

A Systems View of Manpower Planning and Management

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Abstract

The purpose of this document is to examine, at a high level, the Management and Manpower Planning issues of Air Traffic Management organisations, using a Systems viewpoint. By using a Systems viewpoint, additional clarity and insight may be gained over more traditional views. Change and Change Management are discussed, together with organisational effectiveness and efficiency. By using a Systems Theory approach, the reader is able to move from the real world to a model and back into the real world again, thus offering some degree of confidence to those managers wishing for (or contemplating) a time of transit from the current state to some future desired state.

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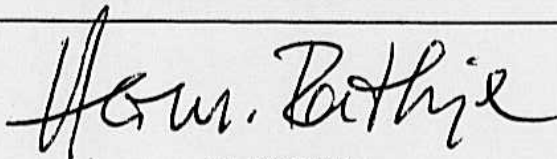
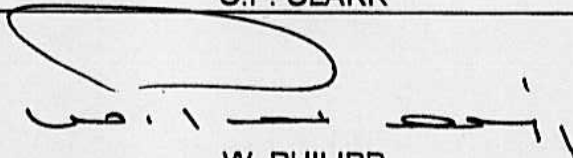
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EXECUTIVE SUMMARY

This document attempts to address the highly complex issue of Air Traffic Services Organisational Management in general and Manpower Planning (MP) in particular.

Considering Air Traffic Control (ATC) as 'a system' does appear to assist in clarifying some of the fundamental as well as some of the finer points that have been known to cause problems within such organisations in the past.

In addition to the clarification, this document attempts to offer at least one resolution (solution) to the challenge of having people in an organisation. Perspectives are taken at both a strategic level and a Human Resource Management (HRM) level - for a more operational view.

It looks at organisational effectiveness and how it can be defined. It looks at how organisations cope with change and how that change can be measured in terms of survival or competitiveness. It suggests that organisations need to anticipate and detect change, measure competitiveness and how it must have plans for its own development.

For those readers that may not have been exposed to formal systems theory before, a brief review of the essential concepts behind the methodology is presented and the three different approaches (Failures, Hard and Soft) are discussed, with the type of outcome each approach is likely to impart on the situation. It is suggested that the adopted methodology permits an approach based on these three, but is a particular mixture of them all.

A discussion on exactly what forms a system, the wider system and the environment is an integral part of the systems theory section, aimed at identifying the components in real life and moving the document towards more practical issues of the what, how and when in planning.

The advantages and disadvantages of the two classic forms of management hierarchy in any organisation are discussed, and then applied to the emerging model of an Air Traffic Management Organisation (ATMO).

Developing the systems model idea further is achieved by introducing the 8-level model scale that runs from a soft approach (people orientated) to a hard approach (solutions orientated).

The systems design section examines the two classic methods of top-down and bottom-up and then compares them in the light of knowledge and experience gained in the real world of ATC and draws a natural conclusion.

Looking at ATC as a system within Europe is not an easy task. The question is posed as to whether or not the European ATC 'system' is in fact a true system, based upon the paradigm that has, by now, been categorically established.

In seeking to further enhance the emerging model of an ATC System, a discussion on the likely inputs, transformation processes and outputs of our generic organisation are openly discussed, together with some measurements for these type of areas.

Human beings play a central and therefore critical role within ATMOs. While a substantial portion of this document is written at a strategic level, there are several chapters given over to the role of humans in systems, defining what a human does, with a brief comparative sideways look how a machine might (or might not) do it in a table called the Fitts list. Human and other resources such as time are defined and issues such as time management and time leakage are examined, together with the topical issue of shift work and its effects.

Finally, we move into the planning and management of ATC as a system, applying the concepts from the underlying theories and bringing them into the real world. The notion of feedback as a control form is discussed and the overall desire to move from a current state to a future state - and the mechanisms needed to successfully achieve that goal.

There are, of course, many routes to a single objective and the need for a business plan, the strategic policies within that plan and the linking of several discrete elements are all discussed under the general topical Management of ATC as a system. Also discussed are task assignments at both system and subsystem level, quality management programmes and the human expertise such organisations depend upon to run smoothly.

Task Analysis (TA) is examined in the light of systematic output objectives with an input provided by Subject Matter Experts (SMEs).

The level of spurious background noise in the feedback loop is examined and discussed as this can have an adverse effect on the overall transformation process an ATMO is trying to implement in its bid to move from the present state to the desired state.

On the assumption that not all staff can perform all activities equally, even if they have had the same level of training, there would be a need for some sort of staff classification procedure. The possibilities for this as a form of non-intervention approach to human resource allocation is discussed, together with possible ways of shortening the learning period using positive transfer effects between domains of expertise.

In summary, this document is written in a manner akin to a layered cake, starting with the basics and moving to a strategic discussion on the possibilities, with the view moving ever more towards the kernel of all organisations - that of the human being and their input(s) and how human resources may be planned, managed and optimised for best operational output results.

1. INTRODUCTION

Objective number 6.4.1 of the Convergence and Implementation Programme (CIP) of the European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) Work Programme 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.

This document is part of the work of HUM.ET1.ST03, a Specialist Task (ST) concerned with Air Traffic Controller (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 Air Traffic Services (ATS) staff.

1.1 Purpose

The purpose of this document is to provide higher management with a model and philosophy to support strategic and tactical planning in ATS organisations.

1.2 Scope

The scope of this document is to link MP to strategic and tactical business planning and to provide a greater insight to managers. Examples are given as to how the systems approach can be applied within MP at several different levels and of the closed loop feedback control.

1.3 Background

Organisational effectiveness can be defined as how organisations cope with change (dynamics), and be measured in terms of survival or competitiveness. From this it can be stated that organisations, in order to survive, need to;

- anticipate and detect change;
- measure competitiveness;
- have plans for development.

During the years, thousands of articles and books have been published on these matters. ‘Management Gurus’ like Peter Drucker, Tom Peters and Alvin Toffler all emphasise the importance of forecasting trends in a constantly changing world. Accurate trendcasting is the only way to capitalise on change. By accurate trendcasting, constant renewing and adaptation to changing

demands is possible. In some circumstances, **creating** change to benefit from directly is preferable to adaptation.

However, change for the sake of change is not discussed in this document, but change for the sake of achieving some clearly defined objective(s) is.

1.4 Philosophy of Approach

The philosophy of the approach adopted in this document is that of using the systems viewpoint to try and help the reader to understand better the complex (and often interactive) issues involved.

In order to achieve this, the document is structured rather like a multi-layered cake - in a manner that permits the reader an overview at the beginning, moving to a review of the sound underlying principles governing the theories that the approach is based upon and to show, often by example (using paradigm and comparison techniques), how the theory might be applied in practical terms within the context of an ATMO.

Clearly, much of the theory surrounding management in large structured organisations is not restricted to just the ATC environment, but is much more generally applicable - hence the wider interest in the adopted approach and the author's overall holistic philosophy.

Such an organisation may be considered to be 'a system' with all the corresponding elements - such as subsystems and an environment - which enable it to operate. For those less familiar with systems theory, a brief review of the methods, terms and logic follows.

2. SYSTEMS THEORY REVISITED

2.1 An Overview

In systems theory, there are a number of clearly defined boundaries which partition the individual sections from each other.

In this chapter we will define and use the following terms:

- The Environment
- The Wider System
- The System
- The Subsystem

Each denotes a different part of the whole picture (in reducing order of size) and each has a different effect and in part at least, different components.

It is intended that the application of systems theory will assist the reader to better understand what is otherwise a highly complex, multiple facet area of work. Refer to [Figure 1](#).

2.2 The Environment

The environment is the widest possible surrounding area of the whole picture. It may include items that have only the faintest of bearings on the subject under discussion normally, but under specific circumstances, one or more of those items may bring direct influence (or disturbance) to bear on either the wider system, the system or a subsystem within it.

The environment will always attempt to exercise some degree of control over both the wider system and the system itself, whilst both the wider system and the system will in turn attempt to influence the environment in which they exist to their own advantage.

2.3 The Wider System

The wider system is the bounded area defined within the environment that provides resources to, and legitimises the operations of, each of the systems operating within it.

The wider system also formulates the initial design of the systems operating with it and makes known its expectations of the system.

The wider system is influenced by the environment and, in turn, attempts to influence the environment itself, based upon feedback from the systems operating within it.

2.4 The System Construct

The System is also a bounded area that operates within the wider system mentioned above. It must comprise the following subsystems that interact closely with one another across several levels:

- A decision making subsystem,
- Transformation(s) subsystem(s),
- Performance monitoring subsystem(s).

All of these subsystems are bounded individually, across which only certain types of information may flow.

Information can flow between the system and the wider system less easily than between the system and its component subsystems.

2.4.1 General Systems Relationship Diagram

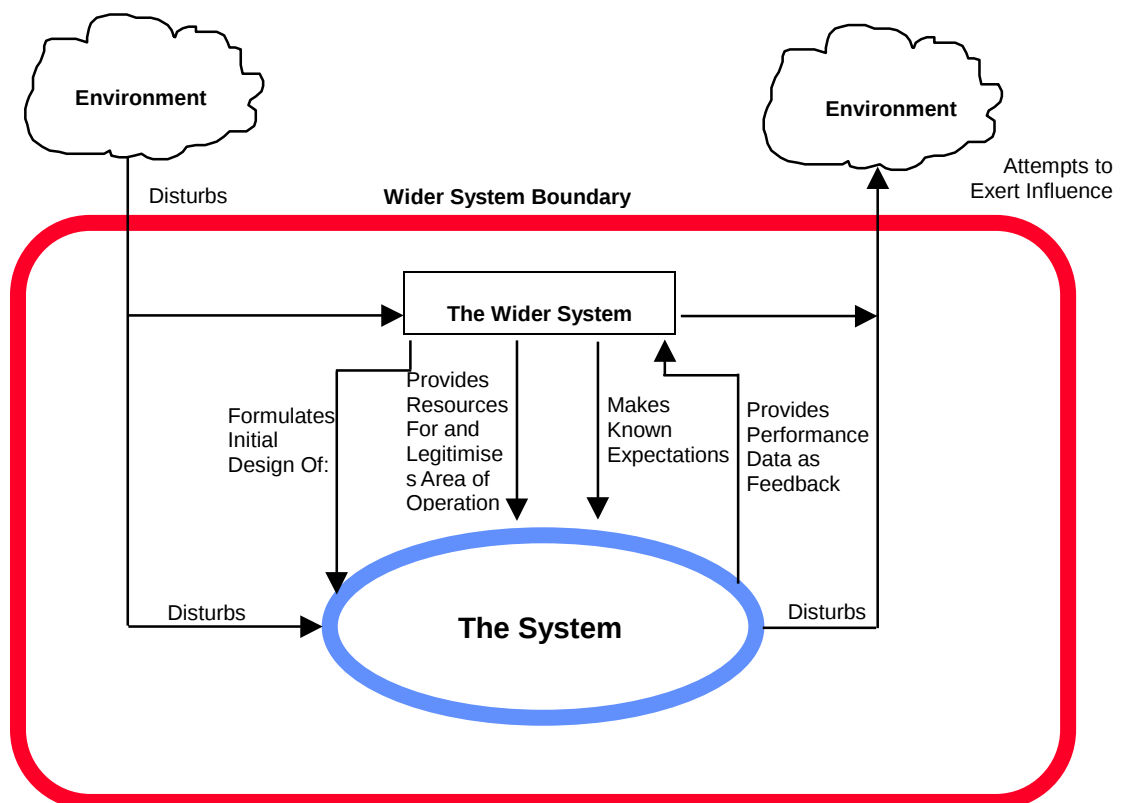


Figure 1: General systems relationship

2.5 The Subsystem Construct

Having mentioned the environment, the wider system and the system itself, it would be an oversight to not mention the subsystem. This is the basic building block of the whole systems concept.

Subsystems may be self contained (viable subsystems) or they rely on inputs from other sources for their process to work on.

Normal subsystems tend to be smaller units and lack one or more of the three essential components - unless they are described as viable subsystems in their own right.

A normal description for a subsystem would be a single item from the bullet list in Sub-chapter 2.4 above.

2.5.1 Internal System Relationships

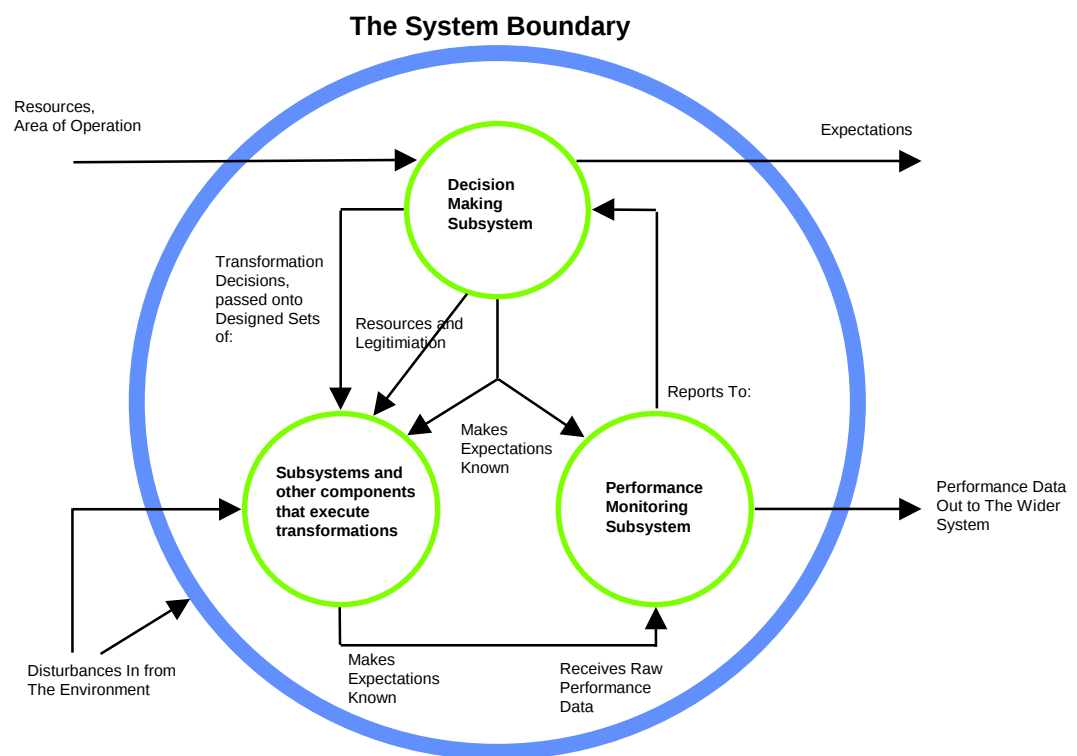


Figure 2: System and subsystem relationships

2.6 The Underlying World Views

There are (broadly) three different approaches to systems theory:

- The failures approach,
- The hard approach,
- The soft approach.

The failures approach relies on the belief that we learn most about the world and ourselves when it surprises us by failing to do what was intended or expected of it, forcing us to reappraise our assumptions or models. The failures approach is generally considered to be a relatively disengaged or academic research approach.

The hard approach relies on the belief that there are people in an organisation who know what is going on, who can identify problems and objectives clearly (which they can put into operational and / or quantitative terms) and who have the level of control and resources to implement the solutions they decide are most appropriate to the problem(s) in hand. The hard approach also accepts that defined problems can be solved by people with the appropriate expertise. The hard approach tends to be the more rational and mechanistic view that treats organisations in an objective and instrumental way.

The soft approach relies on the belief that social reality is built up from the personal assumptions, opinions, perceptions and desires of each of its participants. Ideally, these people all work together, as in a team and they share a common perception of the situation, which they have evolved for themselves, on an individual basis. Problems are not seen as puzzles that can be 'solved' mathematically or technically, but more a process of learning.

For the purposes of this paper, the adopted approach lies somewhere in the middle of the triangle and is a particular mix of all three classic approaches.

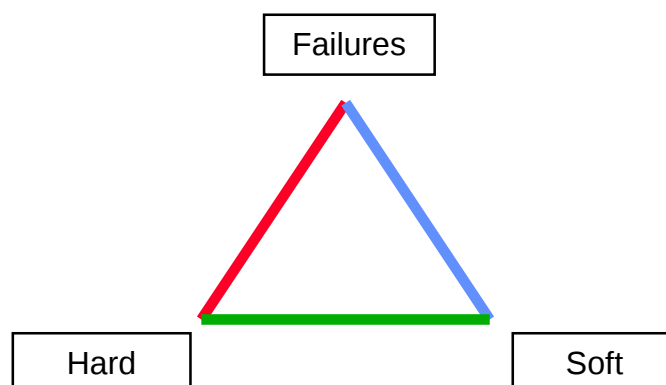


Figure 3: The three approaches to systems

In summary, each of the three classic approaches will produce a different outcome, which are generally accepted as being:

- Failures Approach - Better Understanding
- Hard Approach - Solutions(s)
- Soft Approach - Consensus of Opinion

2.7 Applying a Systems Approach

Having outlined the topology of systems terminology, the application of the theory is to find a way of resolving the problem (or opportunity) as it is presented. For the purposes of this paper, let us concentrate on the problem-solving aspects.

In essence, the process of dealing with a problem is one of identifying the present state (S_0), deciding upon the transformation process(es) needed to successfully move to the future desired state (S_1). This infers that S_0 and S_1 are fully identifiable.

$$(S_1 - S_0) = \text{Transformation Process}$$

Within the systems approach, there are a number of clearly identified discrete steps, individually referred to as:

- System Description,
- Identification of Objectives and Constraints;
- Formulation of Measures of Performance;
- Generation of Routes to Desired Objectives;
- Modelling,
- Evaluation,
- Decision on Choice of Route to Desired Objectives;
- Implementation.

These steps are shown diagrammatically in [Figure 4](#), to be found on page 11.

The decision maker will be presented with a problem of which there will be a certain perception - depending greatly on individual viewpoint. The first task is to be able to describe the system - this we will do later in this document as we describe a typical Area Control Centre (ACC) (being the focus of our attention). Secondly, there has to be an accurate identification of **objectives** and **constraints** pertaining to both the system as a whole and with the particular problem in mind.

Thirdly, there must be a formulating of satisfactory measures of performance, followed by the generation of a number of alternate routes to the desired objective(s). Once all these mental processes are complete, the modelling of the whole system can begin. It is during modelling that one might find that certain parameters are ill-fitting with the model and a partial returning to a previous stage (or stages) is desirable. If the modelling phase is a complete success, the decision maker is presented with a number of routes to S_1 - one of which may prove more desirable than any other.

The implementation of the improvements or modifications recommended by the systemic analysis are then vested in the decision maker.

See the systems iteration loop diagram ([Figure 4](#)) on page 11.

2.7.1 Systems Iteration Loop Diagram

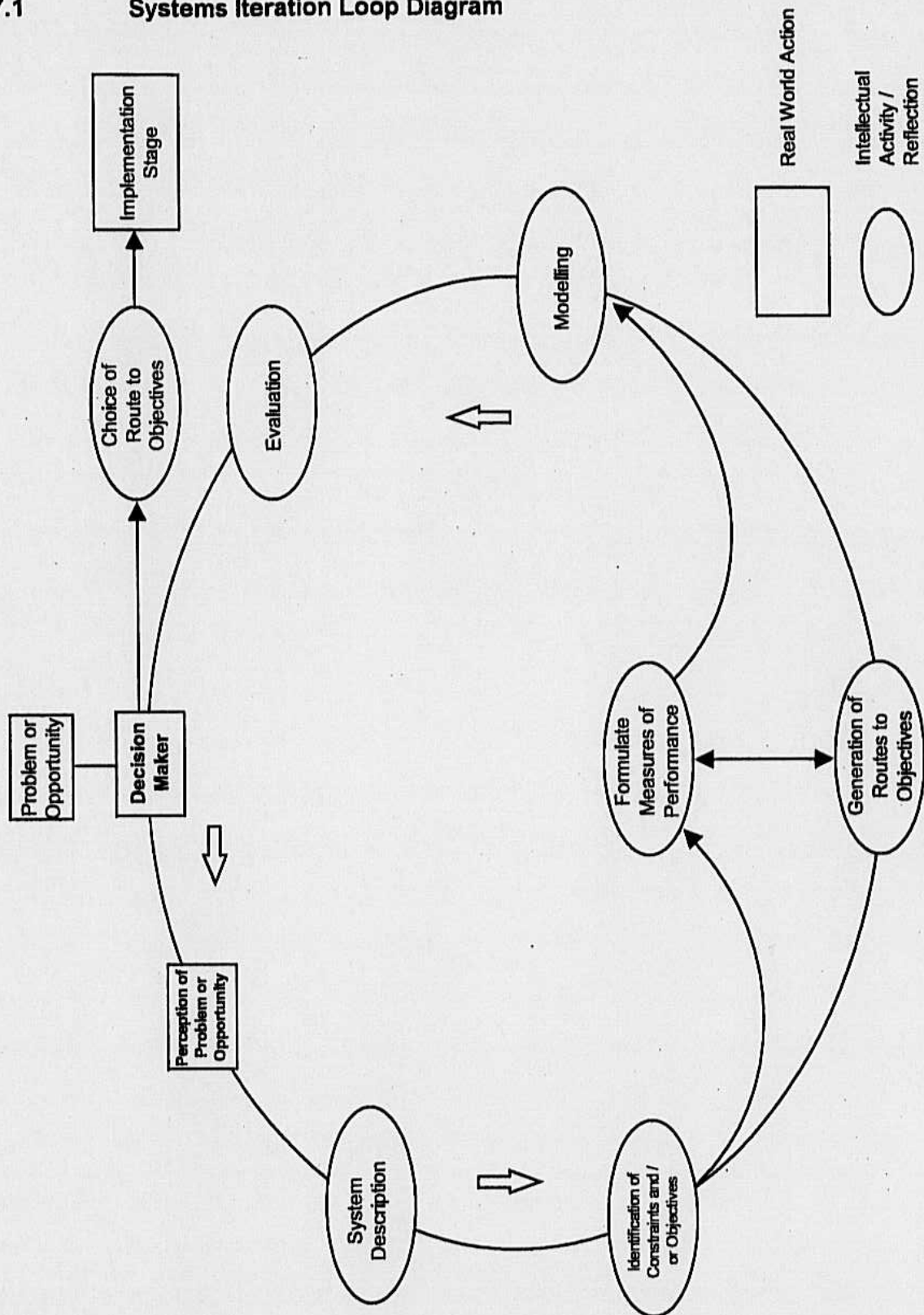


Figure 4: Systems iteration loop

2.8 Complex and Dynamic Systems

In any complex system such as an ATMO, there is an internal hierarchy or structure. Without this, there would be anarchy, chaos and a general lacking of direction and meaningful purpose.

An ATMO may be structured as a collection of several subunits. They may all behave relatively independently, with their own purpose as well as retaining a common purpose and identity in the group format.

This kind of independent subunit is often called a viable subsystem providing it meets all the criteria laid out above for a system.

2.8.1 Viable Subsystems

One purpose of viable subsystems is to remain independent and be able to differentiate themselves from other subsystems.

When these independent subsystems are linked together in some kind of hierarchy or via a network, they still try to control their own destiny by developing their own identity.

Together with their own identity belong their beliefs about themselves and what separates them from other, similar subsystems within the same system or ATMO.

Another characteristic feature of viable systems is their tendency to close themselves to input from their environment - in this sense they are not acting like an open system, but more like a closed (and self controlled) system.

2.8.2 Networking Viable Subsystems

Critical to a viable subsystem is a network organisation.

In any planning or comparison with its environment, a subsystem within a viable system will always concentrate on its own uniqueness – that which separates it from its environment and other subsystems operating in the same network or system.

The problem with viable systems is that they are independent parts that keep drifting away from each other in order to keep their individual identities.

Each independent viable system will probably come up with a different solution for the same problem, and each will consume resources and expend effort in finding and implementing that solution.

Common practices and a common solution might not occur until they have drifted considerably apart, so they no longer perceive themselves as part of one network or one system. Only then will the level of understanding improve.

Realisation that each has adopted a different position can either be achieved by themselves through interaction between themselves, or it can be monitored on a higher hierarchical level within the same network, or even be monitored by an outside agent - such as a customer.

Yolles (1997) recommends - for managing viable systems - to adapt the flexibility aspect and **allow** different solutions in order to control chaos, because adaptability occurs when the parts have drifted sufficiently apart.

As a result , the subsystems (or viable subsystems):

- have to respond to the tension of being differentiated;
- start interacting and communicating between differentiated parts;
- integrate themselves according to their interaction;
- emerge on a common level of understanding.

2.9 Systems Modelling

Any model of a system tends to be less than 100% accurate - some would describe them as poor or blurred. What they do tend to provide us with is a holistic review of the whole appraisal procedure we have applied thus far, which may result in a rethink of the approach.

The essential working of the system can be represented by quantitative variables and the various mathematical equations relating them together. The systems analyst has to write the equations, calculate the parameters and then test how well (or poorly) they overlay reality. However, most practical systems modelling activity requires no special mathematical technique.

The key idea is **credibility** and in order to achieve this, the **validity** of the model(s) used must be firmly established, using accepted and proven methods. Typically, this could mean adopting a particular approach in several different situations, using a 'standard' set of parameters (quantitative variables) and equations to evaluate the approach by and to judge the outcome(s). If similar (and expected) results are obtained, then there is a reasonable probability that the approach is valid and its credibility increases.

Any model should be able to enhance a client's decision making ability - not attempt to replace it. This demands manageability, flexibility and a capacity for interactive use. The model itself should not come to dominate the view of the situation. Models should not be too large - or they become cumbersome. **Simplicity usually provides elegant solutions.**

2.10 The Modelling Scale

Broadly speaking, there are eight levels of modelling, ranging between the softer, human-centred approaches to the harder, mathematical or technologically-based approaches. These are listed (for reference):

Softer, human-centred approaches

- 
- Behavioural science,
 - Socio-technical factors,
 - Human factors,
 - Systems engineering,
 - Operational research and management science,
 - Gaming and simulation,
 - Information systems and other computer-based approaches,
 - Econometrics and forecasting.

Harder, mathematical or technologically-based approaches

3. SYSTEMS DESIGN

3.1 The Top-Down Approach

The top-down approach is a more familiar one and, as its name implies, one starts with an overall or high-level view of the entire situation, albeit a complex one. From that view, a simplified view of what really interests us may be distilled, but without the effects of excessive reductionism.

From that simplified view, but with the holistic picture in the peripheral vision area, we may find one of the many possible routes to an ultimate solution to the problem. With the top-down approach, one tends to have some idea of the shape of the solution most likely to be adopted - in other words, the condition of S_0 and S_1 are already known, so it is likely to be more a question of managing the transformation process(es) efficiently than anything else.

The top-down approach generally permits us to find the optimal route to the solution, rather than being forced to take the first one offered. This is, by definition, management of the situation.

3.2 The Bottom-Up Approach

In the bottom-up approach to finding a solution, one will start with the smallest denominator in the overall equation - such as empirical data (or at least the data types) that might be needed to construct a database that will provide one route to an overall solution to the identified problem.

One of the difficulties with this approach is that there does tend to be a huge number of variables involved at this macro level, requiring much expansive thought and a 'bolting together' process to formulate the independent ideas into a cohesive plan of action - as and when they emerge from the human mind. That suggests that S_0 is not fully known at the time of the plan formulation and that extensive modification to the plan may be necessary.

Although this is dynamic, it may not represent the optimal use of the resources available due to the large amount of mental gymnastics necessary to achieve an implementable plan - or set of plans - to achieve S_1 .

3.3 The Comparison

In the comparison between these two approaches, there are merits to be found in both. Sometimes, it is actually more beneficial to adopt a dual strategy - attacking the problem from both directions at the same time. Generally, in the world of ATC, we would tend to adopt a top-down approach to the design of an ATMO system. This is discussed in the following Chapter(s).

3.3.1 A Generic Top-Down Bottom-Up Diagram

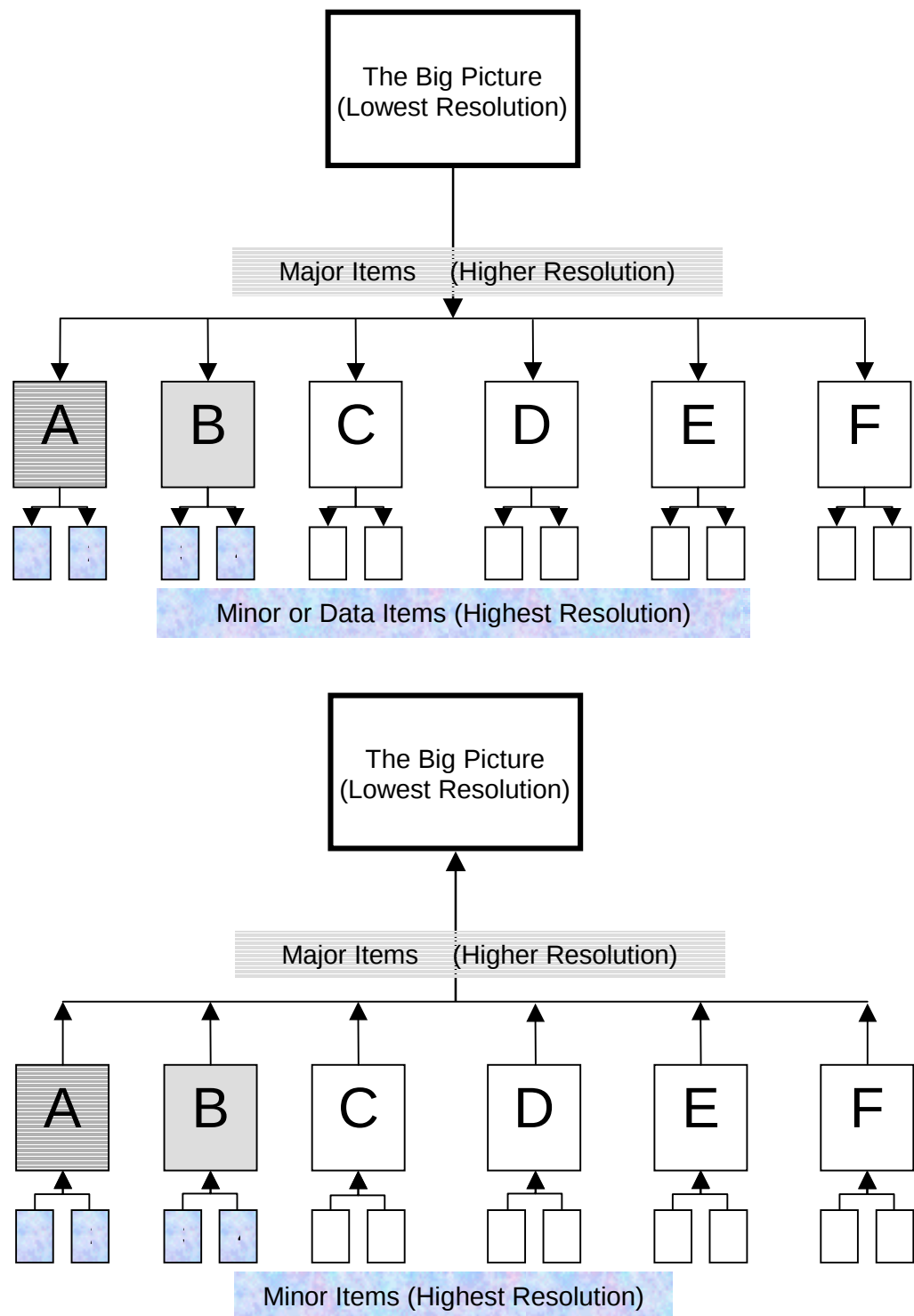


Figure 5: Generic top-down, bottom-up approach

4. AIR TRAFFIC CONTROL AS A SYSTEM

4.1 The Individual Nature of Europe

There can be no doubt in any mind that Europe is very different from the United States of America (USA) when it comes to ATC. The sovereignty issue is probably the major component, with each individual country wanting to retain control over its sovereign airspace and the right to determine how that airspace is used.

However, having said that, there must also be a high degree of cohesiveness between the ATS in each of these countries to enable air traffic to transit safely and economically between them.

This suggests the group behaviour concept laid out above is applicable in this wider context, which in turn suggests that the entire European ATC Environment may be viewed or perceived as a system.

4.2 Is European ATC a True System ?

If European ATC is to be considered in systematic terms, then it must fulfil the established criteria for 'a system'.

If it fails to meet the criteria for 'a system', then it may be considered for candidature in the 'wider system' category.

The comparison process with the formal model of a system is the first step in establishing whether or not an interpretation using the standard dichotomy is applicable, or whether an iteration is called for, perhaps applying different or alternative criteria.

The formal systems paradigm calls for three essential components to be present in a system:

- a decision making subsystem;
- a set of transformation or process-conducting subsystems;
- a performance-monitoring subsystem.

From these criteria, it is quite clear that the whole of the European-controlled airspace simply does not comply with the notion of 'a system' as it does not have all of the above components.

It may be then, that the European-controlled airspace falls into either the category of a wider system (as defined by the formal systems paradigm) or it is possibly even further out than that - forming part of the environment which the wider system operates in (not defined by the formal systems paradigm).

However, the formal systems paradigm calls for four components to be present in a 'wider system'. Such a wider system must be capable of:

- formulating the initial design of the system(s) within it;
- providing resources and legitimisation of the area of operation;
- being able to make known its expectations;
- being able to receive performance information from the system(s).

4.3 If Not a True System - Then What ?

Considering the European-controlled airspace in this manner does permit an improved level of understanding (which is one of the primary keys to Systems Theory), for then it becomes clearer that the sovereign States may be perceived as the individual systems operating within the wider system of the European-controlled airspace - and that individual ACCs may in turn be perceived as viable subsystems operating within each system. Refer to the formal systems paradigm Figure 1.

Of course, it must be recalled that if aircraft are to move safely above Europe, there must be a high degree of intercommunication between the component parts, just as in a system or network. But by definition, it is hard to refer to the European-controlled airspace as 'a system' per se.

In order to facilitate the free flow of information from one node to another it must certainly be a closely linked network, and in this sense, there is a systematic sharing of resources and knowledge, just as on a computer network.

But, just as in a computer network where each machine is able to operate independently of the one next to it until the time for file sharing or transfer occurs, each ACC accepts incoming traffic, processes it through their airspace and then hands it over to the next ACC in turn for further processing. In this respect, each ACC is operating as a transformation subsystem - in systems terminology. But the original question remains - Is European Airspace a true system ?

4.4 ACCs as Viable Subsystems

As a viable subsystem, each ACC will meet the established criteria for being a system in its own right, but as each is operating **within** the context of a National Administration, it is appropriate to consider each ACC as a viable subsystem rather than as its generic parent, the system.

4.5 The In's and Out's of ATC

If the ACC is a viable subsystem, then it must have inputs, and it must have identifiable departments that perform processes that cause a change in state to occur (transitions) and it must have at least one output.

4.5.1 Inputs

A non-exhaustive list of some typical inputs for an ATMO might be:

- the people or staff employed;
- the ATC equipment;
- the influence of government;
- finance;
- the influence of the environment;
- the influence of history;
- the influence of the national economy.

Of these typical inputs for a viable subsystem, probably the most important is the first. This is examined in greater depth in Chapter 5 of this document, together with some of the factors that exert influence on people.

The issue of MP is also addressed from the perspective of a systems approach to providing one further solution to highly difficult and complex problem, whilst keeping in mind the nature of ATMOs and the prime directive for safety of aircraft.

4.5.2 Transformations

What sort of transformations do ATMOs perform ? In general, they are highly technical and of a safety-orientated nature, allowing aircraft to move from S_0 to S_1 safely and with the minimum of delay.

For this service, there is a charge imposed, thus allowing the ATMO to move from an organisation that simply consumes financial resources to one that produces a return on the investment.

4.5.3 Outputs

Generally, ATMOs will provide a service such as the guidance of aircraft from point A to point B safely and in a timely manner, possibly for some form of financial reward in respect of carrying out this function.

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5. HUMANS IN SYSTEMS

5.1 Defining the Human Resource

Human beings may be perceived as a resource when they possess the skills and knowledge necessary to successfully complete some (complex) task. Part of the work involved in defining the human resource is the matching of the task requirements (e.g. from the TA or job requirements capture analysis) with the human being who possesses the skills and who is competent and willing to use them to maximum or best effect.

To a large extent, this is a subjective assessment based upon a written summary of the individual initially, an initial interview by skilled assessors who have an understanding of the job requirements and perhaps a second interview by a senior manager to assess how the candidate is going to fit into the organisational structure or hierarchy.

This matching of people with the activities and tasks laid out in a business plan is sometimes described as human resource allocation. Burke and Pearlman (1988) describe the issue of **improving the match** between human resource characterisations and job requirements as a process common to all methods of improvement in productivity and organisational effectiveness. Human resources can therefore be defined as a critical input component to the job requirement - as captured during the TA.

5.2 Human Factors Paradigm

The Human Factors (HF) paradigm (ideal model) is an awkward brute as it is a collection of many paradigms really, but these are highly applicable in the ATC environment we are focusing on.

Few of these paradigms can be presented as reliable rules - or even a comprehensive layout - for any kind of action. Essentially, the scope of these HF paradigms covers four levels in two distinct areas:

- **As an Individual**

1. Basic Functioning (resources we each have)
2. Control of Tasks

- **As a Member of a Group**

3. Interpersonal Behaviour
4. Complete Organisational Behaviour (Culture)

Within the above, there are six major paradigms that provide the common core (or axis) of all the HF input to the Systems Approach under discussion within the wider context of ATC:

- allocation of function;
- visual display design;
- physical environment;
- motivation of the individual;
- group behaviour;
- training.

5.2.1 Allocation of Function

People must retain the functions of goal setting and / or goal switching because of their improved abilities over a machine in terms of strategic ability. The decision where to land an aircraft in fog could hardly be left to a machine alone without human intervention. See also the Fitts list in [Annex A](#).

In an ATC environment, it is generally the duty supervisor who has to decide when to reallocate some of the staff to a new sector due to the particular workload being experienced at that time.

5.2.2 Visual Display Design

For the most part, the major sense organs used by ATCOs are their eyes when sat in front of a radar operating position. Clear, unambiguous representations that can be readily understood help lead to correct decisions and the appropriate actions being carried out in a timely manner.

Consistency of label colouring, good viewing angles and logical grouping of controls (ergonomics) are just some of the factors that make a more comfortable - and thus more productive - workplace.

5.2.3 Physical Environment

Factors such as temperature, humidity, noise and vibration all contribute to a decrease in the ATCOs effectiveness and work performance.

Research into the effects of heat extremes on human performance are far more conclusive than the corresponding research into the effects of cold.

5.2.4 Motivation of the Individual

Humans tend to respond to situations and other people at work **as they are perceived** and not necessarily as they actually are. Also, different people in an office or workplace will have a different perception of the same thing.

People who meet or exceed their own goals tend to feel satisfied and successful. The converse is also true.

The family, the community and the society we live in, with their applied standards and attitudes all play a part in influencing our perception of a given situation or person. Each national economy also plays a part here as part of the wider global environment we all exist in.

5.2.5 Group Behaviour

Groups tend to form because of work patterns or associations and / or physical proximity. Generally speaking, the smaller the group, the higher the productivity, job satisfaction, regularity of attendance and industrial peace.

Productivity particularly depends on the cohesiveness of the group and their common goals. Peer pressure to conform will exert far greater power than any cash benefits to individual members. Mutual attitudes within a work group will tend to contribute more to output productivity than the cohesiveness of the group taken in isolation.

A small, cohesive group can support - or smash - management goals with relative ease. Individual members of the group will tend to be less influenced by the whole formal ATMO and more influenced by the group leader.

There are also a number of 'Social Paradigms' within the subgroup of team behaviour which are not discussed to any depth within this document but are worthy of mention in this context:

- the 'Anomic Reaction Paradigm';
- the 'Team Cult Paradigm';
- the 'Team Primacy Paradigm'.

5.2.5.1 The Anomic Reaction Paradigm

This looks at the behaviour of a newly-formed team and derives its name from the feeling of aimlessness or lack of purpose provoked by the rapid social change that has occurred due to the enforced change in working relationships and / or personal team values.

It is particularly true of people who move rapidly between teams.

5.2.5.2 The Team Cult Paradigm

This is usually found in an established team that is working normally. Cognitive dissonance and groupthink are two of the underlying principle concepts. Such teams tend to be very tightly knit at both professional and personal levels. The effect of being excluded from a group is remarkable – resistance to findings, resentment at not being chosen, etc.

One strong or charismatic leader may emerge. Professional, personal and social relations may be given undue importance leading to disassociation from the group by an individual member if they feel they have not been consulted on some important point before a decision has been made.

5.2.5.3 The Team Primacy Paradigm

The team has developed a strong identity and coupled with self-importance bordering on arrogance. The team believe that their work is of prime importance to the success of the organisation as a whole and this is seen as counter-productive by the management.

5.2.6 Training

In the ATC environment particularly, poor training can lead to catastrophic failures in judgement which in turn can lead to catastrophic loss.

On a lower point in the scale, one finds a small, but steady, shortfall in performance or output.

5.3 Humans and Machines

In the ATMO, there is a suggestion that much of the work currently done by ATCOs could in fact be completed by machine instead. As always, there is a trade-off. Machines do not become sick or bored doing repetitive tasks, but humans are much more adept at responding to the unplanned or unexpected decision that has to be made, such as resolving conflicts between aircraft. Machines tend to fail at the least convenient moment and in a fairly impressive manner, whereas human performance tends to degrade somewhat more gracefully.

Humans in ATS are a part of an information system in which machines and humans both have a part to play. The human element is there to maintain system stability and to provide a degree of rationale that cannot be attained by a machine directly. The machine element provides a reliable repetition tool and a considerable degree of speed.

Much has been written about the benefits of a Traffic Alert and Collision Avoidance System (TCAS) and similar systems, but it is a known fact that humans can distil complex information to the bare essentials very quickly indeed and react in an appropriate manner.

If the ATCO is considered as a process controller, he or she may have many hours of boredom 'just monitoring' the routine traffic, and a few minutes of intense, concentrated corrective action essential to aviation safety. This is referred to as being a dichotomy:- routine action on the one hand and high speed diagnosis and corrective action on the other. This demands an almost immediate change of mental state by the ATCO and can cause an inability to react to the developing situation. Therefore, ATCOs have to practice their

skills especially in situations where more and more monitoring of electronic systems is evident. This will also have an impact on the number of days ATCOs are away from the operations room (OPSroom).

This conflict is generally solved by manning the position with two ATCOs, one acting as executive and the other as planner. Sometimes an additional person is present in the form of the Flight Data Assistant (FDA) as well.

Another advantage in having the optimal mix of humans and machines working together is the reduced probability of common mode failure. In other words, the human **and** the machine are unlikely to both fail at the same time. Although the individual reliability's are different, in combination, they produce a level of reliability that is considered acceptable.

5.4 Automation in ATC

Air traffic is increasing globally and the demands being made on individual ACCs are increasing as a direct result. In response to this increase in demand, ACCs are becoming more technological and increasingly automated in many of the routine, repetitive tasks in a bid to save time and thereby increase the overall capacity of an ACC to handle more traffic. For example, the days of the paper flight strip are diminishing as more ACCs become fully computerised and the software becomes more adept at the essential handover / takeover procedures between sectors.

One of the effects of increased automation in the ATC industry is to provide ATCOs with a better quality (and quantity) of information about each aircraft under their jurisdiction without overloading the ATCO with the sheer amount of information displayed.

An improved quality of information can contribute to resolving conflicts before they would otherwise be dealt with. This can only have a positive effect on air safety - especially if the increasing number of aircraft cannot be dealt with using the more traditional means of further sectorisation and more ATCOs.

If used properly, automation can be of tremendous help to the ATCO in terms of improved efficiency, safety and reliability. It can help by reducing the scope for errors and this must also have the effect of increasing overall system capacity whilst maintaining or improving the required levels of safety.

Long term trends are towards more information and improved quality of that information, coupled with an ever-increasing number of aircraft in the airspace. This suggests that each ATCO will have less time to deal with each aircraft individually and the only way to increase throughput is to automate.

Wise, Hopkin and Smith (1991) concluded that increased automation in ATC is inevitable. However, it is suggested that this is limited to non-expert tasks such as the transmission of control data over Monopulse Secondary Surveillance Radar (MSSR) datalinks to correlate flight strip data and a real

radar return. The development of more automated 'expert tasks' is proving much more difficult - especially in the realms of four-dimension conflict-free trajectories with the human remaining as the key element, being assisted by the machine and not vice versa.

However, although the total process of ATC certainly cannot be fully automated for the time being, there will always be tasks in the future that may well be delegated to some sort of machinery. Development along these lines is currently in hand, including tools to aid ATCOs in decision making.

One major area of concern is the systematic redundancy. One school of thought suggests that if the planning and control functions of an ACC are physically separated, it may well be impossible for either to fulfil the main core functions of the other in the event of a failure of the fully automated control system.

In Annex A (The Fitts list) some of the Individual HF Paradigms are compared with their machine-orientated counterparts.

5.5 Defining Other Resources - Time

Continuous, irreversible and one-dimensional - this is the most commonly held perception of time as we define it for day-to-day usage.

The passage of time is considered as a constant, and as such, we tend to use a linear model to describe time. This linear model is reflected in the planning cycle as planning is usually referenced to time.

Time is extensively used by humans for a variety of purposes, such as:

- the dimension to spatially anchor events;
- a measurement of accuracy;
- a measure of being early or late.

When people interact, they are interacting in time, so time is an important aspect of human communications. People value (and allocate) their time differently.

ATCOs may spend up to 42 minutes per hour working and the remaining 18 minutes recuperating from the workload. However, the distribution of that workload may not be even across the time period and it is this poor distribution of workload that can cause problems.

For example, an ATCO may have a light amount of traffic for 20 minutes, followed by an intense period of concentration for 22 minutes. During the period of high concentration, there may be a single 30 second period of conflict which requires the ATCO to react to avoid a mid-air collision. This short period of intense mental activity will seem to last for much longer than the

actual 30 seconds duration, suggesting that time should in fact be modelled using a non-linear approach.

It is a known fact that when humans are busy, the passage of time appears to be much faster than when they are idle. This view also supports the non-linear theory for the passage of time.

5.5.1 Time Management

When something is delivered late it is usually perceived as bad. Being late for an appointment or showing up late for work is interpreted as 'not caring'. The converse is also true, for when someone is on time or arriving early, it is usually perceived as good and showing respect for the establishment.

When one is allocated a series of tasks, it means assigning time to do each of the tasks properly and to ones own satisfaction. Therefore, the amount of time allocated to each task can be considered a measure of the importance attached to the task - given that some boring or dull tasks consume far too much time when compared with their relative importance.

To give attention to something for a short time, or to assign someone to a task for a short time is generally an indication of lesser task importance. Time is also perceived as a scarce human resource. Being able to control one's own time (as well as that of others) is generally recognised as a sign of status and power within an organisation. In organisations, people are judged by others by what they spend their time doing.

In the ATMO environment, someone who observed as spending more time outside the OPSroom than their colleagues might be judged as either a poor manager of their time - or worse still - as someone who "can't take it" or as a "quitter". Therefore, as a human resource, time is perceived as personal and precious.

5.5.2 Time Leakage

Time leakage (or loss) occurs primarily due to poor management or activities occurring outside the mainline operations of an ATMO. These are considered as 'stealing time' from other activities. Some meetings might be perceived as unnecessary as they steal time away from 'more important' activities.

One example of poor time management in the ATMO is the frequently repeated complaint of operational staff that managers and supervisors are 'never around' when they are needed. This could be due to poor time management or over running of scheduled meetings elsewhere.

5.6 Shift Work and Personal Rhythms

Different portions of our lives are allocated different names - such as duty time, off time, overtime and leisure time.

Time also serves as an organiser for our personal rhythms. Habits are conditioned to time; we are hungry at about the same time each day.

Conventions like eating habits, the latest time to get up in the morning without being considered lazy or antisocial are all part of a social structure which we are conditioned to from childhood. Any serious disruption of this rhythm or social structure is perceived as a form of depravation. Specifically, this feeling of depravation is encountered over issues such as the right to be free on holidays, like public holidays.

Shift work has been demonstrated to create stress and health problems in some people, but not all. The sources of stress include fatigue, circadian rhythm disruption and disruption of social interactions due to working odd or antisocial hours.

It has been firmly established that there are variations in biology and performance as a function of time of day. Especially, it has been demonstrated that there are some chronic effects of night work (see below).

Working schedules must be considered as contributing toward a variety of additional HF problems.

5.6.1 The Effects of Night Work on Sleep

It has been shown (Bougrine et al., 1997; Signal, 1993) that workers performing some (or all) their work during night shifts report a higher incidence of sleep difficulty than permanent day workers or those that routinely start their day with the first morning shift.

The night shift workers report particular problems in initially getting to sleep, disturbed sleep periods and spontaneous awaking.

However, studies on shift workers suggest that the primary problem is simply one of obtaining enough sleep when working on shifts that require a daytime sleeping pattern.

The reduction in sleep length when working night shift is even greater when workers are employed on rotating shifts. For these workers, research suggests that deterioration in performance is an acute one. It may show recovery when the rotation of the shift allows more normal night-time sleep patterns to be re-established.

5.6.2 The Effects of Shift Work on Health

The question of whether or not health is permanently impaired by shift work has not yet been fully answered.

5.6.3 Fatigue Effects

The issue of shift breaks should be considered under the topic of fatigue: It has been shown (Bougrine et al., 1997; Signal, 1993) that shift breaks (and split shifts) are two methods of breaking up a workday (of any length) and help to overcome acute fatigue effects.

Abuse of how these breaks are scheduled (or used) can result in decreases in productivity. The person should not be working **in any capacity** during the break period.

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6. MANAGING ATC AS A SYSTEM

6.1 Background

Over the past thirty years there has been a growing consensus that a viable alternative to the static view of organisation, staffing and MP is to perceive organisations as social systems.

As yet, there is no conclusive evidence in either direction concerning management skills. Some evidence suggests these skills are not part of the genetic make-up of human beings, but are learned in formal schools of management as a form of successfully coupling 'best practices' with 'profitability' whilst other evidence adopts the exact opposite view.

6.2 Principles

Management in any organisation is one of the most critical aspects to the well-being of the organisation as it encompasses all the components that can make (or break) the organisation. These will include:

- Finance,
- Marketing,
- Sales,
- Strategic Planning.

There are activities and there are relationships and one of the underlying principles of management is to successfully model these in order to obtain the optimal mix for the particular task(s) in hand.

A senior manager will usually have several individual team or project managers working for them. Each team manager has the responsibility for their team's performance and the relationship is usually hierarchical.

The notion of **Objectives > Goals > Mission** (OGM) is a common one amongst followers of management strategies.

6.3 Practice

In essence, the management of an organisation will determine the mission, goals and objectives of the organisation and set these down in some form of a business plan.

Once the business plan is set down by the management of the organisation, it must be implemented, step by step. This is achieved by issuing work packages to staff at a lower level.

The management team establish the policies for the organisation and the non-management staff will execute the instructions contained in those policies to achieve an objective thus moving towards a stated goal.

6.4 Professional Development

What has become more established over recent years is the concept of Continuous Professional Development (CPD). This concept assumes that humans are not born with the skills needed to progress through life, but rather that we are learning all the time.

The continuous learning and development process may begin at school, continue through college or university and right through our professional working lives. We learn by our mistakes and by the mistakes and experiences of others. We attend seminars and conferences to discuss and share ideas.

It is fundamentally true that people are the most valuable resource to any organisation. If people can be trained to a high degree of competence in a given field and they can continue to develop their expertise throughout their career, then they can become experts in their field and help to pass on that knowledge and expertise to others.

6.5 The Issues

ATMOs exist to provide a specific service to their customers in return for some payment.

However, without the people who staff these organisations, they simply could not operate. For people to be involved on such a scale, there must be some element of planning for the optimal use of this scarce resource. This process of MP (and the problems highlighted by it) might be better understood if both the process itself and the problems it highlights were viewed as social phenomena - similar to that found in nature and in some more mechanical systems.

Specifically in MP, issues like staff policies, staffing levels, working hours, licensing, training, recruitment and selection are all end products of social interactions between various people and can be described as having basic open-system characteristics.

6.5.1 Interactions and Interdependencies

There must be constant **interaction** between an ATMO and its environment. Those interactions constitute a flow of input to the ATMO, which may be summarised as customer demands, laws and recommended practices as issued by the regulatory bodies.

Ideas and information flow into such an organisation and are processed internally (one of the transformation processes) to produce policies on best practices which are then fed back into the environment as an embedded product of the organisation via other transformation processes by way of ATS. The entire process is highly regulated and conducted within the International Civil Aviation Organisation (ICAO) rules and regulations. Internationalisation and harmonisation programmes like EATCHIP are part of this ongoing interaction between ATMOs and their environment.

ATMOs, like any other organisation, are subject to the effects of **internal interdependencies**, which can cause changes in one part of the organisation to affect one or more other parts with a 'knock-on' effect.

Even a minor change to one part of a team can affect the larger subsystem, such as an ACC, which in turn can affect the still larger ATMO, which can affect the even larger air transportation system and so on.

6.5.2 The Notion of Feedback

Like most major organisations, ATMOs rely quite heavily on some sort of information about the output of the process being fed back to the input as a method of establishing and maintaining control in a fashion generally called management. Feedback can be useful at any of several stages. It can be used to control individual transformation processes and it can be used to control the whole ATMO process and improve the quality of the output. An example of the use of feedback is to be found in [Annex E](#).

ATMOs are not, by definition, self-correcting systems. However, by designing and implementing appropriate feedback loops, errors can be corrected by the ATMO. Some errors even have the potential to change themselves, but this is not generally an automated process as used in more mechanical systems.

Much effort within an ATMO is put in to designing and implementing these feedback systems. Typically, such systems would be embodied in processes such as refresher training, quality assurance monitoring programmes and safety investigations, surveys amongst pilots, representatives from airlines, airport authorities or staff. Financial reports are also part of the feedback system.

6.5.3 Attaining Equilibrium as S_1

Generally speaking, ATMOs seek a state of equilibrium. When they are out of balance, they tend to seek ways to re-establish their previous comfortable state. This may be in the form of re-sectoring the airspace, altering the level of intake for *ab initio* training or amending charges.

Aviation safety is of paramount importance, so this aspect is usually monitored particularly closely. Intervention programmes are usually implemented immediately if the level of aviation safety appears to be out of balance.

6.5.4 Multiple Routes to a Single Objective

ATMOs tend to display equifinality (same end-result). It is therefore possible to have several different organisational structures (or system configurations) and have them lead to the same conclusion or output or desired state (S_1). It is appropriate to conclude that there is no 'one way' of doing things.

Alternative routes to achieving S_1 have to be considered by the decision maker and cost-benefit analysis should really be conducted as a part of the decision making process.

6.5.5 Survive to Operate

ATMOs can adapt - in order to survive - and evolve. The major stimulus in this respect is frequently a change in the operating environment. Generally speaking, ATMOs will try to retain a favourable balance between their inputs and their outputs.

The inputs are usually considered as 'resources' and these are always limited in quantity and quality. With these limited resources, one is expected to safely accommodate every user of the airspace as the primary task designated in the output field. In addition, the ATMO management will be expected to maintain a viable relationship with the local environmental interest groups.

The act of balancing as one progresses along this tightrope seems an impossible one. Another issue is that of 'what is a favourable level of operation'. This has to be decided by the ATMO management. Clearly the safety of the travelling public must be paramount in this respect, but must also be balanced with providing an affordable solution. We all have budget targets to meet.

To think about ATMOs as open systems gives a hint of the dynamics involved, but the open systems theory is not really sufficiently explicit to use as a model for the purpose of MP. Therefore, the theory has to be expanded somewhat.

6.6 The Need for a Business Plan

As with any business, the ATMO needs to develop and implement a business plan. This document becomes the essential route-map to achieving the objectives and goals as established by the decision making subsystem, with regard to any input received from the wider system and the environment.

The business plan for the whole system will also contain a distribution of responsibilities within a hierarchical system, and should state what control systems are to be used to manage the transformation processes.

It is intended that the ATMO should, as a system:

- behave purposely;
- attain its goals;
- be adaptable to its environment;
- control its resources;
- keep its identity;
- be able to evolve.

The structure of a business plan usually follows the theory of open systems, while the planning process usually starts with inputs in order to define:

- business threats and opportunities;
- historical successes and failures during the past planning period;
- the organisation's strong and weak components;
- areas for improvement.

While the input might be qualitative and more 'soft' than 'hard' information, the output is usually specified as quantitative output that can be measured and which fit into some control system. Specifications and quantification of output usually stated in a business plan are:

- the purpose of the organisation and the most important customers;
- specific output objectives to be reached within a specified time frame.

What the ATMO is going to do can be stated as activities. The resources allocated to the activities form the basis for budgeting. The structure of the organisation and defined resources are then compared with the specified activities, to see if they truly support the activities.

The business plan for the whole system serves as an input for each subsystem, and each subsystem produces its own (specific) form of the business plan. The business plans are then harmonised with each other and with the system as a whole through managerial communication.

In some organisations this planning procedure is distributed to each independent level of the organisation. The procedure is a top-down approach, which starts from the highest level of the system as a whole, down to the smallest independent subsystem or project.

6.6.1 The Essential Components

Strategy may be defined as being the art or science of planning or a particular long-term plan for success - especially in business or politics.

Policy may be defined as a plan of action adopted or pursued by an individual, party, government or business, etc.

If combined together, long-term plans emerge and these may be defined as high-level, long-term plans which may be formulated into a course of action that is to be adopted (or pursued) in order to achieve the stated business objectives of the organisation and confuse (or confound) the opposition.

An ATMO should have a business plan and within that, there are likely to be a number of statements and concepts set out in strategic terms that identify (or at least outline) the organisations attitude or approach to specific areas of business interest. In a highly detailed business plan, it is possible that these strategic statements will refer to a specific piece of work or an area of responsibility for the senior and middle management.

6.6.2 The Essential Components as System Inputs

These long-term policies may be said to form both part of the input to the equation in the business plan drawn up for the whole system and to define (in part at least) some of the outputs of the organisation.

The following (non-exhaustive, alphabetic) list may well appear in an ATMOs business plan and the policies (strategic or otherwise) will probably exist as the organisations prior statement of position on each point:

- aviation safety policy,
- customer satisfaction statement,
- disciplinary procedures,
- grievance procedures,
- health and safety policy for all employees,
- mission statement,
- overall policy for organisational expansion and development,
- pay grade policy,
- policy statement in handling hazards,
- policy to minimise disturbances to the flow of air traffic,
- revenue-related policy or statement,
- recruitment policy,
- training policy.

6.7 Management Hierarchies

In some organisations, horizontal management (a heterarchy tree) is applied as opposed to the more normal vertical (or hierarchical) structuring.

The advantage of the more traditional format is in information dissemination and the distilling of essential information to downstream employees.

One of the major complaints concerning horizontal management structures is that the individual managers fail to communicate effectively with each other over either a prolonged period of time (i.e. they consistently fail to communicate) or they fail to communicate effectively on a matter of crucial importance to the ATMO, resulting in a void and / or decision paralysis. Some of this may be attributed to the sheer overwhelming effect of too much information, which might need further levels of distillation.

A good information dissemination strategy is clearly needed to assist managers to influence the process and to make their decisions.

6.7.1 The Need for a Management Hierarchy

Management is sometimes defined as “the process of planning and controlling activities, often on behalf of those responsible for them.”

Management - as a group function - does not exist for its own sake normally, but to achieve a particular set of goals (see also the OGM notion mentioned in Sub-chapter 6.2). Management is therefore a priori goal-orientated rather than being open-ended.

It is interesting to note that Hamilton (1997) considers that traditional management cannot effectively examine the inter-relationship or the integration of multiple activities. Nor can it provide a basis for an integrated, systematic organisational model. A problem therefore occurs when the target objective is change (or the introduction of change). Management is the control and regulation of the transformation processes that turn inputs into usable outputs.

However, a management hierarchy must exist. In a true hierarchy there must be an uppermost node or element such as the President or Managing Director and a number of people from a diverse range of backgrounds to form the executive decision making body immediately underneath the highest node, each member of which will have his or her own specific area of responsibility to the decision making body. Refer to the team cult paradigm mentioned in Sub-chapter 5.2.5.2.

The advantage of such a hierarchy is the distillation of information downwards from the decision making body to the front line employees via the appropriate member of the decision making body and his or her managers. This allows decisions to be made at a high level - perhaps without the more emotive

factors that often accompany decisions that affect human beings – which might be more prevalent in lower orders of the management structure.

It also allows the line managers to operate at a day-to-day level without the worries or burdens of higher echelons of management.

Returning to the previously established model of a system for a moment, and considering the decision making subsystem as the management levels mentioned above, it can be inferred that the decision making subsystem will have responsibility for items such as:

- steering the business activities along a course for success in accordance with the strategic business plan;
- providing resources (including human resources) to the system components;
- deciding on the transformation processes to be implemented and maintaining control over subordinate components of the system;
- receiving reports and using them to assess the system's performance.

6.7.2 The Importance of Systematic Feedback

By definition, feedback is normally a small portion of the output fed back to an earlier stage of the process, so in order to close the management loop, the system is being judged on its output quality as well as quantity.

The most important information for the system as a whole is the feedback it receives from the wider system (as defined earlier) and the environment.

Information provided as feedback from these sources provides a measure of the effectiveness of the system as a whole. The planning process starts with an analysis of this feedback information. See also [Annex E](#).

6.7.3 Feedback as an Information Source

Feedback on the recent performance of the system as a whole might show a shortfall when compared to the objectives stated in the business plan. These might include factors such as internal or external feedback.

6.7.3.1 Internal Feedback

Internal feedback can be highly subjective unless care is taken by the management to maintain objectivity by using an internal quality auditor who would be responsible for examining the general quality of the output or products supplied and comparing that against agreed objectives or other criteria established by the organisational management.

Typical areas or issues identified by internal feedback might include:

- a current shortage of trained, fully qualified ATCOs;
- a projected increase in overtime costs;

- ATCO equilibrium will not be reached in the coming three years;
- insufficient gross revenue generated;
- insufficient return on investments;
- safety standards are falling below an acceptable level;
- a tendency to mistrust managers on all levels;
- a tendency towards dissatisfaction with opportunities to contribute to and participate in, the overall development of the ATMO.

6.7.3.2 External Feedback

External feedback will often be more objective than internal feedback because the information will be coming from either external quality auditors or consultants or possibly from the customer(s) direct - such as the airlines.

The nature of the feedback received from the outside world (the wider system or the environment) might tell the ATMO:

- the ATMO is not maintaining sufficient control of air safety;
- safety standards are falling below an acceptable level;
- aviation safety must have highest priority;
- growth of air traffic continues to rise;
- restrictions during peak periods might be necessary;
- insufficient flexibility or adaptability towards environmental change exists.

6.8 Linking Strategic Planning to Manpower Planning

Strategic planning combines open systems theory, viable systems theory and general control theory in MP - often based on a three or five year sliding-window model.

Outputs can be identified - such as a purpose for the existence, what makes an ACC unique when compared to other ACCs, how the system is going to adapt to the environment and reach the desired objectives.

One of the essential inputs to the whole equation is the manpower. Strategic planning for the optimisation of the human resources will initially be the domain of the most senior level of management, devolving down to become the responsibility of each individual subsystem as the system moves from being in initial start-up mode to normal daily operation.

In the following table, some of the strategic issues needing to be addressed by top management are tabulated together - with their evaluation methods and possible outcomes. These might form individual strategies.

In summary, these factors may be tabulated as in Table 1.

Table 1: Issues, Evaluation Methods and Likely Outcomes

Manpower Issues	Evaluation Method	Outcome(s)
Poor work performance	Peer or Supervisor assessment	Refresher training, counselling or job review
Refresher training	Supervisor or course trainers formal assessment	Increased individual productivity eventually Short-term loss of manpower
Excessive Absenteeism	Formal, against specific criteria Expert assessment	Offer of professional help Resolution of the problem(s)
Job review	Supervisor, management or expert assessments	Possible loss of affected personnel to the ATMO
Shortage of FDAs	Higher than normal workload on others	ATCOs working as FDAs
Shortage of ATCOs	Higher than normal workload on others	Reduced air traffic capacity High workload level
Low morale generally due to less than optimal management style	Feedback from subordinate staff High workload levels	Development of improved management / leadership training programmes
Equal job opportunities	Comparison ratio of female / male controllers and ratio of female / male supervisors	Promotion of more female ATCOs to supervisor positions
Higher than predicted overtime expenditure	Financial performance figures	Implementation of an improved shift rostering programme

If these issues are addressed at a strategic level, the **quality** of both the evaluation and the eventual outcome must be enhanced, leading to an improved working environment and a lower turnover of personnel as well as to lower long-term business running costs.

6.9 Managing the Input Resources

6.9.1 People as Inputs to the ATM Process

When looking at the bigger picture formed by the ATM Process, there are a small number of very significant inputs. The weight allocated to each input is of critical importance for the successful calculation of the equation.

If people are considered to be one of the key resources in this equation, then the inputs to the people should be considered for a moment, including factors such as:

- age,
- conditions at home,
- financial affairs,
- health,
- morale.

These factors will all have some effect on each and every member (or potential member) of the staff. With these factors in mind, it is reasonable to allocate a weighting to each of the component parts making up the total input.

The authors have allocated an arbitrary figure of 50% to the humans as they are considered so important to the input of the equation, with the remaining 50% divided between the other input factors.

6.9.2 Other Inputs

The planning model needs to deal with the question of what kind of inputs the system has to work with, what kind of outputs it needs to produce, and how the major components of the transformation process interact with each other. In modelling the behaviour of ATMOS, key constructs extracted from system theory will need input information on items such as the:

- ATC equipment in use;
- government influence on policies;
- influence exerted by the environment and by history;
- economic climate.

A weighting of each of these elements needs to be done, to reflect their effects, both jointly and separately.

It is important to weight each factor correctly, or a disproportionate change will be seen at the output of the process for any given delta, rate of change (Δ) on the offending input.

6.10 Managing the Organisational Outputs

Outputs describe what the ATMOs produce as a system. There are basically three items that act as quality indicators for the intended system output:

- goal attainment;
- optimal utilisation of resources;
- adaptability.

6.10.1 Goal Attainment

Goal attainment is a measure of how well the ATMO is meeting its objectives, as compared to those stated in a previously published strategic management document or business plan.

6.10.2 Optimal Utilisation of Resources

Optimal utilisation of resources is achieved when S_1 is reached with minimal wastage or over-allocation of available input resources to complete the tasks stated in a business plan.

6.10.3 Adaptability

Adaptability is a measure of how an ATMO is positioning itself in respect of its opposition and its environment and how well it modifies itself to changes occurring independently within that environment, thus modifying the **effect** the environment is exerting upon the ATMO at any given moment in time.

While the former two are fairly objective in their measurement of the output performance, the third is much more subjective and therefore open to individual misinterpretation.

6.10.4 Measurement of Outputs

In ATMOs output performance is generally measured in a monetary unit or some other quantifiable unit, such as the number of air movements or minutes of delay incurred per aircraft.

A typical (but non-exhaustive) list of output measurement criteria might be:

- profit level or return on investments;
- level of en-route charges or some portion of the landing fees;
- direct sales (e.g. of knowledge, expertise or publications);
- number of air movements within a controlled airspace;

- number of departing and arriving aircraft at airports;
- number of delays due to ATC;
- total delay time;
- number of reported separation losses attributable to ATC.

6.11 Attaining S_1 from S_0

Clearly, one intention of most ATMOs is to improve the level of service they provide to their customers. This future state of the ATMO is described as S_1 in systems terms and may be achieved by progressing through a number of clearly defined transformations under the guidance of management.

As with most organisations, these new (revised) goals should be documented in the ongoing process of revising the business plan and communicated to those within the organisation that need to be aware of the change in strategic planning.

Once agreed by the management as the improved position to strive for, this revised state becomes S_1 and the existing state (whatever or wherever it may be) becomes S_0 and the transformation process is revised accordingly. Clearly, this is a dynamic and continually evolving process.

6.12 Task Assignment - System Level

ATMOs may maintain as 'whole-system' objectives some or all of the following:

- continual improvement in aviation safety;
- continual control (or reduction) of operating costs;
- increased gross profitability;
- increased return on investments;
- reduction of time lost between project development and implementation;
- retention of position as a reliable and adaptive business partner.

All subunits within the organisation should have the same output objectives, but differences will exist between subsystems. Specific activities are derived from these objectives and will be pursued individually.

6.12.1 Total Quality Management Programmes

Typically, our example ATMO is planning on using the next three years to implement a Total Quality Management Programme (TQM).

In the implementation of TQM, the ATMO intends to evaluate risks and hazards (including insurance issues). See also Sub-chapter 7.1 on Risk

Management. Emphasis is put on the prevention of costly operational violations and errors and the use of human resources will be monitored more closely than before.

6.12.2 Improved Information

As well as improving the quality of the management, one has to examine the need of the managers. How do they (as humans) improve their particular domain's performance ? One method is to improve the quality of the information available within the system as a whole. That is not to say increase the quantity, but to perhaps reduce the **quantity** and improve the **quality** of the information which is available.

6.12.3 Expert Skill Areas

The definition of human performance as “the level of expertise with which an individual executes behaviour that has relevance for one or more organisational goals” is relevant to this document. Human effectiveness is very closely linked to the particular outcomes that the ATMO is striving to produce.

All the following activities can be categorised into different tasks that demand expertise and skills. The different demands in this particular subsystem to have the staff involve themselves in are:

- ATC;
- HF and Aviation Safety;
- Operational Procedures within ATC;
- ATC Training;
- Supervision and Management;

These expert skills are partly overlapping each other but each of them also has unique properties that identify them individually.

To the list of activities above can be added the ongoing or constantly occurring activities of ATC such as the training of ATC students for specific ratings and the familiarisation training of *ab initio* students. There is also the rating training of licensed controllers returning from leave or those who transferred in from another unit.

6.12.4 Development of Expertise

Expertise can be seen both cognitively and behaviourally in the mastering of a task. **Cognitively**, experts tend to have a more enriched semantic knowledge concerning the structure of their particular domain of expertise.

Behaviourally, experts can usually present a more detailed level of information concerning problem solutions, as well as being able to describe

more fully causes (and effects) for any given situation within their domain of expertise.

Expertise is something that is recalled dominantly from our long-term memory. This view is supported by William, David and Burwitz (1993) who claim that experts retrieve a greater number of concepts with more defining features when recalling information systematically from their long-term memory.

This superior declarative knowledge is only acquired and proceduralised by executing a task under a range of different conditions over extended periods of time. The learning process takes place through direct experience rather than through formal training or simulation programmes.

Feedback is required for deeper learning. In development of expertise, a well constructed feedback system can substantially shorten the learning process as it provides a valuable input to the learner during the formation period.

6.12.5 Task Assignments - Subsystem Level

Several activities established by the system can be devolved to subsystem level. Typically, these may well be:

- study and evaluation of the phraseology used by ATCOs;
- continuous human performance appraisal;
- methodical development of the executive and planner positions;
- regular meetings between interfacing sub-subsystems;
- monthly evaluation meetings with the staff regarding reported incidence and other operational experiences;
- training in air traffic deviations and irregularities;
- management and supervisor training;
- generation of a regular news letter to the staff;

6.13 Task Analysis (TA)

To assess the differences between specific skills, knowledge and abilities that are demanded in each of the requested tasks, a TA should be completed for each of them.

The TA should include the objectives and goals that are expected as output results from that activity.

6.13.1 The Output Objectives and Goals

The output can be a training course, a rating for a licensed ATCO, a manual on certain procedures, a restructuring of the airspace or the release of a technical manual or an item of software.

The objectives of the TA are to pinpoint the specific behaviours that are connected to each particular task.

Campbell and Campbell (1988), distinguishing between human behaviour, human performance and human effectiveness, found that the purpose of TA and the subsequent construction of performance appraisal instruments fitted in very well with their theory on human performance and effectiveness.

From the goals, the analysis continues with what specific behaviours are connected with each of these outputs. There are several standardised methods to follow when conducting such a TA.

6.13.2 Analysis of Task Mastery with Subject Matter Experts (SME's)

The analysis of performance mastery can be performed by holding interviews with SMEs, to establish 'an informed body of professional opinion'.

Typically, such interviewers could ask each SME a series of questions:

- Q1:** Whether they noticed something being done remarkably well (or not) when it is within their particular domain of expertise.
- Q2:** Address the problem of complexity - as the SME remembers it.
- Q3:** What behaviour was observed in the complex situation ?
- Q4:** What consequences followed the performance of the action - both for the organisation and for the expert ?

From this type of analytical questioning, scales can be constructed to measure mastery of performance in other individuals who are not necessarily classified as SMEs.

Behaviour Anchored Rating Scales (BARS) are sampled by this method. BARS focus on the behavioural dimensions, both cognitive and overt within the cluster representing a specific dimension. Most research has shown these types of scales to be superior to trait scales when measuring mastery of performance.

6.13.3 Behaviour Anchored Rating Scales as a Feedback System

One of the most important issues in MP is to develop tools for complete and accurate description or assessment of human performance.

The advantage of BARS is that they also serve the purpose of assessing various development needs as well as defining the performance components within the domain of expertise.

A development need is defined as the difference between a person's present assessed performance level (S_0) and the level of mastery (S_1) within the same domain of expertise.

BARS have a third advantage in their function to serve as an accurate and precise form of systematic feedback with additional inputs gained from the informed body of professional opinion.

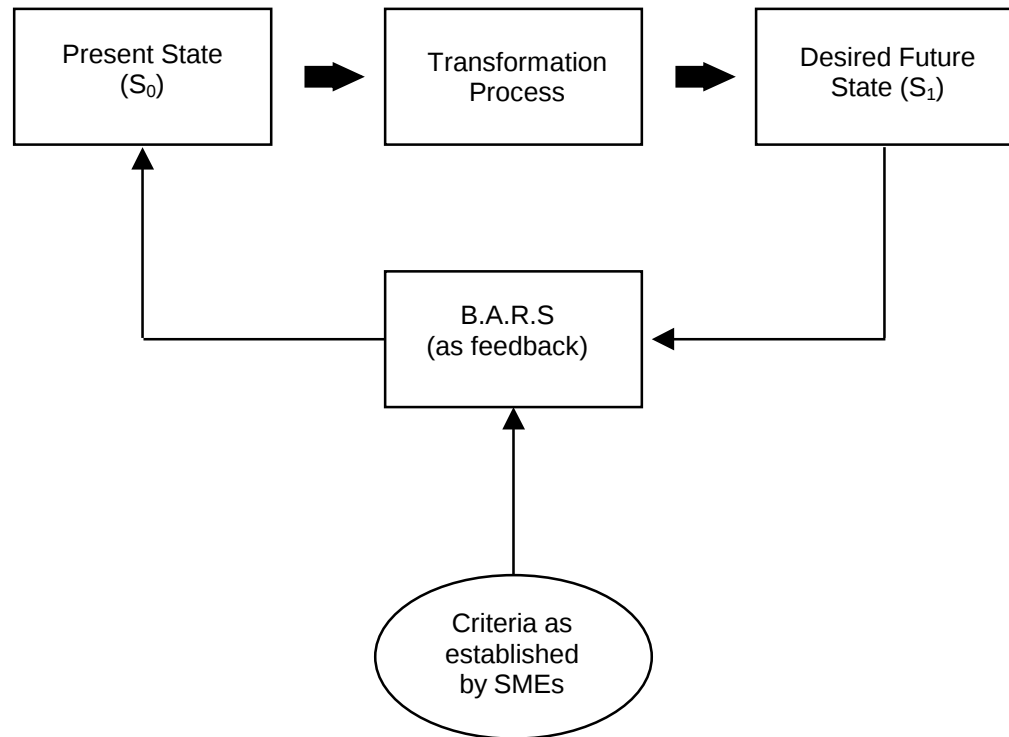


Figure 6: A schematic view of BARS in feedback mode

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7. PLANNING AND DECISION MAKING CONSIDERATIONS

The management of an organisation today has the responsibility for making decisions that affect the ability of the organisation to survive. The need for the decision may come about as a result of the implementation of the business plan, or as a result of an action stemming from the business plan.

There is always an element of risk in decision making and several formal decision making procedures exist. In this Chapter, we shall look briefly at some of the more topical issues surrounding formal decision making.

Risk is a measure of the probability of an event occurring, coupled with the significance of the outcome or consequence of that occurrence.

7.1 Risk Management

Risk management at a project level is likely to include the processes that are concerned with uncertainty. Project risk management usually includes processes that assist humans with the tasks of:

- risk identification;
- risk analysis (including any quantification);
- development of a suitable response (e.g. risk mitigation, risk acceptance);
- risk control.

Risk and opportunity are essentially the opposite sides of the same coin. They go hand in hand. Risk can also be classified by source into one of five broad categories, namely:

- external (predictable, but uncertain);
- external (unpredictable);
- internal (non-technical);
- technical;
- legal.

The major effect of risk has been to force projects over-budget (e.g. to overspend) and over-time (e.g. to prolong). When serious overruns occur, the effects on the organisation can be dramatic and very damaging. In an extreme case, it can turn a profit-making venture into a loss-making one.

7.1.1 Risk Analysis

Risk analysis is defined as one of the decision theory group of mathematical techniques. Risk analysis is a complex study of probability, sometimes used as part of operations or operational research (Johannsen and Page, 1990).

The purpose is to evaluate risks and to analyse how far forecasts might go wrong and to estimate what are the implications and costs of being wrong.

Other decision theory techniques in this area include games theory, sensitivity tests and utility theory. In investment appraisal, risk analysis assesses the danger of failing to achieve the forecast outcome (or yield) of an investment.

Risk analysis is frequently undertaken by insurance companies and banks when assessing their element of risk in a proposed project or new enterprise.

'Risk' implies that the law of large numbers is applicable, and that the outcome of a choice is likely to be known to the decision maker. If the outcome of the same choice is unknown, then the decision is not made under conditions of risk, but under conditions of uncertainty.

Risk analysis also employs comparison techniques, so previous projects that had similar aspects to the present one may be used to provide the risk analyst with knowledge on the sources and implications of the risk elements.

7.1.2 Risk Simulation

This technique is used with the risk analysis technique when modelling a given situation. The simulation allows for several different scenarios to be played out, normally on computer, and their differing outcomes assessed against a standard set of parameters.

The act of simulation allows exploration of the quantification, response and outcome aspects of the risk and will also provide indications as to sensitivity of the model.

Risk simulation may also point to a specific cause that is considered as a threat, thus allowing a suitable directed response to eliminate the threat and thus remove (or reduce) the overall risk element.

7.2 Mental Models

In system dynamics, the term mental model stresses the implicit causal maps of a system, beliefs about causes and effects within that system, the boundary of the model and the time horizon that is considered relevant to an articulation of a problem (Sterman, 1994).

Argyris (in Sterman, 1994) has illustrated the loop in between what is actually taking place in the real world, information feedback, decision making, creating mental models and formulation of strategies and decision rules.

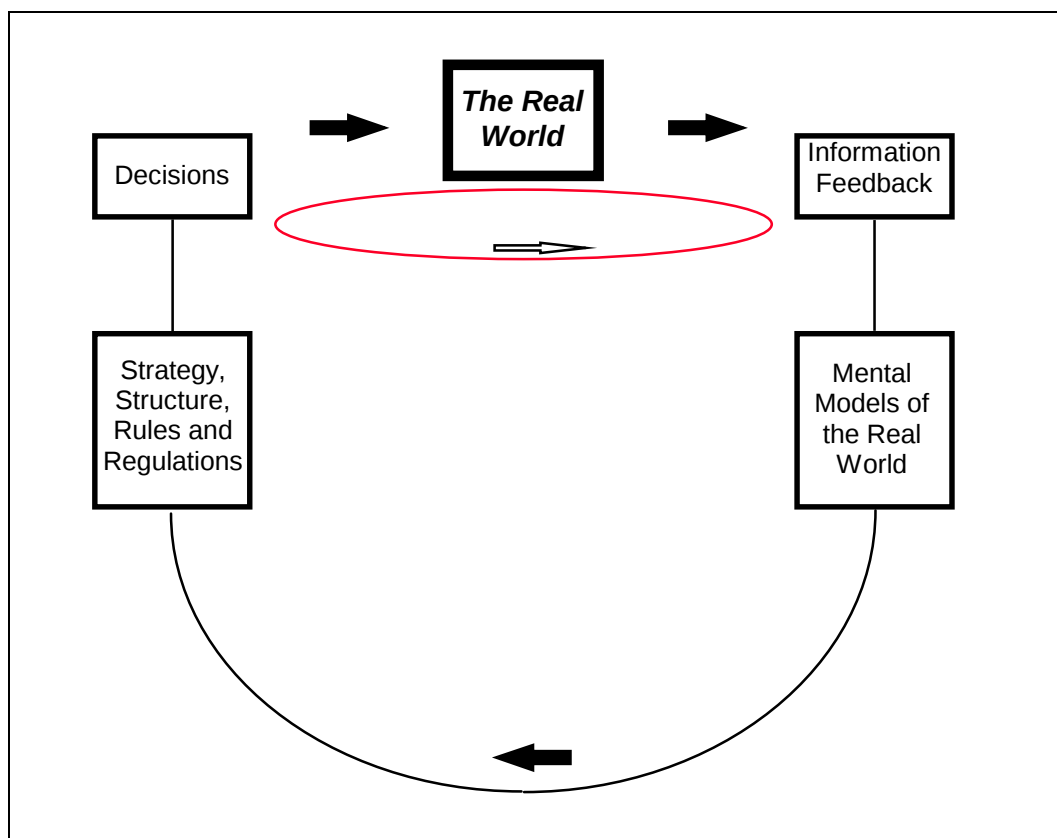


Figure 7: Argyris' single and double loop learning model.

The ellipse between the real world, feedback information and decisions represents a single loop orientation, which can be described as

Action → Change → Reactions

The curved line between the mental models of the real world and strategy, structure, rules and regulations represents the loop between the decision makers understanding of the real world integrated with formal rules and strategic policies that support the decision making process. By integrating a single loop with understanding of the real world, the decision maker is trying to be proactive. Sterman (1994) strongly advocates a holistic approach when trying to cope with change.

7.2.1 Using Virtual Reality to Model S_1

When thinking about the future along a linear time line, the human mind automatically and unconsciously begins to form images of that future state.

These images of S_1 are the product of information fed back from various sources and they act as models for us to base our decisions on. Such a model is sometimes the only information available upon which to base the decision - and these mental images may not be very accurate.

7.2.2 Problems with using the Mental Model to Predict S_1

A problem occurs when **anticipating** the condition of S_1 from the S_0 .

One of the problems with using mental models is that the accuracy of the prediction is less than perfect. As an example, in one State, it was predicted that the speed of technological change and automation would greatly affect the work of the FDA.

Most of their work, such as transmitting information about time estimates of the traffic flow between Flight Information Regions (FIRs) and correcting flight plans that the automated system might not accept, would disappear due to improved automation and reorganisation of flight plan handling.

A decision was taken to invite all FDAs to a retraining programme. 50 applied for ATCO training and 25 were selected as being suitable. Twelve months later the model of the near future was revised in the light of information received back from the ACCs predicting a shortage of FDAs.

Selected *ab initio* ATCO trainees, who had not yet started their training were invited to train as FDAs and work in that role for at least two years.

A few of those who started the training failed to complete and manpower plans for recruitment and selection of ATCOs had to incorporate training for FDAs as well. In addition to calculating the attrition rate for the *ab initio* ATCO trainees, an attrition rate for FDAs during training had to be included as well. This example illustrates the importance of the decision maker's model.

7.3 Time and Its Effects on the Process of Change

7.3.1 The Perception of Change

The perception of change is dependent on feedback information and the duration between change itself and the feedback it generates. If change is caused by deliberate decisions, the time delay between the decision and its effects being felt may well present a problem to management.

One example of this time lag within MP is when managing a project aiming for an improved candidate selection procedure. The objective is to select only those candidates estimated to have the highest ability for ATC work and to reduce the number of candidates who are more prone to failure during training as the place on the training course is extremely difficult (if not impossible) to reallocate.

The basis of the selection procedure is, in most cases, an existing test battery. The initial selection process is based upon the scores achieved by each individual candidate. Also, during the training course, each trainee will be subjected to a number of separate tests which will produce scores of some description.

If, in addition to the initial selection tests, one were to also administer a new test battery in the initial stages, it may be possible to calculate a more specific relationship between the scores attained on the new test battery and some regular performance score achieved during normal ATCO training.

7.3.2 A Valid Test Battery

If this relationship is proven over a number of intakes, then the approach is validated and the second (newer) test battery does indeed have some direct relationship with some specific score on the training course. Once established and validated, it would be possible to administer the second (new) test to incoming candidates to see what sort of score they might achieve at that same test point during their own training course. A valid predictor then ?

However, the time lag between the initial decision to modify the selection procedures (as above) and receiving the empirical data (feedback) on the second (new) test battery takes between three and six years, which includes the time spent collecting and processing student performance data from both the ATC training facility and from the first years a newly qualified ATCO spends on the job. There are also other concurrent-related validation procedures which give results in a shorter period of time (EATCHIP, 1998).

7.3.3 Time for Substitution ?

Assume then that the new test battery has been tested and validated over a period of time, with some very encouraging results in the first instances, but these have been getting progressively poorer as time moves on.

Assuming there exists a positive relationship between the test score and some performance score, a second decision will have to be taken to substitute the original (old) test battery with the new one. However, by the time the change is implemented, the relationship may no longer be valid - due to the passage of time necessary for the validation process itself to occur !

7.4 Problems with Feedback

Feedback is information concerning the outcome of a process which is fed back to an earlier stage of the process in an attempt to refine the process somewhat.

Feedback can take many forms, but is usually a small sample of what is coming out of the process. This may be achieved by a survey for example, or perhaps some form of an operational test - to attain the next step up the normal ATCO career development ladder.

One form of corruption to the quality of the feedback is called 'noise'. This noise can take many forms, ranging from random irregularities in the reporting chain (white noise) to a persistent error being caused by somebody incorrectly filling out a sheet of paper due to misunderstanding the question.

7.4.1 Diversity of Feedback

Over-reliance on any one form of feedback will inevitably create an unrepresentative sample upon which decisions will be made.

In order to maintain the quality of the feedback, a multiplicity of sources should be sought, creating a divergence or diversity that will help to reduce the effects of a single (sole) source.

7.4.2 Noise in Manpower Planning Feedback

In most MP situations there is only limited (and possibly imperfect) amount of information available as feedback. The information available to local managers regarding MP might point towards a state of equilibrium regarding the supply and demand of ATCOs over the next five years. This is the situation they report to top management. The decision that a balance exists in the supply of ATCOs, which meets projected demand for the next five years is taken. No additional recruitment is instigated at this moment in time. In past years many developing projects have been postponed due to a shortage of ATCOs. Those projects now get 'go ahead' decisions.

Both ATM system development projects and personnel development projects start and are staffed with ATCOs. Two years later a shortage of staff is reported by the same managers for the forthcoming years. The situation is reviewed in the light of the new feedback and fresh decisions are taken to expand the intake of *ab initio* trainees. The expansion of the number of trainees leads to a greater demand for instructors by the training facility. The

situation has now become such that the top managers have to revise policies for special leave and have to prioritise between the started projects.

From a systems view, the ambiguity of the feedback arises because the changes are resulting from internal decisions and are becoming confused with changes in a host of other variables. Therefore, effective management is difficult, due to this dynamic complexity.

One may draw the conclusion that noise in the feedback portion of the system is detrimental to the decision and the decision maker when one is considering MP or staffing levels.

7.5 Organisational Effectiveness, Efficiency and Productivity

Mahoney (1988) writes about how managing human resources can help organisations increase productivity. Productivity is an efficiency concept that describes the ratio of output to input in some productive process.

The concept of organisational effectiveness and organisational efficiency (often associated with organisational performance), is linked closely to measures of economic performance.

7.5.1 Organisational Effectiveness

Organisational effectiveness relates to the level of performance in comparison with stated performance objectives.

7.5.2 Organisational Efficiency

Organisational performance efficiency relates to the relationship between input and output, regardless of output.

Mahoney (1988) stresses the importance of organisational efficiency being measured in terms of:

- Outputs from any organisational level in relation to inputs at the **same** level.
- NOT as outputs from one level compared to inputs to a **different** level.

Within our particular framework, a good example is that of:

Enroute control → Approach control → Aerodrome control

7.5.3 Organisational Productivity Relationships

Productivity is defined as a relationship which exists between the input and the output of a production or service unit, where the input is measured in terms of a workforce, machines, materials and money whilst output is measured in terms of products and / or services (Johannsen and Page, 1990).

In systems terms, there are essentially two forms of relationship:- One to Many (1 : M) or Many to Many (M : M).

Organisational productivity (OP) is a concept that relates to the efficiency of the organisation. OP can be couched in one of these two relationship forms:

- total-factor,
- partial-factor.

Total-factor is the relationship where **all** inputs are considered to contribute to the entire output while partial-factor is the relationship where only **some** of the inputs are considered to contribute to the output.

7.5.4 Total-factor Productivity Relationship

Total-factor productivity is a M : M form of relationship where the total system output measurements are related to all the inputs of the system in a complex fashion.

In our ATMO, this form of relationship would include factors such as traffic complexity, weather, technology, training, government, working conditions etc. Each factor makes a weighted contribution to the overall output of the organisation. Each factor contributes to some degree of the overall productivity, depending on the weighting applied to the individual factor.

7.5.5 Partial-factor Productivity Relationship

Partial-factor productivity on the other hand can adopt one of three possible states:

1 : 1	1 : M	M : 1
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- **1:1** One output is compared directly with one input.
- **1:M** One input is compared with many outputs (can be several or all).
- **M:1** Many inputs (can be several or all) are compared with one output.

7.5.6 Output Measurements

Please refer to [Sub-chapter 6.10.4](#) for discussions on output measurement.

7.5.7 Input Measurements

Input measurements are (according to Mahoney, 1988), more difficult to define both conceptually and operationally than outputs. Particular difficulties occur when striving to measure the quality of human resources as an input to the organisation as this does not translate easily into a quantifiable unit.

Another difficulty in measuring an input in respect of outputs is that some categories of input are simply not attributable to any single output from the organisation but rather form an integral part of the whole output package, e.g. research and development or managerial training.

The final recommendations from Mahoney (1988) suggest the manager not be too focused on defining efficiency in a narrow sense, but to concentrate more on the overall performance effectiveness.

Campbell and Campbell (1988) supplement Mahoney's analysis of productivity in organisations, though they try to distinguish between human behaviour, human performance and human effectiveness somewhat more.

They define human performance as the level of expertise with which an individual executes behaviour that has relevance for one or more goals of the organisation.

It is only possible to speak of human effectiveness if it is linked to the particular outcomes that the ATMO is paid to produce. This linkage might not, for a single individual, be too straightforward and can be embedded in the performance of other individuals or groups.

Campbell and Campbell (1988) close their argument with three observations:

- keep non-performance related behaviours at a minimum;
- scale performance fairly accurately;
- develop a good understanding of how the performance of individuals is connected to organisational effectiveness.

Outputs are very rarely transformed by single inputs, but more often by interactions between inputs. Problems occur on the input side of the process too, such as deciding how to define or how to measure the human resources.

7.5.8 Productivity Improvements and Measurement

Productivity improvements need to be measured against some quantifiable unit if they are to be meaningful. Comparisons can be made for example, between production units or different years.

It is important that the comparison is done at the same organisational level, even if the overall performance of a complex system such as an ATMO is (in part) a function of the performance of several different component parts.

In this case, measures appropriate to each level of the analysis must be individually designed for the purpose.

7.5.9 Performance and Effectiveness Measurements

Measurement of organisational effectiveness is generally connected to the services or goods that are produced by ATMOs.

It is very rare that an ATMO produces one single output. There are core products such as ATS and by-products such as training, contracting to other States, provision of technical services or systems and saleable publications.

7.5.10 Human Resources as an Input

In MP, Human Resource inputs in an ATMO can be expressed in terms of the planned or desired outputs (often derived from traffic requirements, or other business opportunities) in relationship to the needed level of expertise and the time needed to execute that expertise.

Critical measurements will be on the level of expertise required, requirements for work hours, motivational forces and structural interactions within the ATMO.

7.5.11 Productivity as an Input Variable for the Planning Process

Productivity can be greatly affected by changes to the state of an input. **For example**, time used to produce / deliver a service or product, number of staff and / or direct costs for producing the service / product.

Changes in the transformation process will also cause a change in productivity. **For example**, automation is usually achieved by substituting one more expensive resource (e.g. staff) by a less expensive one (e.g. machine) for routine tasks. In ATM this is typified by automated message transmissions.

Changes in output(s) will also cause a change in productivity. **For example**, in terms of quality (e.g. less errors, that is less time being spent correcting production errors).

Productivity can hence be calculated and reviewed and a service or product has been delivered or be managed in advance by policy statements which aim to control productivity. The latter is an essential component of 'Management by Objectives' (MBO) where productivity serves as a performance objective to be reached.

In cases where productivity is used as a performance objective, it is essential to understand the determining variables such as measurements of inputs and

outputs. One example in ATM could be the relationship between the number of delayed aircraft passing through a sector and actual worked hours in a controller position.

In MP, it is necessary to know if the planning is for increased effectiveness of the ATMO or for an increase in its efficiency. Rule one for any manager is to know the outcome which they are aiming to achieve. As in all planning, a necessary ingredient is to know the purpose and outcome of the plans. It is therefore necessary for manpower planners to know if the planning is for increased **effectiveness** of the ATMO or for an increase in its **efficiency** or for both.

If the case is to increase **effectiveness** for example, production of ATS, than any means of increasing inputs which relate to output production - such as an increase of labour or capital - might be appropriate.

If the purpose is to improve **efficiency** in the process of labour and capital inputs compared to consumable outputs, then MP should aim for an improvement in productivity which is usually measured in terms of scarce input resources that are relatively costly. This can be done, for example, by more efficient scheduling of ATCOs, optimising the opening / closing time of sectors etc. as will be discussed in later chapters.

7.5.12 Other Factors

Another important distinction in calculating efficiency is the difference between 'rate effect' and 'level effect'.

7.5.12.1 Rate Effect

'Rate effect' is a general effect that occurs due to changes in technology and is generally felt right across a whole industry. Rate effect occurs for example, when changing from procedural (non-radar) control to full radar control.

Due primarily to improvements in technology, smaller horizontal separation distances between aircraft are becoming realistic and more feasible and therefore more aircraft can be handled during the same period of time. The changes being implemented by the ATM 2000+ strategy also contribute to this aspect of rate effect.

7.5.12.2 Level Effect

'Level effect' occurs when changes to methodology are implemented, for example, due to training of ATCOs. The ATCOs learn to apply minimal separation between aircraft in a consistent manner whilst operating in approach radar control and therefore increase the capacity of an airport. Level effect is closer to the concept of efficiency or quality improvements.

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8. THE MANAGEMENT OF PEOPLE

8.1 Overview

The purpose of MP is to provide a sufficient number of qualified personnel, on a timely basis, to ensure the provision of an ATS, (EATCHIP, 1996a). The task of MP can be expressed as controlling the inflow, throughflow and outflow of personnel to an organisation such as an ATMO.

MP is, according to Schuler and Huber (1993), to ensure that the organisation fulfils its business plan by forecasting human resource needs and planning the steps necessary to meet those needs. Thus MP consists of developing and implementing plans and programmes to ensure that the right number and type of individuals are available at the right time and place to fulfil the organisational needs.

If the human resources can be planned, they can also be managed. A controlled environment is a much more efficient one for an ATMO to operate in, than an uncontrolled one, especially in terms of the human resources.

Problems occur when the ATMO is more of a hierarchical system with many subsystems which are partly independent of each other, all of which have different outputs and are therefore in need of different types of human resource input skills.

Some of these differing human resources can be defined as:

- the required expertise, in terms of abilities, skills and knowledge;
- the availability of that expertise;
- the motivational forces that make the expertise persistent over time;
- overall system inflows, throughflow and outflows of personnel;
- manpower transactions between the subsystems;
- variations due to attrition rates in training;
- time spent on professional development.

8.2 Control Systems and Contingency Planning

A commonly used definition in respect of control systems is:

“A control system is one who’s purpose is to maintain control over one or more processes that might be influenced by the environment” (Martin et al., 1994).

To 'maintain control' over one or more processes within an organisation is effectively management, so it is reasonable to conclude that a control system may also be termed 'the management system' or just 'the management'.

The objective behind any form of control system is to make the expected happen. That statement infers preventing the unexpected from happening. However, in reality, there is always a possibility of the unexpected happening, but in terms of personnel management, it should not be totally unforeseen.

8.2.1 Contingency Planning

In control terms, contingency planning is simply an alternative route through the project with the original objective or goal still firmly in sight.

The control system (management) will be operating at typically four levels:

- strategic (or summary) level;
- coordination level;
- detailed level;
- single task or work package level.

Generally speaking, projects tend to be controlled at the second level, that of coordination.

It is generally considered impossible, at the beginning of a new project, to foresee every problem or opportunity, so the management should consider the possible (and perhaps the impossible) options that may cause the project to flounder or deviate from its originally intended course of implementation and construct a number of 'what-if' scenarios. These are usually referred to as contingency plans.

If the implementation of a contingency plan becomes necessary due to circumstances outside the immediate sphere of influence of the management (typically due to something happening in the environment), then valuable planning time will be saved if the management have a suitable alternative path or route available. For example, if the mental process of moving from S_0 to S_1 has already been undertaken for several different sets of parameters, then the project will continue along one of its implementation paths on time.

A typical example of this might be what is outlined in EATCHIP (1997). If the management have already made contingency plans for a drastic temporary reduction in staff due to industrial actions, the impact of the occurrence is minimised and the organisation will continue to function - albeit at a slightly lower capacity than normal.

By minimising the impact on the business objectives of the organisation by forward thinking and careful consideration of the alternatives, the management are controlling the intended outcome of the project or programme.

8.2.2 Control Systems within Social Systems

Within social systems (such as an ATMO), control systems are also very often called 'the management', indicating that there has to be a human decision making process involved. This matches exactly with the systems theory outlined earlier in [Chapter 2](#).

The management of manpower is generally achieved by a combination of:

- operating within the framework of the rules and regulations;
- consent;
- feedback;
- feedforward;

using the information gathered via the above methods to gain an improved understanding of the process or system that is to be controlled. In MP terms, it is also important to consider the range or architecture of exactly what it is that is in need of control to better focus the control system. This is discussed in more detail in [Sub-chapters 8.3 and 8.4](#).

Generally speaking, there are two levels of control applied in social systems unlike the four levels applied in project control. Control methods applied at the uppermost level of the system tend to exert a wider sphere of influence and are typified by the monitoring of system-wide safety levels and the overall financial status of the ATMO. In addition, the outputs of the higher-level control systems tend to be used as inputs to the lower levels of the control system.

Physical control systems however, (like time measurement) are more generally applied at the lower levels of the system architecture.

For control systems to be fully functional, the relationship between what is registered as an input and what is subsequently assessed as output might need some additional clarity.

The relationship between a system's inputs and outputs can fall into one of three categories:

- deterministic;
- probabilistic;
- dynamic.

A deterministic relationship is where the interaction between input and output can be defined precisely - like hours worked and the exact costs associated with that work can be accurately calculated.

A probabilistic relationship is a complex linear (or non-linear) relationship that fluctuates. This is rather like the relationship between the number of *ab initio* trainees accepted by an ATS academy and the number of licensed ATCOs that the academy produces with a rating.

A dynamic relationship requires specific inputs to be present before an output can be ascertained. There can also be a time lag before the true nature of the relationship becomes apparent.

8.3 The Manpower Planning Control Paradigm

What is it we seek to control with MP ?

It is the inflow, throughflow and outflow of personnel in such a manner as to ensure that a sufficient number of suitably qualified personnel are maintained at all levels throughout the organisation.

To fulfil such a purpose adequately, any control 'system' must operate within the normally defined terms of a system. Therefore, a system boundary would appear to be described by:

- a framework of rules and regulations;
- consent by the affected population to adhere to the rules and regulations;
- feedback on the effectiveness of the control system;
- feedforward of certain future input parameters.

The framework of rules and regulations has to exist in order to provide the basic operating parameters for the control system.

The consent is approval of the basic rules and regulations by the people affected and an acknowledgement of their adherence to the policies set down. Consent also provides an adaptation channel for regulations and policies in order to enhance attainment and help control the control system.

Feedback on the effectiveness of the control system can be information on a number of topics, but as people are of prime focus, the feedback should have at least some of the following attributes during the control period:

- provide a record of individual achievements;
- detail the hours actually worked;
- record the actual number of people joining the organisation;
- record the actual number of people leaving the organisation.

This information is fed back into the organisation as regulatory data to enable a reaction to be generated in a timely and meaningful manner.

Feedforward refers to certain input parameters which can be measured in advance, such as the number of staff who are going to retire during the control period, the average attrition rate from the ATS academy, the average number of applicants for each different post and so on.

8.4 Controlling Human Resources

An assumption can be made that not all staff perform their activities or tasks with equal attention to quality, even if they have received the same level of training. There will be individual differences between the staff members in the performance of any particular task.

For example, TA might show that the persons mastering the tasks are licensed controllers with both valid ratings and several years of operational experience in categories such as:

- supervision experts;
- experts in operational procedures;
- experts in ATC training.

For management experts it might not be as significant to be a licensed controller as it is to be experienced in ATM (perhaps with prior experience in other similar, leading positions).

To be an expert in human factors and aviation safety might not include a license as an ATCO or even a background from the ATC industry, but extensive knowledge and a thorough understanding of the ATM systems are considered to be essential components.

The staff of an ATMO system can be classified into three broad areas:

- licensed controllers with valid ratings;
- licensed controllers without valid ratings;
- not licensed controllers.

8.4.1 Use of Assessment as a Guide

Each staff member in each category could be rated on some sort of a scale. Ideally, this should be linear such as an interval scale. This exercise may be performed by the staff members themselves (self-assessment), their peers (peer assessment) or their supervisors (supervisory assessment) or any combination of the above.

The scale would provide numerical assessment on how each person performs (or thinks they perform) within each of the requested behaviour dimensions.

This procedure provides a profile or index indicator for each staff member. Motivational questions can also be asked on how much the subject would like to work with tasks containing the behaviour dimensions under examination.

8.4.2 Matching Employees and Tasks

Once the index indicators are compiled into a database, this may be queried for best matches against agreed criteria for any specific task or function.

However, one important issue in matching tasks and individuals (and therefore controlling the operation of the system) is to be able to measure the distance between the individual skills and the accepted level of mastery as outlined in Sub-chapter 6.12.3.

If there is a great distance in values (and / or attitudes) between the individual and the mastery level, no amount of training will ever close that gap successfully.

The value of this distance is a fairly major contributory factor in determining which individuals are considered 'ready' for further On-the-Job (OJT) training, and thus provide an effective degree of control over who advances within his or her career and who does not. Individuals whose values and / or attitudes initially differ too much from the objectives of the OJT will be held back until their values and / or attitudes improve or alter sufficiently to warrant the additional training. It is quite possible that those individuals will be more efficient to the ATMO doing something other than ATCO functions !

From a practical standpoint, Burke and Pearlman (1988) emphasised that the procedures for matching tasks with individual characteristics (through personnel classification), typically require little organisational change or broad new programme development. The cost and difficulty of implementing a big change programme are less than those associated with more interventionist strategies.

8.4.3 Control of Operations Staff

One method to determine personnel requirements of an ATC unit is given in the ICAO Document 9426 "Air Traffic Services Planning Manual", Part II, Section 1, Chapter 2. This method can be called the 'Manning Factor' (MF) method and can be formulated as follows:

Number of Staff to cover position	=	$\frac{\text{Hours of operation per year}}{\text{Effective working hours per controller per year}}$
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For example, an ATCO might have 65 non-working days in a year in addition to the normal weekend days, giving a total of $(104 + 65) = 169$ non-working days, which gives $(365 - 169) = 196$ normal working days in which to accomplish the statutory requirement for working hours.

Supposing that the regulatory working day is 8h45 - the obligatory breaktime of say 1h45, leaves 7 effective hours per day, which gives $(196 \times 7) = 1373$ hours per year.

For a 24 hours period of operation per day throughout a year makes 8760 hours to cover.

The multiplication factor would then be $(8760 / 1373) = 6.38$ (round up to 7) staff to cover one position for 24 hours a day for one year.

One flaw in this calculation is the fact that the shift cycle is not taken into account (influencing the number of off-days per year), the assumption being that the regulatory number of working hours fits in completely - whatever the shift cycle - on the assumption that all days calculated for leave, sickness and training are equally distributed over the course of a year.

In reality this will never be the case. The number of necessary staff calculated with the MF method will be - by definition - too low.

An alternative calculation method is presented in the following Manning Calculation Formula (MCF):

Number of Staff to cover position	=	$\frac{\text{Number of duties per day} \times 365 \text{ (days per year)}}{\text{Operational working days per controller per year}}$
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In this formula the number of duties per day is the minimum number of shift duties necessary to cover the Operational Requirement (OR).

Depending on operations, this minimum number of duties could be quite different for various periods during the week or even be different per shift per standard working day.

For example, the standard number of off-days in a 4/2 cycle (4 days on / 2 days off) is 122. An ATCO might have 65 non-working days a year in addition to the off-days in the roster, giving a total of $(122 + 65) = 187$ non-working days, which produces $(365 - 187) = 178$ normal working days in which to accomplish the statutory requirement for the annual working hours.

The minimum number of duties to cover 24 hours a day, including other duties and breaktimes, would be 6.

Accordingly, the manning would then be $(6 \times (365 / 178)) = 12.3$ (rounded up to 13) staff to cover one position for 24 hours a day throughout the year.

The difference between the two methods will become smaller if more positions are taken into account as some economy of scale is reached with regard to the breaktimes and other duties.

Consequently, the calculation of staff needed should always be done in combination with the roster cycle to be worked and the minimum number of duties needed to cover the OR.

Provided that actual hours spent in the OPSroom working, plus any hours worked outside the OPSroom, balances with the required number of working hours, the MCF method results in a more precise number of ATCO staff needed to meet the OR of the ATMO.

8.4.4 The Shift Roster

The influence of human aspects is a key element in the construction of shift rosters in order to avoid the physical and psychological effects of excessive fatigue on controllers, and to avoid any misunderstanding between staff and management when agreeing working practices.

Therefore in combining operational work with additional tasks, it is important to balance the needs of the business with those of the individual's personal life.

When combining operational work with other duties, the construction of the shift roster becomes very important - along with the sequences of operational work and any additional assignments.

Experience in some ATMOs has showed that combining additional duties with operational work simply does not function on a routine daily basis. Leaving the operational work centre to attend to other business during a rostered work period can also create a conflict of loyalty for many individuals.

One solution to this problem appears to be to roster the individual on both his additional work and his operational work separately, allowing a concentration on the work hours when in the OPSroom and a concentration on the other duties when not scheduled for the OPSroom.

In rostering for single individuals, the manpower planner has to take into account the number of days the individual has spent employed on other duties outside of the OPSroom environment recently when rostering that person for a duty cycle in the OPSroom.

8.5 Reducing the Process Time

8.5.1 In The Automotive Industry - For Example

Time Management and Shortening the Process Time are concepts that have been developed fairly recently within the automotive industry. Goods being stored do not represent the most effective use of working capital which in turn reflects poorly on the overall efficiency of the organisation.

Therefore methods like “Just In Time” for car parts exist and do a thriving business with car manufacturing plants. The concept is simple:- reduce the amount of working capital tied up in storing component parts for the assembly line in the car manufacturing plant and release the capital to other projects in the plant. This approach can be profitable to all concerned if the components are delivered to the assembly line as and when they are needed. The short period of time between ordering the component and it being delivered and the delivery firm being paid for that delivery are all competitive factors operating within the automotive industry.

8.5.2 In Air Traffic Management Organisations

MP is one method to help shorten the actual process time within ATMOs. MP helps managers to use the available human resources more efficiently than they could do otherwise.

TA shows from which segment of the ATMO staff other (not necessarily ATCO-orientated) assignments can be made from most effectively.

By conducting TA, we can find ways of reducing the time spent in the actual task process by choosing the people to do the task carefully.

In an ATMO environment, TA suggests several categories of an ATCOs function might be classified as follows:

- ATCOs assigned 100% to operational ATC - no additional assignments.
- ATCOs assigned X % to operational ATC and Y% to additional tasks (e.g. assigned as part-time ATC training coaches).
- ATCOs assigned 100% to additional tasks (e.g. management, expert panels, accident investigation etc.).
- Non ATCOs assigned 100% to core tasks (e.g. ATC students, FDAs or administrative staff).
- Non ATCOs involved X% in core tasks and Y% in additional assignments, (e.g. FDAs, system engineers, etc.).

8.6 Programmes or Projects ?

There are some fundamental differences between programmes and projects when viewed in the light of organisations such as an ATMO.

In global terms, the programme tends to be widespread and corporate whilst the project will be focused and local.

Projects

Programmes

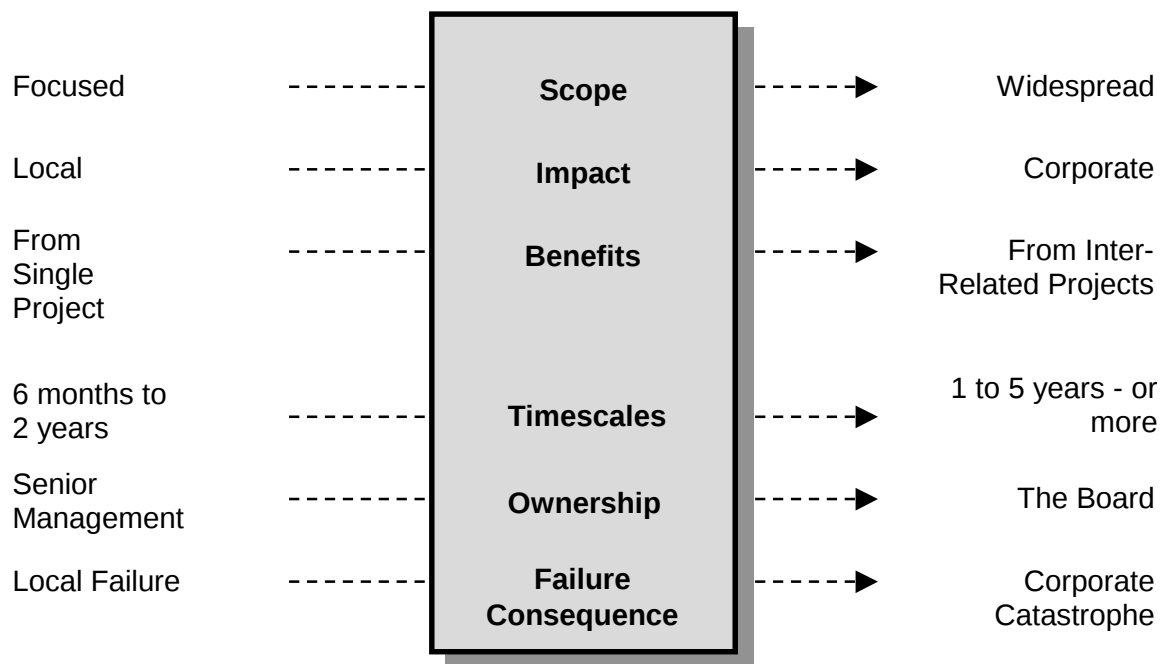


Figure 8: Relationship between projects and programmes

8.6.1 Managing Change

Whereas projects are implemented within a specific framework of requirements and at modest cost, programmes must accommodate changing needs on a more global scale within the wider system and address all of the points that have been identified as being critical.

This infers that timely setting up of management controls to accurately assess the impact of the perceived benefits throughout the programme lifecycle is an essential prerequisite.

The management model of the programme used to judge where the key milestones lay should also be used as the evaluation model for direct comparison between S_0 and the emerging S_1 position.

Remember that change is an emotive subject. It creates uncertainty and a degree of risk. It is considered as a potential threat by some and as a political opportunity by others in the ATMO hierarchy.

Change should instil a sense of well-being in the affected staff and act as a catalyst for them to perform their tasks better. The need for effective leadership and communication to reinforce the goal of the change is paramount.

8.7 Projects and the Learning Curve

8.7.1 Projects in ATMOs

One can view most additional tasks an ATMO has decided to accomplish (beside ATC), as projects rather than programmes.

A project is something that has a defined output, is run for a limited time period and has a number of specified responsibilities. With this definition, even the training of a single ATC student can be expressed as a project. Within the terms of project management, eight broad rules for success have been established for the Good Project Manager to follow. In summary, these are:

1. know your outcome;
2. plan the achievement;
3. organise for success;
4. gain and maintain commitment;
5. take action;
6. monitor and control achievement;
7. stay focused;
8. have fun.

8.7.2 Shortening the Learning Period

New domains become new projects and new projects have targets which demand a learning period from the participants. This period is generally referred to as 'the learning curve' which is normally exponential in shape.

The shape of the curve indicates that at the start of a learning process, the progress of the student is quite slow, but increases rapidly with the passage of time as knowledge or information absorption rates rise. This principle is also true when replacing an expert with a novice where the novice has to learn much of what the expert already has at their fingertips.

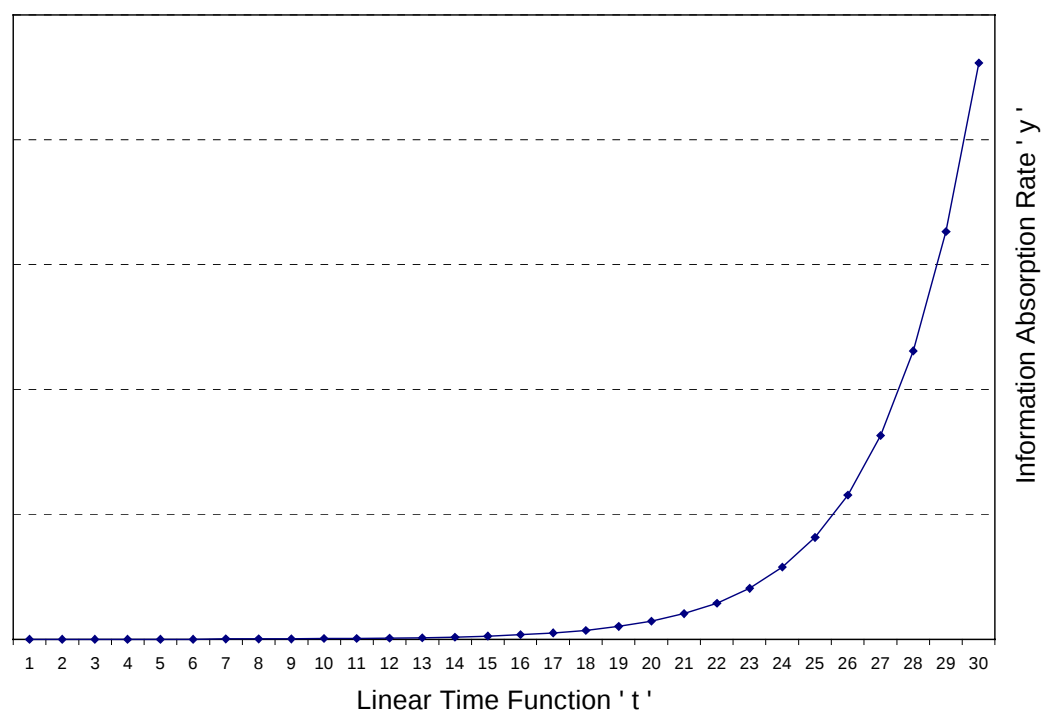


Figure 9: Typical exponential learning curve

ATC students are required to undergo a period of initial OJT and the time needed to fulfil this function is usually calculated by the management and built into the overall project cost planner, together with time considered necessary for individual topic study, expenses for study visits etc. For all projects, this can be reduced to a common denominator:- **cost**.

This learning curve can be considerably shortened by increasing the rate of change at the starting end (nearest N⁰1). This is especially true if the participants entering training (or joining a project) have already reached a certain level of expertise before they join the course (e.g. are already at N⁰24).

The exact definition of that 'certain level of expertise' is specific to the task being established by the project, and is therefore completely individual.

The relationship between time and the information absorption rate can be expressed as delta, the rate of change of the curve. Mathematical convention usually expresses the rate of change in the capital form (Δ) whilst the amount of change on either axis is given in the small version (δ). Thus:

$$\text{Rate of Change } (\Delta) = (\delta y / \delta t)$$

Note: t is the linear time function and y is the information absorption rate

Different individuals assigned to any project will have different levels of ability as well as differing levels of skill and differing rates of absorption, so the pre-project 'certain level of expertise' will vary from person to person. Some will be more able than others and the Δ in their specific instances can be made higher than for those at the opposite end of the absorption scale. However, this will affect the duration of the project and therefore the costs attached, suggesting that only the more able should be selected for these projects due to their native ability to absorb information faster.

8.7.3 Positive Transfer Effects

Another important planning principle is to always look for positive transfers between domains of expertise. This means when manning a project it should be staffed in such a way that expertise previously acquired can be used to augment that required in the new project, further minimising the learning period by altering the starting point of the learning curve referred to above.

This might be achieved for example by manning a project with contracting experts or people from other ATMOs who have already developed relevant expertise. Projects are also wonderful opportunities to increase the interaction between systems, wider systems and subsystems.

There should always be an opportunity for someone who is participating in a project to learn. One of the secrets of manning a project (which in an ATMO is probably aimed at solving a complex problem at an expert level) is to find the right mixture of existing experts participating in the project who are willing to help the other members of the project team (such as novices) to develop their own levels of expertise.

8.8 Time Management Awareness in Projects

Most of us have fairly standard daily routine which is time-driven. We live in a time-orientated society. Consider the time we get up in the mornings, the time we start work, the time we have lunch and the time we finish work and the time we go to bed.

8.8.1 Time Culture in Commercial Organisations

Many private commercial organisations (and airlines in particular), are trying to create a 'time culture' amongst their staff. This is usually achieved by setting specific deadlines for almost everything. In a time-oriented culture, everything has a starting time and a projected finishing time. In a time-critical project, there will be a deadline to be met.

To reinforce the concept of on-time performance, many companies construct some kind of reward or bonus system. These bonus systems send a clear message to the people in the organisation that 'time is money'. In a time oriented corporate culture, policies have to be established for resolving a possible conflict of objectives like 'On Time Performance' -vs- 'Safety Performance'.

The important thing to remember in creating an 'On Time' corporate culture is to use positive reinforcements and create some kind of reward system for on-time performance. A negative aspect is using the on-time philosophy to punish people. Generally it is not acceptable to use aversive means in time control, but to positively encourage those who manage their time well.

People are usually more attracted to pursue time than cut costs, so transferring costs to time is the first step in creating a higher level of organisational efficiency.

In a time oriented corporate culture, delays on projects are simply not tolerated.

8.8.2 Management Delegation

The responsibility for day-to-day management of projects should be delegated to a specific project management team by the top management or the board of directors of the ATMO. This will ensure that the project is managed in a fashion appropriate to the needs of the project, whilst the board or other governing authority maintain overall control by monitoring progress and costs associated with each of their projects.

It is highly probable that the project management team will be reporting directly to the board of directors or other governing authority and will have to justify their actions - and their inherent project costs.

8.8.3 The Effect of Delays

When major projects start incurring delays and no remedial or corrective action is initiated by the project management, it sends a clear signal to the remainder of the organisation that delays are perfectly acceptable. This in turn creates a willingness to accept that projects will over run their allocated time - and budget - more and more.

When a major project is prolonged beyond its original deadline it is costing more than originally planned. Corporate profitability suffers, the workforce can become demoralised and the whole project implementation programme can physically slow down. In some projects, this can become a self-perpetuating downward 'escalation effect' that is almost impossible to halt.

In an extreme case, this downward escalation effect can increase to a point where it become 'the black hole effect'. When this effect occurs, no matter what resources are allocated to the project, it continues to slow down, the staff morale falls lower and lower and the project continues to consume resources at an ever increasing rate.

8.9 Other Factors to Consider

Staff preferences are a good source of feedback when evaluating a work system or creating a new one. Systematic surveys, interviews and / or group discussions are all appropriate methods of gathering this information from operational staff regarding their shift schedule preferences.

8.9.1 Work Systems Preferred by Staff

To avoid any misunderstanding between staff and management when discussing (and possibly agreeing to new) working practices, the following human aspects are considered to be important:

- Determine jointly what changes to rostering and working practices are necessary to improve performance to meet the operational and customer requirements.
- Make changes to rostering and working practices based on a previously agreed framework of clear rules and regulations.
- Ensure rhythm of life and fatigue considerations are acceptable to the affected ATCOs.

Problems associated with learning how to cope with a new system might be more acute than the inability of staff to cope with a system once it has been implemented and in use for a period of time. It can be argued that most shift workers quickly become 'experts' at planning around any work system.

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9. CONCLUSIONS

9.1 Strategic and Business Planning

- The need for a business plan is discussed since without such a strategic tool, the organisation would have little direction or motivation. Most ATMOS operate on four levels of management ranging from the longest term (strategic planning) to the daily shift rostering that takes account of each task assigned to each individual (task assignment).
- The business plan will provide the ideas and the direction, but not necessarily the 'how'. That expertise and knowledge will come from the individuals on the input side of the plan. But, before that input can become most effective, a management structure must be in place that allows a flow of information upwards and downwards as well as providing a control infrastructure.
- Managing those input resources - the humans in particular - is the most crucial element of the whole equation. The management organisation must therefore be sensitive to the many environmental variables that can influence the human being.
- By building on some of the concepts and notions put forward earlier in the document, the concept of using Behaviour Anchored Rating Scales (BARS) as a good feedback system is established. The BARS allow SMEs to provide the essential knowledge base and then this may be applied to non-experts by comparison. The improved feedback will then assist the management to attune the transformation process better and attain the desired S_1 more easily than otherwise.
- Caution is recommended when the manager is basing a decision upon one set of feedback or information. A diverse number of sources of such information should be sought to ensure maximum reliability of the feedback.
- When looking at inputs and outputs and comparing them, Mahony (1988) stresses the importance of equality of level in this regard.
- Mahony (1988) also suggests that the measurement of inputs is much more difficult than the measurement of outputs - and it is by outputs that most organisations are judged (as mentioned above). So any attempt to judge an organisation by its inputs is likely to produce incorrect or severely flawed results.
- There is a clear need for some form of a control system that must be able to operate across all four levels of the normal management pattern for such organisations. This control system is usually called 'management'.

- As not all opportunities or problems may be foreseen with clarity, the management should normally have a set of contingency plans established for rapid implementation should the specific need arise.
- There are broadly two approaches to problem solving:– top-down and bottom-up. The former has application at the strategic levels whilst the latter has application at an empirical level. Sometimes it is necessary to adopt a dual option and tackle the problem from both directions at the same time.

9.2 Change

- Organisations need to be able to cope with change. That change may be imposed from the environment that the organisation is operating within or it may have evolved from within the organisation in an organic manner.
- If properly and effectively managed, change can be highly beneficial to the organisation. If it is **not** very well managed, the same change can be disruptive or even damaging to the organisation.
- Change should instil a feeling of well-being amongst the affected staff and their implicit approval of the change should also be present in the feedback received by the management. A typical change is the shortening of the learning period when one is allocated to a new project within the existing ATMO structure.

9.3 Models

- Any model that is used **must** be credible and valid - or at least capable of being validated through empirical data collection and testing.
- Models should be capable of enhancing the decision making ability of a client and should demonstrate a number of attributes such as, manageability, flexibility and a capacity for interactive use.
- Modelling scales tend to range between 'soft' when one is dealing with human-centred approaches to 'hard' when dealing with mathematical or technologically-based approaches.
- Caution is recommended when using mental models to describe the S_1 state, especially when the mental model is all we have to base a decision upon that will have an effect (impact) upon S_1 .

9.4 Humans

- The human beings in any organisation are usually considered to be the most valuable resource of that organisation. They certainly need managing and handling carefully. The HF paradigms are reviewed and expanded upon in the specific light of the ATMO and some of the problems associated with humans working in teams are examined because ATCOs often work in teams, so team culture is important.
- As humans appear to work better as a member of a team, and the 'team' for this purpose may be considered as the shift, membership of one particular shift may be favoured over membership of another shift. Personal inter-relationships will exist and a close bond of cooperation and coordination will exist between members of such a team, resulting in a better quality of work output and perhaps some friendly rivalry between the teams, all of which contributes to the improved output of the organisation.
- All members of the staff should be able to be assessed against some specified job-related criteria that produces a numeric result that can be used as a comparative guide between personnel in the same job at the same grade.
- The concept of feedback is used as an essential component to improve the quality of the output product of the organisation as most organisations are judged on their outputs. It is fundamentally true that one can only adjust the output by either altering the **inputs** or the **processes** undertaken. If the process is impossible to alter, all that is left are the inputs.
- CPD – This assumes that we, as humans, are learning all the time. CPD should therefore be encouraged amongst all staff as one tool to help improve the output in terms of both quality and quantity as this is one route to the further development of individual expertise and a step towards SME status.

9.4.1 Manpower Planning, Task Analysis and Rostering

- The planning and control of the inflows, throughflow and outflows of people to the organisation is of fundamental importance and comparison of actuality with established MP paradigms is one method of effectiveness judgment.
- In addition to the planning and control of the inflows, throughflow and outflows of personnel, it is necessary for the management to exercise some form of control over the tasks carried out by those personnel.
- TA also helps manpower planners to allocate personnel to work areas more efficiently.

- Specific problems exist with the ATCOs working in the OPSroom due to the nature of their licencing structure. There are formal procedures to be applied when calculating their on-duty and off-duty rostering that can often only be achieved by computer program.
- From the simple maths shown in the worked example, it can be seen that the minimal MF method of MP will result in a shortfall of personnel. A preferred method is presented in the MCF.
- When rostering personnel with the MCF method, personnel officers should keep in mind the roster cycle to be worked and the minimum number of duties to be worked to cover the OR.
- Separate rostering of the individual in two key areas - operational and non-operational duties - would appear to provide a solution to a major problem that has been facing manpower planners.
- Shift work and its effects have been looked at as it is known that this causes higher than normal levels of stress and that in turn causes health problems amongst humans. The shift pattern does need to be fairly predictable and stable over a long period of time for optimal performance from the staff.

9.4.2 Our Biggest Enemy - Time

- The concept of time, whether or not it is in fact linear and the management of time was discussed. The ATCO is expected to respond to a few critical moments per day and perform the substantial remainder of the day in an almost monitoring condition.
- In a normal time environment, the more time allocated to a function, the more important it appears to become. In an ATCOs world, it is diametrically the opposite. The most important things of all (avoidance of mid-air collisions) have very little response time allocated to them at all.
- Time is revisited in the light of the effect the passage of time has on a test battery and how events may actually overtake the intended outcome of a planned improvement in such a battery. Again, this is a good example of the non-linear effect of what is, essentially, a linear mathematical function, t (time).
- The establishment of a positive time culture in organisations is considered to be beneficial. The establishment of a negative time culture however, is considered to be counter-productive.
- Work systems / working practices vary in several dimensions and they tend to interact with a number of biological, psychological, social, and industrial factors. It is incorrect to assume that there is one ideal working system as a general solution that is equally applicable for all applications that have the similar demands on time.

9.4.3 Automation

- Brief mention is made of the increasing degree of automation in the daily role of the ATCO together with some comparisons between the human and the machine in a variety of roles.
- It is clear from the Fitts List (see [Annex A](#)) that the human being has a far better ability to deal with the unexpected than any machine we have created to date. At a strategic level particularly, the human is far superior to a machine, but at a task level, where repetitiveness and / or tiredness are in the equation, the machine will usually out-perform the human being.

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ANNEX A: THE FITTS LIST

Property	Machine	Human
Speed	Much superior	Lag one second
Power	Consistent at any level Large constant standard forces and power available	2 Horse-power for about 10 seconds 0.5 HP for a few minutes 0.2 HP for continuous work over a day
Consistency	Ideal for routine, repetitive or precision tasks	Not reliable - should be monitored Subject to learning and fatigue
Complex Activities	Multi channel	Single channel Low information throughput
Memory	Best for literal reproduction and short term storage	Large store multiple access Better for principles and strategies
Reasoning	Good deductive power Tedious to re-program	Good indicative power Easy to re-program
Computation	Fast, accurate Poor error correction	Slow, subject to error Good error correction
Input	Some outside human sense range - i.e.; Radioactivity Insensitive to extraneous stimuli Poor pattern detection	Wide range (10^{12}) and variety of stimuli dealt with by one unit Affected by heat, cold, noise and vibration Good pattern detection Low signal detection Good signal discrimination in high noise levels
Overload reliability	Sudden breakdown	Graceful degradation
Intelligence	None Incapable of goal switching or strategy switching without specific directions	Can deal with the unpredicted Can anticipate Can adapt
Manipulative abilities	Task specific	Great versatility and mobility

(Source: Martin et al., 1994)

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ANNEX B: PLANNING FOR SUCCESS

Identification of Problems and Opportunities

Arlanda Airport in Sweden is one of the ten largest airports in Europe, in respect of air movements. In 1995 there were a total of 225,000 movements recorded and, based upon the growth rate seen, this figure is predicted to rise to 255,000 recorded movements for the period 1 Jan '97 - 31 Dec '97 (Svenska Dagbladet, 1998).

From Monday to Friday, the Aerodrome Control Tower (TWR) at Arlanda handles between 880 and 930 movements daily.

During the 16 hours of daily operation, the peaks are equivalent (or close to) the capacity of the airport. Number of peak hour movements are constantly increasing. During peak hours, traffic is queuing for departure, all gates are occupied and incoming traffic is waiting on the taxiways for a free place on the ramp to become available.

Arlanda TWR has at present 63 employees, consisting of ATCOs, FDAs and administrative personnel. When the third runway is ready in 2001, the number of employees in the tower will increase by 25, to a total of 88 persons.

The Decision Maker

The Chief Executive Officer (CEO) at Arlanda TWR reports directly to the Air Navigation Services (ANS) Director and faces a major challenge in both managing a quality improvement programme and managing a third runway project which is currently under construction.

The Planning System

In order to succeed, the CEO relies on a systematic approach to planning and decision making. His planning depends heavily on inputs such as:

- customer requirement information (customer feedback);
- traffic prognosis for the forthcoming planning period(s);
- reliable ATC performance information.

These diverse sources of information are used to create two overall airport-improvement plans which then have to be implemented. Each plan has a different lifespan and contain strategic goals and tactical objectives that guide the subsequent business performance of ATC. The plans are called:

- The Short-Term Business Plan - which is valid for 6 months
- The Long-Term Business Plan - which is valid for 3 years

The short-term business plan is then transformed into a series of 55-day 'action plans' which then require implementation. Each 55-day action plan will produce their own set of decisions regarding:

- all operational work;
- any additional individual tasks to be performed;
- the rostering of each operational staff member.

Within the field of HRM, the long-term business plan is concerned with decisions on:

- service / TA;
- identification of key competencies;
- organisation and staff allocation;
- recruitment and selection;
- prioritised training;
- improvements to internal and external relationships.

After the business plans are discussed with customers and staff, a decision is taken to implement the plans. The CEO uses several milestones to evaluate the effectiveness of the two business plans. The feedback from the milestone data is then fed into the strategic planning process as new inputs for the next edition of the business plans. This infers that the business plans are dynamic and adaptable to change.

Identification of Objectives

The business plan objectives are established by using the feedback gained from several diverse sources. Each provides a different view on a particular topic. The sources may include:

- the customers - identifies customer needs and requirements;
- the output of the organisation - identifies quality issues;
- feedback from the local population - identifies environmental issues;
- feedback from the electronic devices - identifies pollution issues;
- feedback from staff - identifies staff issues;
- feedback from staff and customers - identifies planning issues.

In addition to these objectives, the CEO has identified two important additional objectives which are wider in scope than the previous items:

- to constantly strive to improve the performance of the tower (and therefore the airport generally);
- to identify the requirement for, and to accommodate, change.

In achieving these objectives, the CEO is meeting the ever-increasing demands being placed on the services delivered by the tower.

Measures of Performance

As measures of performance, the CEO routinely records for each shift and for each runway configuration, a number of specific parameters:

- visibility;
- number of arriving aircraft per hour;
- number of departing aircraft per hour;
- degree of cooperation and team work with neighbouring branches of ATC, airport services, meteorological services and airlines;
- number of deviations from normal routines or procedures;
- additional supervisor reports.

The Arlanda CEO also uses qualitative information from regular management meetings, weekly staff meetings and customer meetings to assess the overall performance of the aerodrome control service.

Modelling and Simulations

The CEO of Arlanda TWR feels the need to present his action plans both to customers and to his own staff to ensure the plans address the needs of the customers whilst meeting all the requirements for safe operation and are capable of being implemented by the staff.

In the past, a mental model of S_1 has been used, but it is acknowledged that this is not really sufficient and alternative models are being sought. There are several types of model available, such as the physical model (useful when designing a new terminal or tower layout), a computer-based model such as a Computer Aided Drawing (CAD) or a spreadsheet or, more recently, a virtual reality model that combines the power of all the above and adds substantial visual impact for the viewers.

In creating the model to demonstrate how the plans will work, he relies on the experience of his staff to achieve the optimal mix. This input is obtained during discussions on standardised working practices and methods.

Fortunately for Arlanda Airport, they do have access to a new computer-driven tower simulator that will allow the staff time to try out the suggested ideas or procedures during a period of pure simulation where aircraft safety may be compromised without endangering anyone or anything.

Implementation

At the moment, following discussion and general consensus, the mental model presented by the CEO is presented to the customers to obtain their feedback. This feedback helps refine the model and permits implementation of an informed decision with a higher probability of success than without any modelling, but with a lower probability than could be obtained using more sophisticated modelling procedures.

Monitoring and Problem Identification

As each action plan is implemented, a number of criteria are used to evaluate the progress of the implementation. This in turn provides some indication of performance. Some of the procedures employed to complete the picture are:

- 30 minute shift debriefing session - chaired by shift supervisor;
- regular meetings with the customers;
- regular meetings with the safety committee;
- regular supervisor meetings;
- regular safety auditing - carried out by the Swedish Civil Aviation Administration (CAA);
- evaluation points on the standardised Total Quality Measurement Scale.

The outcome from these evaluation checkpoints are then fed into the planning and decision making process as new inputs, and the whole planning and decision making process starts over again. This refinement process is called 'iteration' and is fundamental to good management techniques.

ANNEX C: MANNING AND ROSTERING

The Upper Area Control Centre (UAC) Maastricht Approach

A Task Force (TF) was established in 1995 at Maastricht UAC (MAS) to study the possibility of creating a more efficient shift roster for the ATCOs working there. As a term of reference, the Director of MAS gave the TF the following objectives:

- Reduce the night manning by one person in each of two specified sectors.
- Bring the manning as close as possible to the ideal distribution of manpower present, following the traffic distribution of the day.
- Investigate opportunities to take advantage of the seasonal fluctuations in workload.

The TF decided to start work on the assignment by first defining the variables controlling the MF.

The first variable the TF investigated was the OR.

Linking Operational Requirements and Human Resources

At MAS, the ATCOs are working in specified controller environments. Each controller environment constitutes several sectors and each sector is divided into ATCO positions. Each position is manned with 2-3 ATCOs (the executive, the planner and possibly an assistant).

The first finding of the TF was that the opening and closing times of sectors and positions control the demand for ATCOs. If traffic is increasing to the extent that a new sector needs to be opened - this immediately demands additional ATCO manpower.

A new sector is opened when the traffic exceeds the load threshold value. This figure is calculated from the reasonable amount of traffic that can be handled in a sector. Once a sector is opened, it usually remains open regardless of traffic throughput during the remainder of the day. From the number of open sectors, the minimum number of positions that need to be operating can be calculated and from the number of positions operating, the number of ATCOs needed can be calculated.

The Distribution of Manpower During the Day

Traffic usually varies over the course of a day, with less traffic during the night. Seasonal fluctuations exist in the ATCOs work environment caused by events such as summer holidays and Christmas.

When the manpower plan is designed to produce optimal staffing for peak traffic, periods will occur when the OPSroom is overstaffed, due to the closure of positions and emerging sectors. The TF ruled this as inherent to the work of an ATCO.

Human Needs

When the TF had determined the operational factors controlling the demand for manpower during the day, they continued to investigate the human needs that were influencing the demand for manpower.

ATCOs are human beings with needs. They need rest and breaks. They need to be away from the premises and to take special leave. They need to stay home when they are sick. They need to learn to operate new equipment and to become familiar with new working procedures.

Therefore the TF calculated the average special leave days, average sickness days and the percentage of break time in a working day.

Working Conditions

Working conditions for staff are regulated either by law or by agreement with unions or staff associations. The TF at the MAS included the regulated working days (and hours), off-days and the average number of vacation days per person.

The TF found that to run the existing roster demanded more manpower than the minimum number calculated by manpower calculations. The need of additional staff is governed by regulations in respect of:

- minimum shift length;
- maximum shift length;
- average working week;
- maximum number of consecutive working days;
- minimum time between any two consecutive shifts;
- maximum number of consecutive Sundays to be worked;
- time of the day to start or finish work.

Manpower Modelling

The TF at MAS used shift roster software in order to calculate the optimal number of shifts needed each day to provide adequate cover for the ORs. In order to do so, the TF had to choose the relevant input parameters.

First the TF fed in the traffic parameters such as peak and off-peak volume, density and complexity for day time operations, which in turn lead to figures for opening and closing of sectors and positions.

The shift roster program was given (fed) with the fixed constraints which could not be manipulated. These constraints were:

- minimum and maximum shift length;
- average weekly working time;
- possible start time intervals;
- forbidden time intervals to start and end shift work;
- the swing cycle.

After these factors had been fed in, the next step was to input the computer program with the desired number of duties and time on position for each member of the staff to perform per day. The 'time-on-position' factor should reflect the feasible duration an ATCO can actively work whilst maintaining safety. The number of duties should also include the number and duration of breaks.

The final steps were to input the program with the number of staff calculated as a manning factor to cover the operations for a whole year, together with any additional staff needed to cover for absences.

Evaluating the Model

The evaluation of the modelling provided by the software showed that with a roster totally adapted to ORs, without overlap between staff at shift breaks, the staff could actually work a shorter number of hours per day than those required in their working conditions.

One Finding of the Model

The model also showed there was a trade-off between ORs, working conditions and human needs.

Even if a roster is totally adapted to the ORs there will be overstaffing on certain days due to the minimum weekly working hours constraint, coverage for staff on leave, sickness etc. On these days the extra staff can be used for project work, training or to reinforce other teams. The number of standby duties required to be performed by each staff member can also be reduced.

Cost-Effectiveness

When the issue is to reduce costs (which should always be in focus), the TF concluded that the roster itself was not the most effective means of achieving the objective. The roster only proposes an optimal distribution of manpower and duration of duties during one day.

What impact do costs have when applied as fixed factors in rostering instead the working conditions ? The TF compared different scenarios where they changed the number of actual working days in the OPSroom. From the ORs

on opened sectors and positions per day, they calculated the actual manpower needed, which really affected the costs.

Manpower Need

The need of manpower was calculated as the ratio between the number of duties per day x 365 and the actual operational working days of an ATCO per year (see the MCF in Sub-chapter 8.4.3).

Manpower need is reduced if the number of duties per day can be reduced, because that in turn affects the number of breaks and the real time coverage, as well as the need for coverage during leave, sickness etc.

Manpower need may also be reduced if the number of away days from the OPSroom is reduced as well, because that increases the number of actual operational working days for each ATCO.

TF Final Conclusions and Recommendations

The TF completed their report by stating the following conclusions and recommendations regarding rostering and manpower calculation in ATMOs:

- Rosters will always have a 'slack' due to their adaptation to peak hours.
- On some days, during certain hours, there will be more ATCOs on duty than is actually needed in the OPSroom.
- MFs do not account for the real need for manpower as they do not include coverage of breaks, shift overlaps etc.
- When constructing a roster or calculating the MF, it should be transparent to all affected parties.
- Rosters should be based on ORs.
- Manpower should be calculated as the ratio between the number of duties per day x 365 and the actual operational working days of an ATCO per year.
- The number of hours per day a sector is kept open, the number of duties per day a controller has to perform and the working days per year are the major impact items on costs.

ANNEX D: CAREER PLANNING - ADAPTATION TO CHANGE

A business plan usually contains strategic decisions on business objectives and on what the ATMO is intending to export out to the environment. Some outputs or services are likely to expand, while other services will appear to no longer match with either customer or environmental demands.

The structure of the ATMO will tend to mirror this effect. Some parts of the organisation will need to be expanded to meet the evolving demands of the customer or environment whilst others will appear to correspond less to either the stated business objectives or any of the desired outputs. The result is an effective increase in resource consumption as these departments begin to consume resources from other parts of the organisation.

In some instances, new departments will need creating to provide a better service to the customers or the environment. These dynamics are accurate reflections of a constantly changing environment.

Such changes in structure as well as in output are normal for any system. This adaptation to changing external and internal demands are part of system survival strategy.

Action Plans

Before any changes are implemented, it is essential that the whole procedure has been thought through and a series of logical steps and evaluation criteria established. When all put together, this is normally referred to as an action plan and it may include strategic goals as well as details of individual tasks.

The virtue of greater flexibility in the workforce means that when change presents itself as the obvious choice for an ATMO, there is a greater degree of freedom to vary the quantity and quality of the human input in direct response to the new demands. 'Management by projects' is a typical example of the need for a flexible workforce. In order to put a successful action plan together, several stages of mental process are needed, together with some research:

- How many people does the new demand need to fulfil it completely ?
- Are there existing staff preparing to retire ?
- Do the revised demands require internally available expertise ?
- Establish what expertise is available from within the organisation.
- Can existing staff develop the skills required by the revised demands ?
- Do the revised demands require additional staff skills or competencies ?
- Will in-house training suffice or do the staff need external training ?
- Establish what expertise is available from outside the organisation.

Survival Strategy

Any organisation needs a survival strategy. As the staff represent such an investment to most organisations, management decisions must be taken on staff composition, when to maintain equilibrium, when to expand and when to reduce, based on the demands of the customer and the environment.

One crucial goal towards achieving the survival strategy will be to control the costs incurred by the organisation.

Other goals will include maintaining competitiveness and market share. In order to achieve these higher level goals, lower level objectives will have to be met - such as ensuring an adequate supply of staff with relevant experience and appropriate age and sex distribution to meet existing commitments and planned changes which are coming about as a result of altered demands by customers and / or the environment.

Policies will usually have been established by the management to cover organisational structure, salary, health and safety, working conditions and leave amongst others, but for the purpose of action planning, the following are considered important staff-orientated items:

- annual staff turnover;
- average days of absence per employee;
- consultancy;
- human performance review summary;
- manning calculations for staff working on shift;
- outplacements;
- recruitment;
- staff training and professional development.

Planned Career Development as Adaptation to Change

One of the key items under this heading is the career development of an individual working within the organisation. Most professional persons these days have some form of an action plan or career development plan set out somewhere in their lives and they tend to use it to judge the progress of their career as they move between functions, departments, jobs or organisations.

The general idea is to adopt a personal strategy and to develop personal and professional qualities which aim at improving one's career development within the framework of lifelong learning instead of fostering further the concept of 'a job for life' which is generally considered to be a thing of the past.

Mention has been made earlier of CPD and it is this concept which is now at the forefront of career planning.

This approach provides several benefits to the individual and to the organisation. Flexibility and mobility are two of the keywords used in this context, because it is generally felt that one should not 'put the books down' once graduation is achieved, but the learning process should be maintained throughout the career development.

This change has been brought about by the environment that human beings find themselves working in. It produces a higher degree of flexibility in the workforce of an organisation because those subscribing to the CPD ideals are prepared to learn new skills quickly in order to best adapt to the new environment caused by the change in customer demands. In addition to just learning those new skills, the adaptive workforce will be documenting their skills and will employ the positive transfer effects mentioned earlier when they move between functions, projects, departments, jobs or even organisations.

The CPD subscriber needs to:

- decide upon career orientations;
- develop insight into their skills and expertise and document them;
- determine the optimal use of their skills and expertise;
- expand and apply those skills and expertise beyond their natural horizon;
- maintain and update their skills through training or cross-training;
- be adaptive to career planning and have contingency plans prepared;
- undertake a CPD programme with a recognised professional body.

This approach assumes that the professional's career is something that is owned more by the individual and falls under the responsibility of the individual. However, the organisation should provide the means for it to be implemented and should foster the spirit in which it is offered, as this route does provide for the maximum survivability of the organisation itself.

Table 2: A typical ATMO staff development pattern, based purely upon age.

Age Range	Career Stage
< 39	Early Career Stage: Establishment & Achievement
39 – 45	Middle Career Stage I: Transition
46 – 54	Middle Career Stage II: Growth
> 54	Late Career Stage: Maintenance

The table shows that nearly all staff are in career stages where further development of their knowledge and expertise would be of use to both the ATMO, the needs of its customers and the staff concerned.

Only about 10% of the staff will, in most instances, fall into the late career stage. These tend to be the least adaptable to new ideas and technology and will probably wish to plan their retirement. A specific action plan will be necessary for those that elect to follow this route to ensure the transition to retirement is made with dignity and without prejudice to pension rights. Such a plan might include a period in management or administration.

The different career development stages are described below, together with at least some of the tasks required of both staff and management.

Early Career Stage

Staff are in the younger age bracket. They are adapting to their role and getting established professionally. They begin to achieve professional success at a modest level.

Staff at this stage of their career can be encouraged to develop and will be more adaptable to rotation into new functions, departments or jobs and will be quick to develop the new skills to a competent (as opposed to expert) level.

Staff Tasks:

- maintain effective performance on the job;
- develop career opportunities as they are presented;
- set realistic career objectives, goals and eventual outcome;
- understand the relationship between individual career opportunities and accomplishment of individual objectives and wider career goals.

Management Tasks:

- help in career exploration and opportunities;
- encourage staff to participate in self-assessment;
- development of Assessment Centre exercises;
- identification of under achievers;
- identification of individual talent for other professions.

Middle Career Stage I

Personnel in this category tend to be the emerging expert (transition stage I) and the established expert (transition stage II).

Staff at this stage are capable of developing expertise and skills by updating technical skills as required for specific technical projects or developing their own expertise beyond their normal level or scope. They may develop expertise in other areas of the organisation (e.g. in administration or finance).

Some of the more able members of staff can be considered capable of rotating into new jobs or projects requiring new skills.

Middle Career Stage II

Staff at this stage of their career will be in senior or supervisory positions, encouraging those in the early stages of their careers to develop and may be somewhat less adaptable to rotation into new functions, departments or jobs. They may not be very quick to develop any new skills as they have to maintain their expert level which infers complete mastery of the skill.

Staff Tasks:

- reappraisal earlier career decisions;
- determine optimal use of expertise beyond technical specialist skills;
- attain expert mastery of newer skills;
- review of obsolete skills.

Management Tasks:

- consider optimisation of functions, based upon lateral transfer of skills;
- consider project appointment / promotions;
- offer skills assessment and career counselling to subordinates;
- encourage participation in training or cross-training opportunities.

Late Career Stage

Staff at this stage are concerned about remaining productive in their job. Very seldom do employees prepare themselves for second (or third) careers into senior leadership roles.

Staff Tasks:

- mainly to prepare for effective and graceful retirement;
- continue with the work and maintain status and expertise.

Management Tasks:

- help staff at this stage prepare for retirement with minimal difficulties;
- offer continual top-up training to maintain motivation and expertise;
- offer positive incentives for early retirement;
- minimise any stigma attached to retirement.

Adaptation and Career Planning Conclusions

- The structure of an ATMO will usually reflect the demands of the customers and the environment that it operates in.
- Change is evolutionary and needs to be planned to be effectively implemented. One successful method is by using Action Plans.
- Action Plans, like any other plan, needs to be thought through from start to finish and contingency plans made to cope with mid-stream changes. Amongst these contingency plans should be a survival strategy.
- A key element in any organisation are the people. Planned career development for each of those people is a good example of action planning at work, alongside CPD.
- CPD allows for a more flexible and adaptable workforce that will accept change more readily than one that does not have this mentality in place as part of the corporate culture.
- Examples of CPD and typical career development based on age alone age shown, together with staff tasks and management tasks in each stage of an individual's career development.
- Staff should be prepared by training and motivated by management to accept a degree of mobility within their specific job function and should aim to stay in the service.
- A specific retirement Action Plan should be developed and agreed that will allow retiring staff to leave with the minimum of trauma. One possibility here is by offering the retiring individual some part-time work.
- It must be borne in mind however that staff with about ten years before retirement do suffer from lower chances of alternative employment. This leaves staff with some degree of uncertainty and the termination of service could cause unrest. This needs to be addressed in a separate branch of the programme.

ANNEX E: CLOSED LOOP APPLICATION

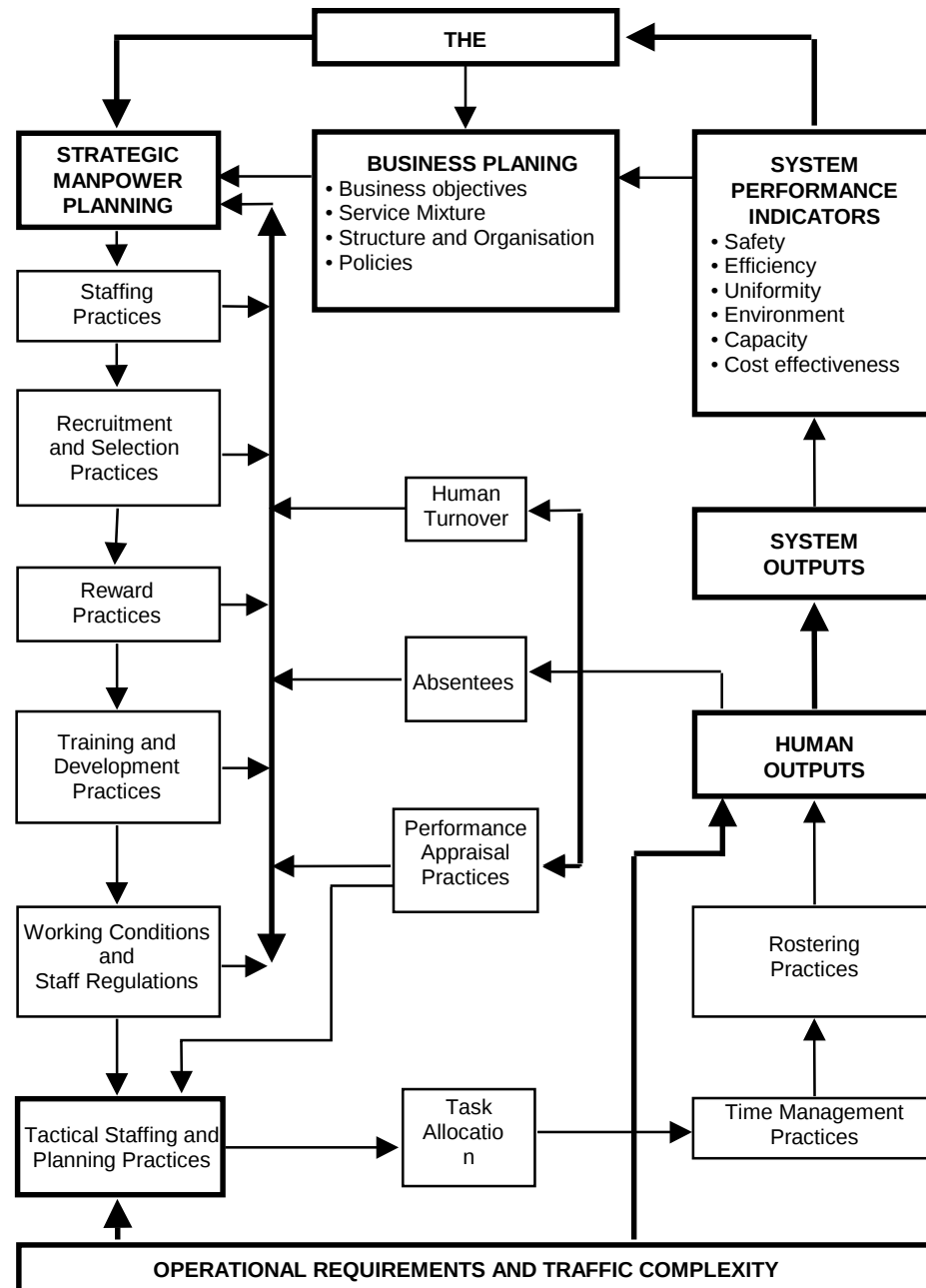


Figure 10: Application of the closed loop principle

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GLOSSARY

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.

Action Plan: Individual or specific item plan derived from a business or strategic plan.

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

Air Traffic Management (ATM): The ground part of ATM comprises the functions of air traffic services, airspace management and air traffic flow management. The air traffic services are the primary components of ATM.

Air Traffic Management Organisation (ATMO): An organisation that has the management of aircraft either in flight or on the manoeuvring area of an aerodrome vested in it and which is the legitimate holder of that responsibility.

Air Traffic Services (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.

Aviation Safety: The entire issue of safety as applied to aircraft, on the ground and especially when airborne.

Behaviour Anchored Rating Scales: Focus on the behavioural dimensions (both cognitive and overt) within the cluster representing a specific dimension. Used to measure Mastery of Performance.

Bottom-Up Approach: A specific scientific approach to a problem or opportunity, starting with an individual component contributor view and increasing on each iteration toward the overall holistic view.

Business Plan: A document or series of documents intended to determine the mission, goals and individual objectives of an organisation in preparation for implementation over some stated period of time.

Consensus: General or widespread agreement referring to collective opinion.

Contingency Plan: Course of action to be taken in the event of a technical / catastrophic outage or disruption of service due to industrial action (EATCHIP 1997), or any other abnormal incident occurring.

Continuous Professional Development: The systematic maintenance, improvement and broadening of knowledge and skill together with the development of personal qualities necessary for the execution of professional, managerial and technical duties throughout the practitioner's working life.

Decision Maker: Person(s) responsible for a judgment, conclusion or resolution reached or given.

Decision Making Subsystem: Group of persons responsible for a judgment, conclusion or resolution within a system.

Diversity: The logical relation that holds (or exists) between two entities when and only when they are not identical.

Efficiency Measurement: Any quantifiable unit resulting from the ratio of output over input.

Failures Approach: A specific approach to systems theory using the basis of a failure as an aid to greater understanding.

Fatigue: Physical or mental exhaustion due to exertion.

Feedback: The return of part of the output (as a signal or information) to the input in order to modify the output.

Goal: The middle level in the organisational ambition plan. A goal will be considered achieved once a series of pre-determined objectives have been completed. May also be referred to as a milestone in a project or programme.

Goal Attainment: A measure of how well an ATMO is meeting its objectives, as compared with objectives stated in a previously published strategic management document or business plan.

Hard Approach: A specific approach to systems theory using a technological or mathematical basis as a foundation for an effective solution to the problem(s).

Human Factors (HF): A multi-disciplinary effort to compile and generate knowledge about people at work and apply that knowledge to the functional relationships between people, tasks, technologies and environment in order to produce safe and efficient human performance.

Human Resource Allocation: The matching of people with activities or tasks as laid out in a business plan.

Human Resource Management (HRM): 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.

Inputs: A generic term meaning various components that are essential to any transformation process in order to produce an output.

Iteration Loop: Method within the systems theory refinement process. Basically it describes the process of mentally moving between the real world situation, a model of that situation and back to the real world.

Learning-Curve: An exponential curve showing the differential rate of learning absorption during the process of learning. This rate of learning is slower at early stages of the learning process than at later stages.

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.

Management: Effective use and co-ordination of resources to achieve pre-defined objectives.

Management Hierarchy: The structure or organisational arrangements of the management within an organisation.

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

Manpower Modelling: A model used in conjunction with shift roster software in order to calculate the optimal number of shifts needed each day to provide adequate cover for the operational requirements.

Manpower Planning: The inflow, throughflow and outflow of personnel in such a manner as to ensure a sufficient number of suitably qualified personnel are maintained at all levels throughout the organisation.

Mental Model: The picture or concept that is formed in the human mind when no other model is available.

Mission: A set of high level statements in an organisational ambition plan giving the ultimate reason for an organisation to exist. A mission is usually considered achieved once a set of pre-determined goals have been achieved.

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

Networked Organisation: An organisation consisting of multiple (remotely located) parts, either fully interconnected (as in a computer network) or connected via some form of hierarchical structure.

Objective: The lowest level in the organisational ambition plan. An objective will be considered achieved once a series of pre-determined tasks or work packages have been completed

Off Time: The hours a particular individual or group of individuals are not normally required to be at the workplace (Tepas and Monk,¹ 1987).

Open-System Characteristics: A system that has no feedback loop to control the process of the system, resulting in wild fluctuations of the output(s) according to the input variation(s).

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 Operation Units*, HUM.ET1.ST05.4000-GUI-01. Brussels: EUROCONTROL). The training enables student controllers to check out as operational controllers at a specific operational unit.

Operating Costs: The inherent price of producing the output(s), calculated by summing the many individual variable input costs and any fixed internal process costs.

Operational Procedures: ATC Operations Manuals, incorporating international, national and local rules and regulations, procedures and working practices.

Operational Requirements (OR): ATC positions open and manned in accordance with varying Air Traffic demands.

Operational Research: The analysis of problems in business and industry involving the construction of models and the application of linear programming, critical path analysis and other quantitative techniques.

Outputs: A generic term meaning various products or services that occur as a result of inputs being applied to a process (or processes) undertaken by an organisation or an individual.

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

Planned Career Development: A generic career development programme for a given group of individuals similarly employed (such as ATCOs or Engineers) with identifiable steps.

Position: Work area (workstation) equipped for providing ATC functions.

Process: A series of logical and normally sequential actions which result in the transformation of an item from one state to another or some development.

Professional Development: The systematic maintenance, improvement and broadening of knowledge and skill together with the development of personal

¹ 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.

qualities necessary for the execution of professional, managerial and technical duties.

Project: A temporary endeavour undertaken to create a unique product or service.

Risk Analysis: A complex study technique used to evaluate risks and to analyse how far forecasts might go wrong – and at what cost.

Risk Control: Responses to changes in risk over the course of a project by executing a risk management plan.

Risk Identification: Determination of the likely sources of risk and the magnitude of that risk.

Risk Management: A management plan to be implemented under risk control. This is modified by the outputs of the risk control procedures.

Risk Simulation: A method of analysing and assessing (usually by computer) particular aspects of a project.

Rostering: The allocation of human resources in order to ensure services 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).

Sector: A specific area of controlled airspace.

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.

Sliding-Window Model: Rather than a specific date or time, the mean or average figure across a range of days, weeks, months or years is used. Typically a 3-5 year period may be used and the mean or average figure for that period is then applied to the problem. Tends to remove extreme peaks (positive or negative).

Soft Approach: A specific approach to systems theory that starts with utter confusion and little clarity or understanding and which progresses through rich pictures and iterative loops until improved clarity (or consensus) is obtained by the parties concerned.

Strategic Planning: The longest-range planning / goal setting / ambitions of the organisation.

System: A system tends to be a set of interconnected, interdependent parts, forming an identifiable, organised complex and dynamic whole. It may encompass elements, activities, people or ideas.

System Architecture: The arrangement of the component parts of a system and the manner in which they communicate with each other.

Systematic Feedback: A small portion of the system's output taken to, and compared with, one or more earlier stage inputs on a regular and routine basis.

Systems Engineering: Engineering principles rooted in systems theory and applied to systems.

Systems Model: A model created to try and help human understanding in respect of some situation where systems theory is being used to try to clarify matters.

Systems Theory: The sound underlying theory upon which all systems knowledge is based.

Task Analysis (TA): A group of analytical procedures directed at describing work activities in detail. A TA aims to provide a comprehensive breakdown of the content of tasks.

Task Assignment: Allocation of work task(s) to individual person.

Task Mastery: The level of professional expertise expected of a person considered to be an expert in the field.

Time Leakage: Inexplicable or unaccountable loss of time from working shift time.

Top-Down Approach: A specific scientific approach to a problem or opportunity, starting with a holistic view and reducing on each iteration toward the individual component contributors.

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.

Viable Subsystem: A system component considered to be above the chosen limit of resolution for a component. Also exhibits all the characteristics of a system and is capable of existing independently, but with limited decision making powers. May interact with other viable subsystems.

Viable System: An autonomous or separate entity operating within the wider system with purpose. Exhibits all the characteristics of a system and has higher level decisions making powers than subsystems.

Vision: The main conceptual mental picture containing the very broadest of guidelines as to where the project, programme or company is going and how is it likely to get there and how it will recognise when it has arrived there.

Wider System: The area defined within the overall environment that provides resources to, and legitimises the operations of, each of the systems operating within it. It also formulates the initial design of the systems operating with it and makes known its expectations of each system operating within it.

Work Package: A deliverable at the lowest level of the work breakdown structure. A work package may be divided into activities.

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ABBREVIATIONS AND ACRONYMS

Δ (Delta)	Rate of Change
1:1	One-to-One relationship
1:M	One-to-Many relationship
ACC	Area Control Centre
ANS	Air Navigation Services
ATC	Air Traffic Control
ATCO	Air Traffic Controller / Air Traffic Control Officer
ATM	Air Traffic Management
ATMO	Air Traffic Management Organisation
ATS	Air Traffic Services
BARS	Behaviour Anchored Rating Scales
CAA	Civil Aviation Administration
CAD	Computer Aided Drawing
CEO	Chief Executive Officer
CIP	Convergence and Implementation Programme
CPD	Continuous Professional Development
ECAC	European Civil Aviation Conference
EATCHIP	European ATC Harmonisation and Integration Programme
EUROCONTROL	European Organisation for the Safety of Air Navigation
EWP	EATCHIP Work Programme
FDA	Flight Data Assistant
FIR	Flight Information Region

HF	Human Factors
HP	Horse-Power
HRM	Human Resource Management
HRT	Human Resources Team
ICAO	International Civil Aviation Organisation
M:M	Many-to-Many relationship
MAS	Maastricht UAC
MBO	Management by Objectives
MCF	Manning Calculation Formula
MF	Manning Factor
MP	Manpower Planning
MPSG	Manpower Planning Study Group
MSSR	Monopulse Secondary Surveillance Radar
OGM	Objectives > Goals > Mission
OJT	On-the-Job Training
OP	Organisational Productivity
OR	Operational Requirements
OPS	Operational Services
OPSroom	Operations Room
S ₀	The present (undesired) state
S ₁	The future (desired) state
SDOE	Senior Director Operations and EATCHIP
SME	Subject Matter Expert
ST	Specialist Task
TA	Task Analysis

TCAS	Traffic Alert and Collision Avoidance System
TF	Task Force
TQM	Total Quality Management
TWR	Aerodrome Control Tower
UAC	Upper Area Control Centre

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