopted as an important guideline.

Before any further lengthy planning is abandoned, the demographic balance sheet needs to be weighed carefully. The relative equilibrium might be found to be very temporary.

A balance sheet can be produced with the aim of a periodic view, as the one recently developed during the International Civil Aviation Organisation (ICAO) Human Resource Planning and Training Study Group (HRPTSG) meeting. The calculation of a new surplus or shortage takes into account, for example, revised operational demands, outputs, contingency losses, redeployment, new trainees and retirements over a period (ICAO, 1997; see also ICAO, 1998).

Hypothesis: In an equilibrium situation (i.e. neither surplus nor shortage), damaging illusions and false expectations that no corrections are needed might be developed.

3.7 Model VII: A Pendulum Approach

When a significant surplus is accumulated (see right scale of Figure 8), MPs may come to the conclusion that the pendulum has swung too far and needs to be pushed back somewhat in the direction of a shortage.

For example, MPs request to delay a planned advertisement campaign. As a result one session of interviewing is cancelled, and one intake of *ab initios* is postponed. At the end of the chain a shortage was created after an ATCO has decided to take an early retirement (see left scale of Figure 8).

The pendulum can also be pushed back in the direction of positive territory to recreate a surplus. However, too many big adjustments could send it in the wrong direction (i.e. surplus higher than necessary). Maybe equilibrium advocates realise that nothing is as irreversible as it once seemed?

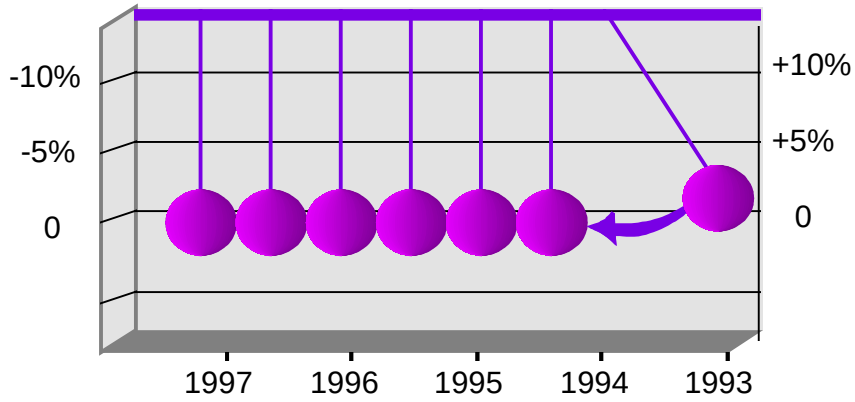

Figure 8: A pendulum approach

If an unsustainable rise in surplus goes into sharp reverse, this can trigger manpower instability. A collapse in MP can harm any organisational system, including an ATS one.

Since pricking a 'manpower bubble' is a risky business, it is clearly better for ATS organisations to step in early to prevent one developing. The tricky questions are how to distinguish a 'rational' surplus, (e.g. a rise in the number of ATCOs) which reflects real future gains in traffic from an 'irrational' one, (e.g. a rise in the number of ATCOs which reflects copious gains in overstaffing)? How to distinguish a 'rational' shortage which 'grease' the system from an 'irrational' one which is unlikely to be fully justified by faster productivity growth of ATCOs (or when ATCOs are not available for other duties in training, projects etc. due to shortage)?

3.7.1 ATCO Loss at Different Levels

This is why the manpower at all levels needs to be looked at. 'Bubbling in' at an *ab initio* level does not solve a lack of manpower in 'higher' levels.

Figure 9 shows a labyrinth where *ab initios* enter the system at one door, but may exit from one of the others during training before becoming fully qualified as controllers. It also shows that a newly licensed ATCO cannot easily replace losses due to other career paths ATCOs might be entitled to choose.

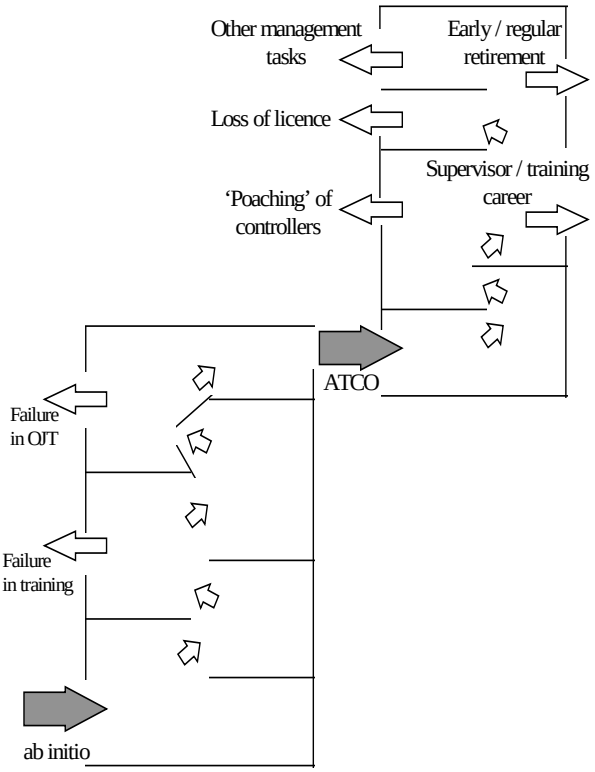

Figure 9: A labyrinth manpower path

One reason to suspect that an overstaffed situation has been created, is when, for example, the 'landing charge per ATCO' decreases. The growth of staff in an individual sector or position or in a function outside the OPSroom has long ceased to be a reliable compass by which to steer intake rates. Could the global ATCO-supply growth rate expressed in terms of 'landing charge per ATCO' be a useful indicator?

Higher intake rates could trigger a reduction in overtime payment, which would displease the ATCOs. The MP will then once again come under attack.

There is an awkward asymmetry in how MPs can respond. It is organisationally much easier for them to slash intake rates quickly to cope with a surplus than it is to raise intake rates in the nick of time (i.e. early enough) to anticipate shortage. However, at strategic levels one sometimes needs to be anti-cyclic and be able to take unpopular decisions.

Hypothesis: A multi-stage personnel production system is like a pendulum. A stronger than necessary rescue effort at the recruitment stage can create aftershocks at the bottleneck of OJT.

MPs need to distinguish between ‘rational’ and ‘irrational’ shortages. One of their main tasks is to raise intake rates early enough to anticipate shortage.

3.8 Model VIII: The Relationship Between Predicted Shortage and the Predicted Traffic Growth

The above mentioned models have many caveats. Some of the variation in deviation among ATS organisations, for instance, may reflect different levels of traffic growth forecast, rather than misjudgements about expected manpower. In addition, new technological developments or unique age distribution, (e.g. the US Federal Aviation Administration (FAA) situation in the early part of next century) may also affect the deviation.

It largely depends on what is in the equation. One could possibly control the input or the speed of the process, but not necessarily the output.

It is trickier to spot changes where the shortage is relatively small if the general traffic level is rising rapidly. This argument is generally applied to the shortage at current traffic levels. But it surely also applies to the shortage with regard to future traffic. Rapid increases in traffic can distort the manpower prediction. If a sharp shortage occurs, ATS organisations will be tempted to overinvest in staff, particularly in *ab initio* training.

In the past, the magnitude of this effect may have been fairly modest, but it may have grown in many States over the past years as traffic has increased but ATCO training facilities have not.

One could test another kind of hypothesis by measuring how much an individual State deviates in its prediction from its actual traffic growth.

Traffic growth considerations lead to at least some possibilities:

1. Control the rate of traffic growth in your airspace and thus, with a lag of two years or so, bear down on shortage. This is probably not always feasible.

2. Fix the intake rate against the traffic growth, provided that the training facilities have not reached their full capacity. This is probably not always realistic.

3. Use general shortages target (e.g. lower the shortage by 15% within one year). This is often not easily achievable (see Sub-chapter 3.8.1).

4. Concentrate on the bottleneck within the production system: forget the traffic growth, unhook yourself from intake capacities of *ab initio* and aim at OJT itself. Set a target range for success at OJT (and the total training chain) and adjust all available resources as necessary in order to meet the target. The results may be encouraging by keeping shortage in check.

3.8.1 Discussion on General Shortage Targeting

The great success of shortage targeting may be more to keep shortage down than to get it down in the first place. A policy of shortage targeting may help achieve equilibrium in an adequate supply of ATCOs without penalising traffic (and revenue) growth. The reason for this is that by adopting a shortage target, ATS authorities are giving a clear commitment that can be readily grasped, preferably by the public. Traffic delays are probably more easily understood than 'deviation rates'; they are certainly more fathomable than 'real shortages'.

This simplicity can be backed up by greater transparency. Private ATS organisations may one day be obliged to publish shortage forecasts - and, if they miss their deviation targets, to explain why. Other private sector managers can be dismissed if they fail. Such clarity and accountability may dampen deviations, and so help to curb shortages.

If, one unforeseeable day, pay cheques of MPs will be tied to levels of shortage, they will have a sharp incentive to reduce a shortage.

Does all this mean that deviation targets are the answer to MPs' prayers? Not exactly. Meeting a deviation target is not costless. Too tight (or stringent) a target, or too zealous a pursuit of it, means pain - in terms of staff development needs or staff working conditions. And if the ATS authority does not already have a good record on predicting shortage, and so must establish that they mean business, the pain is likely to be all the worse.

In addition, following a rigid rule could harm an ATS organisation. Suppose, for example, that air traffic movements were to slow down, as occurred in 1991. This situation may increase any existing surplus of ATCOs. If the ATS organisation tries to stick to its shortage target e.g. by tightening annual leave schedules, it would increase the surplus still further. In such circumstances, it would be better to allow a brief breach of the shortage target. An ATS organisation that uses such an approach usually has some leeway on this.

Moreover, a target is likely to work better if it is clear who is responsible for meeting it. Any shared responsibility (e.g. between the training institute and MP) may cause doubts about the ATS organisation's commitment to cutting shortage.

Would this approach allow for flexible allocation of tasks between units (e.g. in training projects) depending on the situation in a unit? Those who are close to their targets could be excluded in terms of, for example, giving support to projects from their staff.

And just as important, shortage targets have to be believable. This may require a manpower planner to throttle high shortage before putting its target into effect. Whatever its target, a MP's credibility is still an important ingredient in the ATS organisation policy.

Hypothesis: Rapid increases in traffic can distort the manpower prediction. Instead of trying to control the rate of traffic growth, or to fix the intake rate against the traffic growth, one could concentrate on the bottleneck and aim at specific success targets at OJT (and the total training chain).

3.9 Model IX: A Permanent Surplus is Costly and Counter-productive

A short-term staff surplus can be handled with more flexible planning (e.g. planning which is continuously smoothed and adjusted to the demand by flexible refresher training). But excessive, permanent surplus and underutilised personnel can be just as expensive as a chronic shortage.

A permanent situation of surplus which resulted in overstaffing is not only costly, but may lead to a potential underload, boredom and monotony. These in turn may also serve as sources of stress. If this surplus is in the OPSroom and no other functions are taken into account, too little work can be as stressful as too much, or even more so.

Since ATC work requires a high degree of vigilance irrespective of traffic density, Stokes and Kite (1994) noted that frustration may result when the stimulus which is needed to maintain this constant alertness is not associated with high levels of activity (e.g. due to a surplus of people).

It is an oversimplification, but not an egregious one, to suggest that ATCOs are stressed not only by a shortage but also by a permanent surplus (see also Figure 10).

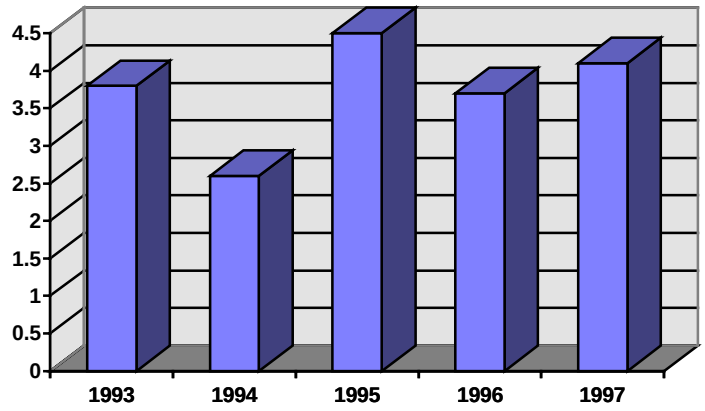

Figure 10: A permanent surplus (in %)

In addition (and as with overtime payments in the case of chronic shortage), in a permanent surplus situation staff become accustomed to a situation where they benefit from a low number of effective working hours.

In some instances a surplus can become a money earner. In the future perhaps more ATS organisations will explore the examples of one European State's surplus controllers who were contracted to another in 1992.

Hypothesis: Non used personnel can be quite expensive. An exceeded permanent surplus can result in a potential underload which is dangerous.

When national restrictions are removed a surplus can be a money earner through cross-border arrangements.

3.10 Model X: Better Control of ATCO Loss

Before MPs forecast a shortage they must be certain they do everything possible to keep current ATCOs in service. Otherwise they may find themselves recruiting again sooner than they had expected.

3.10.1 Process-Improvement-Opportunities

MPs may be reluctant to report real-shortages or real-surpluses to senior management. But instead of owning up to 'mistakes' in their forecasts, they can file 'process-improvement-opportunities'. This task of lowering, for example, unexpected resignations is still more an art than a science, but the need can be a pressing one, as a few cases of shortage (due to early retirement and / or resignations) demonstrated in 1997.

The **first** step is naturally to collect data on the frequency and size of past resignations of fully licensed ATCOs. This enables an ATS organisation to get a feel for what might befall it in the future.

An ATS organisation may be interested only in its own 'operational failures'. Other numbers are irrelevant because the way each ATS organisation runs its business and their legal environment are fairly unique. However, anyone else's failure to keep their ATCOs might one day become common. Once these numbers have been collected, statistical models can be build mapping the severity and frequency of past losses and use this to judge the risk in the future.

In a **second** step, MPs may want to judge the sorts of regions, sectors, or even positions associated with losses of ATCOs. Apart from normal attrition of ATCOs, shortage can be created by responding to requests by controllers for reassignments to geographic regions with lower costs of living and a less complex workload (Gethin, 1997).

Another 'process-improvement-opportunity' can be to increase the number of flights within a given sector which arrive without ATC-related delay. This kind of specific target combines the targeting option outlined earlier (see Sub-chapter 3.8.1) and the identification of 'process-improvement-opportunities'.

One needs to decide whether a more strategic approach or an operational improvement will be the best solution to a given situation. It still remains to be decided on the MP responsibility: who will know and decide.

Hypothesis: Lowering unexpected resignations of ATCOs or increasing the number of flights within a given sector which arrive without ATC-related delay are examples of specific 'process-improvement-opportunities'.

3.11 Model XI: How to Finance an Increase in Training Capacity?

The navigation fees for an average flight in Europe are 632 ECU and the landing fees for an average flight in Europe are 941 ECU (Dalichampt et al. 1997).

Landing charges per passenger in some of Europe's most important hubs are barely half that of some under-used regional European airports, or just over a third of those at Tokyo's Narita. One could consider a modest, new 'ATC levy' (e.g. £0.05 multiplied by 50m passengers in an important hub) which could also be used to increase training capacity of ATCOs.

Even more acceptable to the airlines can be an 'environment levy' added to landing charges paid by airlines, the revenues from which could also be used to increase training capacity of *ab initio* trainees (including more instructors in the academy) or to fund re-training of the existing ATCOs and any other positive purpose related to maintaining the level of safe, timely and smooth flow of traffic. Some measures of pollution charges are now being explored for the first time in one of the European airports.

One could consider introducing in addition to individual staff evaluations - flexible group bonuses. Subject to safety regulations and environmental interest group pressures, part of the landing charges (including the ATC levy) which can be shared by the sector's ATCOs as a group bonus.

ATS organisations are more and more influenced by changes in revenues due to environmental pressures. Costs which were picked up by the airlines (e.g. as a result of accommodating the crew in hotels after a ban on all night flights was applied) will not only be transferred to the passengers, but may also result in re-routing flights to less demanding routes. The result will be a loss of revenues to the ATS organisation.

Hypothesis: A revenue-oriented ATS organisation can find creative means to finance an increase in training capacity, by using portions of current and future landing charges.

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4. SUMMARY

4.1 Main Principles of Manpower Shortage or Surplus Management

The following summarises the main MP principles outlined in the different models.

1. Any shortage of trained, able staff complicates any MP system and therefore is undesirable.

2. A temporary shortage has operational and staffing distortional consequences.

3. A chronic, large shortage can become uncontrollable. It may reflect a total lack of any sort of planning.

4. A low level shortage which creates a healthy but controllable organisational stress can serve as a constructive motivational factor. It can 'grease the wheels' of the ATS organisation.

5. This positive effect of the low shortage can turn into an obstacle if ATCOs overtime payments become the dominant factor in evaluating OJT success.

6. The benefits of the low shortage also diminish when the costs of overtime payments rise, and when route charges which resulted from the shortage are lost.

7. Recruitment, selection and training cannot be easily switched off and on. Therefore, a stop / go approach is unlikely to provide a solution.

8. In an equilibrium situation (i.e. neither surplus nor shortage), damaging illusions and false expectations that no corrections are needed might be developed.

9. A multi-stage personnel production system is like a pendulum. A stronger than necessary rescue effort at the recruitment stage can create aftershocks at the bottleneck of OJT.

10. MPs need to distinguish between rational and irrational shortages. One of their main tasks is to raise intake rates early enough to anticipate shortage.

11. Rapid increases in traffic can distort the manpower prediction. Instead of trying to control the rate of traffic growth, or to fix the intake rate against the traffic growth, one could concentrate on the bottleneck and aim at specific success targets at OJT (and the total training chain).

12. Non used personnel can be quite expensive. An excessive and permanent surplus can result in a potential underload which is a dangerous situation.

13. When national restrictions are removed a surplus can be a money earner through cross-boarder arrangements.

14. Lowering unexpected resignations of ATCOs or increasing the number of flights within a given sector which arrive without ATC-related delay are examples of specific 'process-improvement-opportunities'.

15. A revenue-oriented ATS organisation can find creative means to finance an increase in training capacity, by using portions of current and future landing charges.

4.2 Operational Ways and MP Means to Cope with a Shortage

Some of the commonly used operational ways to cope with a shortage are

- to reduce capacity;
- to group or close sectors;
- to re-sectorize;
- to temporarily delegate ATC responsibilities across national FIRs;
- to accept a ban on all night flights;
- to increase effective operational hours.

Some of the commonly used MP means to cope with a shortage are

- to postpone refresher training courses;
- to reassign ATCOs from other areas;
- to increase supervisor's time handling air traffic;
- to implement a policy of partial licensing in order to speed the production of new ATCOs;
- to impose a moratorium on annual leave or to tighten annual leave schedules;
- to cancel participation in associated duties outside the OPSroom or to use more flexible allocation of these associated tasks between units;
- to increase work scheduling (i.e. overtime);
- to raise ATCOs' pay for overtime;

- to revalidate licences of ATCOs serving in administrative positions;
- to better allocate future ATCOs within the ATS system;
- to increase dramatically intakes into training;
- to review the demographic balance sheet in the light of revised operational demands and new training success rates;
- to carry out a job analysis and to improve selection tools as a long-term solution.

4.3 Which Model?

Like any model, the above mentioned ones simplify reality. Nonetheless, the models suggest some intriguing conclusions.

In spite of the big differences in the countries' working conditions and regulations, the problem of shortage is surprisingly (or not) uniform.

General guidelines may well make sense. Guidelines for targeting the best model might be an ideal way to spread good MP practice. However, there are important cultural differences and legitimate differences in business strategies and conditions, management philosophies and labour markets.

Many MPs dislike the daily stress of the small shortage (Model III) which exposes them to the necessity of using creative solutions. They would rather follow the equilibrium (Model VI), which involves rigid dependency under the guise of OJT success rates, but which demands less need for coping in the short-term.

Most managers are naturally preoccupied with the costs involved in maintaining a long-term significant surplus (Model IX) or the loss of route charge revenues resulting from a significant shortage (Model II).

The positive stress which can motivate ATCOs in one culture can be a hampering factor in another (see Model IV). This varies enormously.

The decision, for example, which surplus size worth its costs is by no means coherent. No agreed consensus has yet emerged, nor ever will.

4.3.1 Some General Principles

Nevertheless, some general principles might meet a consensus:

1. MP should be carried out proactively both on strategic, long-term and tactical, short-term levels.
2. Planning as an ongoing dynamic process should be adopted as an important guideline.

3. Flexible planning, which is continuously smoothed and adjusted to the supply and demand of staff is a key to MP success.

4. The link between MP and efficient rostering can be monitored and used on a regular basis, e.g. by reports per day, per season etc.

5. No stress at all in the ATCO's job (e.g. resulting from a significant surplus) is likely to cause harm to the need for constant alertness. Some (cultural-dependent) stress (e.g. resulting from a small shortage) can serve as a healthy, constructive motivational factor. Too much stress (e.g. resulting from a chronic shortage) can turn the workload into an unbearable one.

6. Individual States should make their own decision regarding the cost-effectiveness of which shortage / surplus model of MP is worth following.

4.3.2 Important Questions to be Answered

In choosing a shortage or surplus of ATCO policy, MPs need to answer four important questions:

1. What are the real shortages?

2. Where are the bottlenecks?

3. What is the cost optimum (e.g. small shortage below peak traffic demand which can cause acceptable level of delays and loss of some revenues but still not at a level where a further shortfall of ATCOs will be cost inefficient, or a slightly / fair / significant spare supply of ATCOs (higher than traffic demand) but yet one which is not too costly)? In other words, what is exactly the optimum number of ATCOs which still provides a positive added value?

4. What actions need to be taken toward achieving this cost optimum?

4.3.3 Planning Parameters

MP needs simultaneously to take into account the following planning parameters and management tasks: recruitment seasons, selection ratios, training capacity, training success rate, potential OJT delay-causing bottlenecks, hidden OJT delay-causing root causes, present and future traffic volumes, revised operational demands, manpower demands in training, management and projects, staff loss, contingency losses, airport, ACC and sector declared capacities (including safety buffers), staff age pyramid, threshold of acceptance of traffic delays, current level of equipment, impacts of future data processing system improvements on capacity, structured workload, complexity of regional traffic characteristics and above all, the need to allocate costs for each of these factors.

Therefore, MPs need not only to possess an ability to analyse all these factors and apply optimisation algorithms, but also a good understanding of human behaviour as well as some considerable knowledge about traffic patterns, flow and sector regulations.

4.3.4 Operational, Economical and Organisational Factors

Luckily, MP will be more manageable in the future due to several operational factors:

- The development and validation (against expert controller opinion) of fast-time modelling techniques based on models of ATCO workload in different European States. An ATCO workload can be associated with each a/c e.g. as a function of its flight (climbing / descending). It can also be defined as a traffic level where ATCOs are directly occupied 70% of their time. A workload can also be built up on a sector by sector basis.

- The beneficial influences of corporate ownership of ATM service provision compared to past governmental bodies. The trend away from public ownership could have a positive effect by subjecting planning decisions to more predictable logic.

- The relationship between anticipated slow economic growth (e.g. in South-East Asia) and traffic growth is now more predictable than before. Traffic forecasts nowadays can make use of more sophisticated optimisation algorithms which can reflect recuperation effect of demand after a period of traffic decline.

- The impacts of recent open skies agreements signed by a number of European States allow carriers to fly direct to any US city and back without restrictions on the number of operations or size of a/c are now better understood than few years ago.

- Full liberalisation of air transport in Europe, with more direct non-stop services to a greater number of airports is to be completed soon.

- The trend of unprecedented growth at regional (or secondary) airports of international short and medium-haul operations and the introduction of mid-sized long-haul have recently become more controllable.

- Charter airlines are expanding increasingly in scheduled services and thus making it easier to sell capacity to the travel industry and to plan in advance.

- The impacts of the opening of high speed trains (e.g. Eurostar) on traffic levels on the important air routes are now clearer.

4.4 Final note

The road of MPs contains treacherous twists and turns. However, planning does pay. If virtue gets its reward in heaven, planning gets its pay off on earth.

MPs must remain vigilant - but they must also recognise that if there is one thing certain about the future, it is that it can be unpredictable.

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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.

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

Air Traffic Flow Management (ATFM) Departure Delay: The difference between the scheduled off block time and the calculated off block time, taking into account slot time and estimated taxi time (CODA, 1997).

Air Traffic Service (ATS): A generic term meaning variously, flight information service, alerting service, air traffic advisory 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.

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

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.

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.

Off Time: The hours a particular individual or group of individuals are not normally required to be at the workplace (Tepas and Monk,[2] 1987).

[2] Tepas, D. I. and Monk, T. H. (1987). Work Schedules, in: G. Salvendy, (Ed.) *Handbook of Human Factors*, Chapter 7.3, p. 819-843. New York: John Wiley and Sons.

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 Human Resources Team, (1995). *Air Traffic Controller Training at Operational Units*, HUM.ET1.ST05.4000-GUI-01. Brussels: EUROCONTROL).

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.

Overtime: The time during which a person works at a job in addition to the regular (statutory) working hours.

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

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.

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.

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.

ABBREVIATIONS AND ACRONYMS

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

a/c	Aircraft
ACC	Area Control Centre
AEA	Association of European Airlines
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Services
CIP	Convergence and Implementation Programme
CNS	Communications, Navigation and Surveillance
CODA	Central Office for Delay Analysis
DED	Directorate EATCHIP Development
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
FAA	Federal Aviation Administration
FAP	Future ATM Profile
FIR	Flight Information Region

HRM	Human Resources Management
HRPTSG	Human Resource Planning and Training Study Group
HRT	Human Resources Team
HUM	Human Resources Domain
IANS	Institute of Air Navigation Services
ICAO	International Civil Aviation Organisation
IFATCA	International Federation of Air Traffic Controllers' Associations
MP	Manpower Planning
MPs	Manpower Planners
OJT	On-the-Job-Training
OPSroom	Operations Room
REP	Report
SDOE	Senior Director Operations and EATCHIP
MPSG	Manpower Planning Study Group
ST	Specialist Task

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