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Shiftwork Practices Study - ATM and Related Industries

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Abstract		
<p>This document presents the study on shiftwork practices both in Air Traffic Management (ATM) and non-ATM industries. The purpose of the study was to identify (best) practices that can help to define common solutions for managing shiftwork in European ATM. This document is the second of the "Managing Shiftwork in European ATM (MSEA)" Project, which was conducted by EUROCONTROL within the EATM Human Factors Domain as part of the Human Performance and Training Enhancement (HPTE) Planning and Feasibility. Shiftwork practices were collected from the areas of international ATM, and from the medical, police and airline industries. The findings were rich and are likely to provide valuable input to the process of developing shiftwork solutions for European ATM.</p>		
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EXECUTIVE SUMMARY

This document presents the study on shiftwork practices both in Air Traffic Management (ATM) and non-ATM industries. The purpose was to identify (best) practices that can help to define common solutions for managing shiftwork in European ATM. It represents the second deliverable of the “Managing Shiftwork in European ATM (MSEA)” Project, which was conducted by EUROCONTROL within the EATM Human Factors Domain as part of the Human Performance and Training Enhancement (Hpte) Planning and Feasibility.

This deliverable describes the rationale, approach, methodology, data collection and analysis related to the different shiftwork solutions identified.

Chapter 1, “Introduction”, outlines the background, objectives and scope of the document.

Chapter 2, “Setting the Scene”, describes the most central aspects of shiftwork in the ATM context.

Chapter 3, “Framework”, describes how different industries were selected to identify industries related to ATM on features relevant to shiftwork.

Chapter 4, “Findings from ATM”, presents the findings from the data collection on different shiftwork solutions and practices within ATM, inside and outside Europe.

Chapter 5, “Findings from Related Industries”, presents the findings from the data collection on different shiftwork solutions and best practices within the police, airline, and medical industries.

Chapter 6, “Findings from other sources”, outline different sources of information (tools, guidelines, conferences, etc.) relevant for shiftwork solutions.

Chapter 7, “Insight Gained”, summarizes the main findings, lessons learned, and insights gained from this study.

Chapter 8, “Conclusions and Recommendations”, highlights the overall conclusions from the study; directions for further research and possible solutions are outlined.

Annex 1 describes the data collection plan used for the different case study interviews.

Annex 2 summarizes some central conferences, courses and workshops on shiftwork.

Annex 3 provides a listing of software tools for shiftwork.

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

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1. INTRODUCTION

1.1 Background

European ATM is confronted with many challenges in designing shiftwork practices which match traffic demand as well as planning and managing flexible working practices to maintain/improve individual Air Traffic Controller (ATCO) performance.

Managing shiftwork practices tailored to accommodate predictable traffic demand benefits European ATM cost-effectiveness. This was highlighted in a study on the “Comparison of Performance in selected US and European En Route centres”¹. The study found that “staff planning and management is not always designed to match traffic. In many centres rosters have remained unchanged for some years and certain practices appear to be imperfectly adapted to current patterns of traffic variation.”

A greater understanding is needed of the interaction between shiftwork practices, health and safety implications, ATM productivity and safe ATM operations. In many cases, adopting best practices from other Air Navigation Service Providers (ANSPs) should bring improvements. It is believed that improving awareness of shiftwork practices will enhance productivity in Europe as well as the health and safety aspects related to human performance:

- cost-efficiency gains in the area of delay reduction and responsiveness to traffic changes;
- solutions to manage the safety impact of working in an ATM shift environment.

Consequently, a feasibility study was launched on MSEA to define with stakeholders common solutions and/or adaptations that will facilitate the planning and management of flexible working practices (with a focus on shiftwork) to improve safety and productivity in ATM. The duration of the feasibility study was May 2004 to December 2004. A key task within this feasibility study was to identify and learn from good practices within ATM and related industries.

This “Shiftwork Practices” report is one deliverable of the feasibility study. The other main deliverable is “Managing Shiftwork in European ATM: Literature Review” (EUROCONTROL, 2006).

¹ A EUROCONTROL comparative study (2003) carried out during February 2002 and March 2003 by the Performance Review Unit on the request of the Performance Review Commission, with the cooperation of a number of European Air Navigation Service Providers (ANSPs) and the US Federal Aviation Administration (FAA).

1.2 Purpose

The purpose of the Shiftwork Practices Study was twofold:

- to report on effective tools and methods for managing shiftwork in ATM and related industries to support the identification of solutions within the context of the MSEA feasibility study;
- to identify current practices of managing shiftwork that adequately manage productivity and health/safety issues both within ATM and in related industries.

1.3 Scope

The scope of the Shiftwork Practices study was focused around six areas of interest for MSEA (identified at a workshop in Brussels, July 2004 [EUROCONTROL, 2004]):

1. Flexible application of resources.
2. Selecting and adapting shift systems.
3. Implementation of a new shift system.
4. Managing individual differences in shiftwork.
5. Team/individual shift systems.
6. Tactical and strategic shift management.

Within the timeframe and scope of a feasibility study, rather than identify and analyse all practices relevant for shiftwork solutions in ATM, it was envisaged to give an idea of what information is available and what value it can provide to the areas of interest for European ATM.

1.4 Benefits

- To gain up-to-date knowledge about what can be learned from ATM and related industries to help define solutions to managing shiftwork in European ATM.
- To gain valuable insights that may pinpoint solutions and fast-track the development of solutions for MSEA areas of interest.

1.5 Approach

A five-step approach was designed for the study:

1. Information Source Identification
 - Literature and Web search
 - Experts' viewpoints
 - Ideal shiftwork solution

The different information sources on shiftwork solutions needed to be identified and explored in order to guide information collection. As part of this process, different experts on shiftwork were contacted, a Web search was conducted and an “ideal” shiftwork solution was developed as a benchmarking tool.

2. Framework and criteria for industry selection

To collect data from non-ATM industries, it was important to evaluate how relevant this data would be for ATM. For this purpose a framework was developed in order to compare domains on relevant criteria.

3. Data collection

The study included data collection from the various sources of information that were identified. A data collection plan specified the approach towards data collection.

4. Data analysis

The collected data was structured, interpreted and evaluated.

5. Reporting

The drafting of this report.

1.6

Structure

As shown in Figure 1 the document is organized into the following main chapters:

- Introduction
- Setting the Scene
- The Framework
- Findings from ATM
- Findings from Related Industries
- Findings from Other Sources
- Insights Gained
- Conclusions and Recommendations

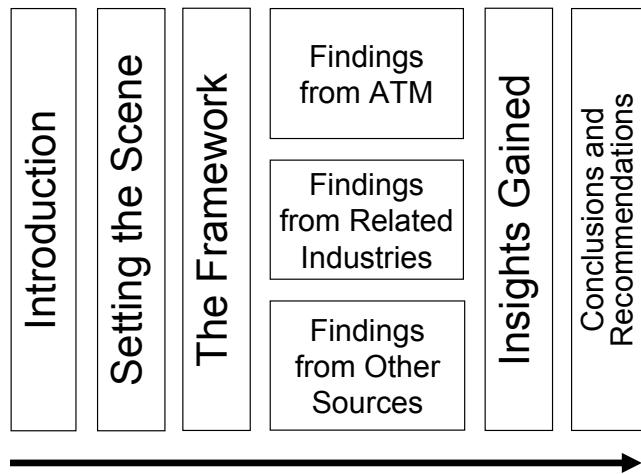


Figure 1: Structure of the document

2. SETTING THE SCENE

2.1 Introduction

This chapter outlines the specific aspects of the ATM context relevant for shiftwork, and highlights key elements of the shiftwork system from research regarding safety, efficiency and productivity. Also included is the view of experts on an “ideal” shiftwork solution.

2.2 ATM Context

ATM-specific features impacting shiftwork and which may differ from other industries are as follows (EUROCONTROL, 2006):

- Safety is of critical importance compared with other businesses.
- ATCOs always have to sustain a high level of performance.
- Complexity and dynamics are high compared with other businesses.
- Overload (stress) as well as underload (boredom) is an issue. The latter has a special impact on situational awareness during night work as most units have to deal with low volumes of nocturnal traffic.
- Workload varies substantially during the day (inbound and outbound rush), during the week (working day vs. weekend) and during the year (holiday and fare season, summer vs. winter traffic). On the employer side, these fluctuations challenge cost-effectiveness. The fade-out period of traffic peaks can be critical times owing to overshooting relax responses.
- The handover of ATCO positions is critical because the traffic picture has to be quickly taken up.

Furthermore, within European ATM, a few additional factors impact the extent to which new shiftwork solutions can be introduced:

- Cultural differences: What works in one area may not work in another area. For example, practice that works well in one of the Scandinavian countries may not work well or be feasible in the southern European countries and *vice versa*.
- Labour relations: Unions/social dialogue partners are involved with any changes to the shift system, which requires negotiation with the social partners. Trade Union and individual resistance to radical change makes moving from a historical static system challenging.

- European countries have various labour laws in place on working time, to which ANSPs need to subject their rostering rules.

2.3

Research on Shiftwork Systems

There are a great variety of shiftwork systems today which bear little resemblance to traditional shiftwork systems. Shiftwork, especially night shifts, can have a number of adverse effects with respect to health, social life, work efficiency and performance quality. These problems occur in any industry that makes use of shiftwork.

Research (EUROCONTROL, 2006) reveals that a common-sense approach to good shiftwork management is required. Different features of a shift system need attention with respect to their implications on individual health, performance, and safety, e.g.:

- number of successive shifts,
- length of a single shift,
- effect of a certain time of day (early, late, night shift),
- interactions with task,
- quality and quantity of breaks.

In terms of efficiency, research indicates that there is a growing trend towards individual rostering in staff planning and allocation. Also, attention needs to be given to the allocation of breaks and the handover of positions.

2.4

Experts

Highly experienced specialists in the field of shiftwork were considered as constituting a particularly valuable source for accumulating information about best practices. For this reason one element of the project involved identification of, and contact with, such experts. On the basis of a relatively large pool, a sample of three experts was contacted. Two of them have for the most part worked with the topic from a theoretical perspective, while one of them has also been involved in the practical design of several specific rosters.

The experts were asked about their knowledge of methods that might be valuable in the practical design of rosters. Overall, there seems to be a general agreement between the experts in that there is much to learn from existing rosters. They emphasize that some roster solutions are definitively better than others, which implies that there is a need to study specific rosters in more detail, to extract the lessons learned from these when concurrently considering the theoretically defined “ideal shiftwork solution”.

An important point revealed during the discussions was that the attempt to define “best practices” is a task that has not previously been addressed, but that this constitutes an important ambition, which should be encouraged. It was however noted that the task of defining *the* perfect roster, which is directly

applicable across all individuals, workplaces, and domains is a very difficult task, as there will be several factors (e.g. individual and contextual factors) unique for the particular workplaces that determine the “goodness” or “badness” of particular rosters.

It was furthermore noted that the “ideal shift solution” is impossible to implement in practice, as several of the guidelines are conflicting. One experience was that the organisation and/or union are often reluctant to comply with the guidelines, which implies that it is difficult to design rosters in accordance with these. Again, this indicates that the practical usefulness of different shiftwork solutions should be further explored in order to try to solve the difficulties that arise when attempting to design rosters solely in terms of theory.

Three guidelines for the “ideal shift solution” were identified as particularly important:

- forward rotation,
- need for extended free time after night shift,
- reduction in the number of successive nights.

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3. THE FRAMEWORK

3.1 Introduction

A framework was developed:

- to identify and then evaluate the differences between industries on shiftwork-related features;
- to develop specific criteria for domain comparisons, which in turn serve to guide the selection of other domains for data collection;
- as it was deemed necessary to agree on a realistic interpretation of the term “related”.

The framework works in two ways:

- by being able to select organizations that are relevant for comparison;
- by making it possible to interpret observed shiftwork practices in relation to domain-specific features.

The following paragraphs outline the approach, method, assessment and selection of relevant industry.

3.2 Approach

The framework was developed using the following steps:

1. Identifying the ATM specific features that serve to define the ATM context.
2. Generating a list of domains for evaluation.
3. Gaining knowledge for each domain on each feature, through experts and literature.
4. Scoring how similar or different the specific domain is compared to ATM on each feature.
5. Evaluating the overall compatibility with ATM on relevant shiftwork features in order to select domains for data collection.

The list and items were subject to evaluation and iterations, and were assessed against their relevance for the practical task of producing shiftwork solutions.

3.3 Method

The framework consists of three different dimensions:

- the list of features relevant to shiftwork,
- the list of different domains and, finally,
- the scoring of similarity between ATM and the domains on the different features.

As all these dimensions were interdependent, the final framework was developed through several iterations.

3.3.1 Identification of shift-relevant features for domain comparisons

The interesting descriptions, and thus criteria, of the ATM context are only the features that are important for shiftwork solutions. A filtering process was therefore required in order to produce usable features in the framework.

The features included in the framework need to be the necessary and sufficient information required about a domain for the purpose of designing or specifying shiftwork solutions. Put another way, there was a need to know about the domain-specific aspects of shiftwork solutions. Based on a critical evaluation of the initial features identified, a revised list of features was produced. The list of features was divided into two categories, essential matches (i.e. features that should match), and informative features (i.e. features that might provide valuable but do not constitute necessary or essential information).

Essential features:

- continuous shiftwork system,
- regulations,
- unwanted consequences,
- effort,
- predictability.

Informative features:

- level of expertise,
- drivers,
- organizational factors,
- degree of individual difference.

The above list thus makes up one dimension of the framework.

The rationale and subcategories for each of the features is described below:

- *Continuous shiftwork system* refers to the fact that the organization applies a so-called 24/7 business, as opposed to semi-continuous or non-continuous systems. It is thus believed that best practices will only be relevant if practised in a continuous fashion.
- *Regulations* refer to the extent to which different regulations, laws, agreements or any other fixed criteria influence the applied shiftwork solution. Regulations might apply in one domain that makes it hard to transfer best practices to other domains having different regulations. Regulations are also likely to vary between countries.
- *Unwanted consequences* refer to the safety aspect. Safety is seen as avoiding the unwanted consequences that might result from a human operator's error or mistakes. These consequences can either affect other people (i.e. responsible for others' safety) or one's own (personal) safety.
- *Effort* is the demand or workload put on the operator, or required of the operator, when he/she is on duty. Effort can be addressed by its subcomponents such as mental effort, physical effort, variation in effort, and stress (and sources of stress). Effort includes both overload and underload.
- *Predictability* refers to how predictable the need for staff is, due to the nature and variation of the tasks, and/or situations.
- *Level of expertise* refers to the level of specialisation and nature of tasks performed by the staff, which might be relevant to shiftwork.
- *Drivers* are the current and near-future demands and trends outside the organization that will have an effect on shiftwork, as preparations for future situations. Different drivers are identified in the literature review.
- *Organizational factors* are the factors that affect the operator in his/her tasks, residing in the organization and the way it operates. A large number of factors might be relevant.
- *Degree of individual difference* addresses the practical challenges to shiftwork solutions that exist because there is a need to take individual or personal factors into account when designing shiftwork solutions. There might be a large number of different factors at play.

The features described above were analysed for relevant subcategories, and these were included in the framework for a more accurate scoring. The shift-relevant features for domain comparisons can be seen in the framework as presented below.

3.3.2 Identification of different domains

Domains that practise shiftwork had to be selected for scoring on relevant features for domain comparisons. As the different domains include a variety of professions and/or tasks, specific shiftwork environments within each domain had to be selected. This was accomplished by investigations of occupations and tasks within the domains. A central reference here was the U.S. Ministry of Labour (<http://www.bls.gov/search/ooh.asp?ct=OOH>), which has developed descriptions of relevant features (e.g. Nature of the Work; Working Conditions; Employment; Training; Other Qualifications, and Advancement; Job Outlook; Earnings; Related Occupations; Sources of Additional Information) on a large number of occupations. Each of the different domains is described and evaluated below.

3.3.3 Scoring of each feature for each domain

The scoring of the different shiftwork relevant features for each domain was based on an initial scoring of the ATM context. The scale applied had seven points, ranging from -3 to +3, describing the degree each feature overlapped with the ATM scoring. Features difficult to evaluate were just ticked if present.

Based on the scoring of ATM features, each of the different domains was scored individually, and then the individual scores were transformed into relative scores expressing the degree of difference from ATM, rather than absolute scores. A score of 0 indicates a close match, a score of 1 indicates a good match, 2 a lower match, whereas 3 a very low match. The +/- indicates the direction of the described feature, i.e. if the compared domain scores higher or lower on the relevant feature.

3.4 The Framework

The framework is presented in [Table 1](#). The different domains are listed on the top. The shift-relevant features are listed down at the left side. The evaluations of similarity with ATM for each of the other domains are scored within the grid. Note that not all of the features were possible to score. The different regulations for the different domains in different countries or organizations are hard to obtain. The same can be said about the organizational factors affecting shiftwork. The different values given as indications of degree of similarity with ATM were coded by the use of shades of grey for easier analysis. Thus, the lighter grey the cell is, the more similar to ATM, and the darker grey the more different. This coding does not consider the priority of the features, however. Some of the features will be included in the framework in the future. These features require more specific domain knowledge and will be addressed as part of the data collection.

Table 1: The Shiftwork Framework

Shiftwork Framework	Railway Control Centre	Emergency Dispatchers	Medical Emergency Room	Road Transport Centre	Fire Station	Military	Meteorologist	Oil	Airlines	NPP	Police	Shipping
Predictability	+3	+1	+1	+1	0	0	+3	+1	+2	+3	+1	+2
Avoiding unwanted consequence - Safety												
• Others	0	-1	-1	-1	-1	-1	-1	-1	0	0	-1	-1
• Self	0	-1	0	-2	+3	+3	-2	+1	+2	+2	+2	+1
Effort												
Mental	- Skills	-1	-1	0	-1	0	+1	-1	-1	0	-1	-1
	- Rules	-1	0	0	0	0	+1	-2	-1	0	+1	0
	• - Knowledge	-2	-1	0	-2	-2	-2	-1	-1	-1	-1	-1
• Physical	0	0	+2	0	+2	+3	0	0	+1	0	+2	+1
• Variation	-2	-2	0	-2	0	0	-2	-2	0	-3	0	-1
Stressors	- Physical conditions	+1	<u>0</u>	<u>+2</u>	<u>0</u>	<u>+2</u>	<u>+2</u>	<u>0</u>	<u>0</u>	<u>+1</u>	<u>-2</u>	<u>+1</u>
	- Balancing the demands of home and work	0	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>+2</u>	<u>0</u>	<u>+1</u>	<u>+2</u>	<u>0</u>	<u>+1</u>
	- Job design	-1	<u>-1</u>	<u>0</u>	<u>-1</u>	<u>0</u>	<u>+1</u>	<u>-1</u>	<u>+1</u>	<u>0</u>	<u>-2</u>	<u>0</u>
	- Relationships in organisation	+1	<u>0</u>	<u>0</u>	<u>-1</u>	<u>+1</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
	- Work organisation & conditions	0	0	0	0	0	+2	+1	0	0	0	0
Level of expertise	-1	-1	0	-2	-2	-2	0	-1	0	0	-2	-1
Shiftwork rosters type Continuous or conti-systems (24/7) * = weeks on/off	X	X	X	X	X	X*	X	X*	X	X	X	X*
Organizational factors												
Degree of individual difference needs												
• Age												
• Others												
Regulations												
Drivers												

3.4.1 Railway

The railway domain is for this purpose represented by different rail traffic controllers working either at railway or subway/metro control centres. The scoring of compatibility with the ATM domain is based on “a documentation of rail traffic controllers’ skills – in order to identify the qualities aspirant controllers should possess” (Skjerve & Ludvigsen, 2001). The typical rail traffic controller has the task of supervising and controlling the rail traffic. The controller has to relate to different procedures, schedules and deviations.

The overall comparability with ATM is quite good with exception to the predictability and the variation in effort. In addition, the level of effort is generally lower.

3.4.2 Paramedic communication centrals

Paramedic communication centrals, or public safety dispatchers, monitor the location of emergency services personnel. The workers dispatch the appropriate type and number of units in response to calls for assistance. They are often the first people the public contacts when emergency assistance is required. Typically, a team answers calls and relays the information to be dispatched. Responsibility then shifts to the dispatchers, who send response units to the scene and monitor the activity of the public safety personnel answering the dispatched message. During the course of the shift, dispatchers may rotate these functions.

The overall comparability with ATM is quite good. The variation in effort is the biggest difference, and the effort is somewhat lower.

3.4.3 Medical

The medical area chosen for comparison to ATM is the emergency medical personnel working at hospital emergency rooms. These rooms are typically manned on a 24-hour basis, receiving patients with different needs.

Overall comparability with ATM is very good. The only differences are physical effort and stress, which are higher. It certainly appears that medical emergency units should be approached for best practices.

3.4.4 Transport

Within the transport area the traffic control centres are compared with ATM. The traffic control centres are typically manned 24 hours a day and serve to monitor and control traffic, as well as providing information to different users.

Overall comparability with ATM is not too bad. The major impression is that the work at a road traffic centre is slower and demands less of the operator, which in turn affects the shiftwork solutions.

3.4.5 Fire

Fire fighters help protect against dangers by rapidly responding to a variety of emergencies. During duty hours, fire fighters must be prepared to respond to a fire or any other emergency that arises. Fire fighters spend much of their time at fire stations, and have work hours that are longer and vary more widely than hours of most other workers.

The fire fighters deviate from ATM on a number of features. Possible contributions to shiftwork solutions would possibly only be on specific problems or issues, rather than an overall approach.

3.4.6 Military

A number of military organizations are likely to be suitable for comparison with ATM. When focusing on shiftwork the military runs a number of operations 24 hours a day. An example imagined here is active duty on typical military activities in serious situations such as different kinds of conflicts.

The military deviate from ATM on a number of features. Most central are the specific regulations and the extensive periods away from home. Possible contributions to shiftwork solutions would be only on specific problems or issues, rather than an overall approach. Still, the military consists of more practices than are evaluated here, and different practices could be more relevant.

3.4.7 Meteorologists

The satellite domain was interpreted as meteorologists. Meteorologists study the atmosphere's physical characteristics, motions and processes, and the way in which it affects the rest of the environment. Most weather stations operate 24/7. Jobs in such facilities usually involve night, weekend, and holiday work, often with rotating shifts. During weather emergencies, such as hurricanes, operational meteorologists may work overtime.

The overall comparability with ATM is not too good. The most prioritized features for comparison differ significantly.

3.4.8 Oil

The oil business is here defined as the operators in the control rooms on board oil rigs. These control rooms are usually manned with two or three operators, 24 hours a day. As the oil rigs are offshore they typically employ twelve-hour shifts, with two weeks on board and then four weeks off. The oil operators' work environment and tasks were evaluated by the Norwegian Research Institute for energy and nuclear technology (IFE) staff working on oil projects.

The overall comparability with ATM is not too bad on most features, even if the level of effort is in general somewhat lower. The most important difference, however, is that the operators usually stay offshore for extended periods and then home for another period.

3.4.9 Airlines

Airline pilots have a variable work schedule, working several days on then several days off, and also spend a considerable amount of time away from home because the majority of flights involve overnight layovers. In addition, the pilots' work is safety critical and demands alertness.

The overall comparability with ATM is quite good, except for predictability, and the fact that pilots might end up far away from home at the end of the shift. Still, airlines might provide interesting practices on shiftwork.

3.4.10 Power plant operator

The Nuclear Power Plant (NPP) operators were chosen as representatives of power plant operators. Reactor operators control equipment that affects the power of the reactor in a NPP. In addition, there must be a licensed shift supervisor on duty during each shift. A NPP is run 24 hours a day, and involves critical safety issues.

The overall comparability with ATM is not too good. NPP operators experience less variation in effort and higher predictability, even if most of the other features are not that different.

3.4.11 Police

By police we intend a regular police force practising a shiftwork operation. The police stations are usually manned around the clock. Police work can be very dangerous and stressful.

The overall comparability with ATM is quite good. According to the analysis, the demands on the police force are not that different from ATCOs. Shiftwork solutions in the police force might therefore be informative for ATM.

3.4.12 Shipping

Captains, mates, and pilots of water vessels command or supervise the operations of ships and water vessels. Merchant mariners on ocean-going ships are hired for periods ranging from a single voyage to several continuous voyages and may be away from home for months on end. At sea, these workers usually stand watch for four hours and are off for eight hours, seven days a week.

The overall comparability with ATM is not very good. The most central features differ too much. The predictability is much higher and mariners spend long periods away from home.

3.5

Selection of Relevant Industry

The comparison of the domains indicated that the Medical Emergency Room personnel, together with the airlines and the police would make good subjects for data collection on best practices. The Emergency Dispatchers also seemed promising, but were left out as it is expected that research into Medical Emergency Room shiftwork will be related to this, and is even run by the same institutions.

Based upon the framework, the domains *police*, *medical emergency units* and *airlines* were selected in addition to ATM, in order to identify shiftwork practices.

3.6

Data Collection Shiftwork Practices Case Studies

The next task was to find interesting shiftwork management case studies.

Case studies were sought that would match the criteria identified in the Framework (the domains). One important factor concerns the interpretation of “best practice”:

- For a case to be included, how “good” should their shiftwork practices be? That is, what lies in the interpretation “best” practice?

Realistically, for the feasibility study the aim was at least to incorporate the following two criteria:

- in general, a case study should contribute information useful for MSEA six domains of interest;
- relevant experience in a domain of interest and the lessons that can be learned.

For the data collection the following plan and structure was developed:

- data will be gathered through telephone conferences to be arranged with representatives from industries that are of particular relevance for ATM with respect to shiftwork management, as well as different ANSPs.
- for practical reasons, as an alternative to the telephone interview, the questions were distributed and responded to electronically.

The data collection plan is detailed in Annex 1.

3.7 Summary

The development of the framework has made it possible to identify specific domains that are believed to be similar to ATM on shiftwork-related features. The selection of domains (related industries) has thus been based upon a methodology developed to avoid the selection of domains to be based upon a more intuitive and thus probably biased process. Whether the model and thus selection of domains is accurate still needs to be validated. The process of data collection might confirm the selected domains, but will not validate the exclusion of the ones left out.

4. FINDINGS FROM ATM

4.1 Introduction

This chapter outlines the information gathered from European ATM and outside Europe, including AirServices Australia, Airways New Zealand and US Federal Aviation Administration (FAA).

4.2 European ATM

4.2.1 Introduction

During this study, a sample of ten ANSPs was interviewed to discuss their shift systems, recent changes, and challenges. They represented large, small, and other European areas including:

- Austrocontrol (Austria),
- AENA (Spain),
- ANS Czech Republic,
- Avinor (Norway),
- DGAC (France),
- DFS (Germany),
- Lfv (Sweden),
- Maastricht (EUROCONTROL),
- NATS (UK),
- Skyguide (Switzerland).

Within the ECAC area there is a mix of large and small ANSPs, and the degree of sophistication in how shiftwork is managed varies. In Europe some key varying factors that impact shiftwork and the degree to which changes can be made are:

- cultural differences,
- labour relations,
- labour laws,

4.2.2 General shiftwork features

The following are general shiftwork features in European ATM:

- Range from team, teams with staggered start and finishing times to individualised rosters. The large centres are more likely to have a team-based roster and the medium to smaller centres an individualised roster.
- Most ANSPs (six out of ten) have forward rotating shifts, some use backward rotation (two) and some have no fixed cycles (two).
- Shift lengths vary during the day from four to twelve hours and during the night from eight to twelve hours.
- Shift cycles' working days and days off vary from country to country. In many centres with team-based rosters, longer cycles (4/2, 5/2, 6/3) exist or no fixed cycles in centres with individualised rosters.

4.2.3 Recent changes

There is a general trend within European ANSPs to move towards a culture of continuous adaptation to managing shiftwork, mainly to increase flexibility and improve productivity. The following provide an example of the types of initiatives that have taken place over the last five years:

- change to forward rotating shifts;
- keep team concept, but introduce staggered shifts to increase flexibility;
- reduce working time;
- change starting and finishing times;
- introduce floating breaks according to demand;
- change shift lengths;
- change how the shift system is managed and set up roster office;
- introduce incentives for changing shifts to meet unexpected absences (short shift, switch to night duty, day in lieu, use of overtime, selling of annual leave, additional voluntary attendance);
- revise ATCOs' salary structure;
- move from fixed cycles to open cycles;
- make ATCOs responsible for managing their roster with the support of a software tool;
- introduce software tool to support flexibility.

4.2.4 Implementation factors

The most important factors to consider when implementing a change to a shift system are as follows:

- check compatibility with regulations;
- check if change is feasible with the number of ATCOs;
- communicate: explain changes to gain understanding of benefits; set scene with trade unions and allow enough lead-in time for this but have a specific timeframe in mind to achieve results; “working together” principle: policy to have no surprises in the communication process;
- critical success factors are: social acceptance, finances available, resources and preplanning;
- for negotiations: highly experienced management, respect and knowledge of issues;
- business case needed for the board;
- requirements, tool selection, customisation.

4.2.5 Key lessons learned

- Be open and flexible to adapting the system (e.g. not possible to go directly from team to individual, i.e. splitting the team into individuals by having staggered shifts and maintaining the concept of a team).
- Each ANSP should plan for some surplus of ATCOs to help alleviate others in time of need.
- Communication essential: difficult for people to understand the change and listen to the people. An essential part of development process: participation helps process, builds openness and trust, engenders trust.
- Changes are possible without increasing the number of staff.
- Flexible rostering has limits (regulations have to be adhered to).

4.2.6 Areas for change in the current shift system

The following areas are considered necessary for further improvement to the current shift system:

- move from a team and stable roster to the individual,
- develop a culture of continuous adaptation,
- economic: more flexibility and productivity required,
- introduce a new shift software system,
- change shift lengths.

4.2.7 Experience among European ANSPs

Table 2 below shows an example of practices being used with European ANSP to cope with these six domains of interest. However, the application of a procedure is highly dependent on the ANSP context and culture.

Table 2: An example of practices used with European ANSPs to cope with shiftwork challenges

	Issue	Suitable practices according to the location and context of ANSP environment
1.	Flexible application of resources	<ul style="list-style-type: none"> ▪ Centralised planning and roster office ▪ Individual rostering as opposed to team ▪ Financial compensation for duty changes ▪ Overtime and standby duty for additional attendance ▪ A kind of adapted shift system: different starting and finishing times for controllers in the same team ▪ Incentives for short-term changes to shift; duty changes compensated financially ▪ Voluntary selling of annual leave
2.	Selecting and adapting shift systems	<ul style="list-style-type: none"> ▪ Develop a culture of continuous adaptation ▪ Experience in introducing rostering tools ▪ Different rostering tools
3.	Implementation of a new shift system	<ul style="list-style-type: none"> ▪ Implementation needs negotiation ▪ Compromise between leadership and participation ▪ Communication with staff, staff acceptance and involvement ▪ Involvement of controllers; controllers' opinion requested before a new shift system is used
4.	Managing individual differences in shiftwork	<ul style="list-style-type: none"> ▪ Internet Swap System ▪ The shift system is same for all controllers; within a shift, the supervisor is in charge of individual differences ▪ Individual difference accommodated – satisfaction of ATCOs ▪ Computer-based scheduling makes this easier to manage ▪ Individual roster system can cater more easily for individual differences
5.	Team/individual shift systems	<ul style="list-style-type: none"> ▪ Two thirds team roster, one third directed roster
6.	Tactical and strategic shift management	<ul style="list-style-type: none"> ▪ Centralised planning and roster office ▪ System of preparing rosters twice a year

4.3 ATM Outside Europe

4.3.1 Introduction

In this section the practices/experience of ANSPs outside Europe are reported. These ANSPs are:

- Airways New Zealand,
- AirServices Australia,
- US FAA.

Recent changes/practices that are of interest to European ATM are highlighted.

4.3.2 Airways New Zealand

ATM context

Airways New Zealand is in charge of 18 control towers, 2 radar control centres, and 1 oceanic centre. 14 of the control towers are not open 24/7, whereas the rest are. Airways New Zealand employs some 330 ATCOs. The traffic pattern is typically very busy during the day and very quiet at night. The Civil Aviation Authority Rules require Airways New Zealand to have a Fatigue Management Plan (FMP). At the organisational level there is the Collective Agreement with Unions, which is quite specific and very detailed.

Shiftwork features

The typical shift cycle is 4/2, or in some cases 6/3, or a combination of both. A backward rotation (late, early, night) is practised. The rosters are planned for the individual and not for teams. The time off between shifts is 12 hours, but this can be reduced to 9 hours once within the cycle. The minimum off-duty time in the 4/2 roster is 60 hours, whereas the minimum off-duty time in the 6/3 roster is 84 hours. The maximum rostered length of shift is 7.5 hours (10 hours for night shift provided staff agree and minimum 3 hours horizontal rest provided). There is no fixed start/finish time for an early/late shift or night shift as the individual sets his or her own specific shift.

Maximum hours per week are 35 hours with a maximum of 39.5 hours in a cycle (not week) on a 4/2 roster. For a 6/3 cycle the maximum would be 58.5 hours. Overtime can be worked as part of the 39.5 hour maximum and can be by way of shift extension or recall on days off. Recalls are limited to 1 in 10 days and 2 in 36 days. Blocked free time at weekends is a big factor influencing shift cycling. There are no rules regarding the number of successive night shifts, except that custom and practice has no rosters utilising consecutive night shifts (i.e. there is only one in a cycle of shifts).

To manage unexpected absences, staff can be recalled during their day off or extend shifts up to 9.5 hours. The in-house tool called “SUMS” is used for rostering staff, but it is not, however, a shift optimisation tool.

Each roster has a roster representative. In planning the roster, management decide the coverage required (positions and hours open) and the staff design a roster to deliver the coverage required and the sequence of work they prefer, as long as the roster is efficient. The final decision on the roster rests with the manager.

A leave roster is maintained which generally allows a set amount of people away on leave at any one time. Once designed, the roster is set in concrete. If they then want to change, the staff can arrange swaps. Management may change shifts with 48 hour notice or less by agreement. Rosters are published a minimum of one month in advance. The system for swapping shifts that documents the changes made to the original roster are done electronically in SUMS (provides an audit process).

Good practice experience

- **Individual rosters:** Airways New Zealand has individualised roster based around shifts and positions. This is because the nature of traffic flow is such that the daylight hours are busy and the night is very quiet. Team rosters would therefore not be very efficient. The individualised roster works very well when you haven't got consistency traffic flow over a 24-hour period.
- **Fatigue management:** For safety reasons fatigue management studies are performed. A few different strategies are applied to reduce health problems caused by the shiftwork solution. During solo night shifts self breaks are implemented. The organization either pays for a motel at end of a night shift, so that staff do not drive home tired, or provide sleeping facilities. In addition, there is a booklet on managing fatigue (fatigue education) and counselling available to staff on a confidential basis to assist with any stress encountered.
- **Strategic and tactical shift management:** The strategic part of shiftwork management is looking at night shifts and taking into account appropriate human factors, traffic management, and future sector configuration and roster reviews. The tactical aspects are that on a sector level rosters are reviewed, and on a daily basis the supervisor ensures there is adequate coverage provided in the event of sick leave, etc.

4.3.3 AirServices Australia

ATM context

“The Brisbane and Melbourne FIRs spans eleven per cent of the world's surface and span from Indonesia to the South Pole and from halfway to New

Zealand to halfway to Africa. We provide air traffic management services to some 5200 flights total daily, in the two FIRs."

The service providers described are 2 major en-route/TMA Centres in Brisbane/Melbourne that operate 24/7. In Brisbane there are approximately 300 ATCOs divided into 8 groups (5 en-route, 3 arrivals, 1 terminal). There is also one remote TCU in Cairns. The ATCOs tend to be radar only, procedural only or a mixture of procedural/radar. In Melbourne there are approximately 300 ATCOs, divided into 10 groups, plus 3 remote TCUs for Adelaide, Perth and Sydney. The ATCOs here tend to be radar only, procedural only or a mixture of procedural/radar. For each position there is one executive ATCO. The traffic varies for both centres throughout the day with peaks and troughs in the morning, afternoon/evening. With Sydney being "the hub" of Australian domestic traffic.

At an organisational level the Staff Union Agreement locks in specific principles of rostering. The agreement is valid for three years. The trend is to move away from this to get more flexibility. At a national and international level there is the Safety Regulator and also an aim to meet International agreements/laws.

Shiftwork features

The shift cycle is either 4 days on / 2 days off, or 3 days on / 3 days off, and a continuous combination of morning, afternoon, late and night shifts. The ATCOs are contracted to work 36 hours a week. The shift length varies from 7 to 10 hours (maximum). There are no split shifts and the ATCOs work continuous alternating shifts. The backward rotating shift starting with afternoon and finishing with morning is generally favoured and difficult to change.

The free time after the shift is 10 hours after day shifts and night shifts, but this can be reduced to 8 hours if called in unexpectedly. The roster does not take into account having specific free time at the weekend or two coherent days or single days. However, the roster cycle does automatically ensure that a weekend will be off over 4/6-week period. The number of free days (off days) per year is 5 weeks holiday.

There are individual rosters, with staggered start/finish times. A rostering committee made up of staff/management and union discuss and agree changes to the roster. Then roster is signed/agreed by the centre manager. The centre manager will decide on the coverage and will leave it to the committee to design the roster taking into rostering principles and efficiency measures. The ATCOs are normally given 15 days notice of the shift schedule. Once the roster schedule is published it is fixed. However, ATCOs can arrange a mutual swap among themselves, to be approved by their supervisor. Overtime covers unexpected absences/requirements up to minimum of 4 hours (even if only needed for two they have to be paid for 4 hours). After 2 hours at the screen/console ATCOs get 30 minutes off (during normal/peak traffic). Break can be longer if traffic is low.

Good practice experience

- **Fatigue management system:** Regulation requires that there is fatigue management system in place. The Fatigue Management System (FAID) is a tool to check the roster for fatigue measures. All rosters are fed into the tool that then tells where shift cycles are generating fatigue issues. Individual shifts are scored and if the roster is above a benchmark score, it needs to be adjusted. Typically, the night shift generates the most fatigue. The Fatigue Risk Management System is in process of introduction phase. In addition, a fatigue education program (3-hour modules) has been started for ATCOs, as well as organised family days.
- **Implementing a new shift software tool:** A rostering software (microster) has been introduced over the last 18 months. This is an “off-the-shelf” tool that has been customised for air services to take into account traffic variation. It gives printouts of planned and actual shift cycles, and takes into account staff endorsements and ratings. The tool can deal with optimisation issues and developing rosters 18 months in advance. It is considered an asset when it comes to strategic planning. The next step is to link/integrate the FAID tool.

4.3.4

U.S. Federal Aviation Administration (FAA)

The information gathered relates to the Indianapolis Air Route Traffic Control Centre and reflects general FAA shiftwork practice for this type of environment.

ATM context (extract from the study on the “Comparison of Performance in selected US and European En-route centres”²)

Indianapolis Air Route Traffic Control Center (ARTCC) is responsible for an area of airspace in the US Midwest covering all or portions of Indiana, Illinois, Ohio, West Virginia, Kentucky and Tennessee. The airspace sits above the major airports of Cincinnati, Port Columbus, Dayton and Indianapolis. In addition, it handles northbound arrivals to the Chicago airports, Detroit, Cleveland and Pittsburgh, westbound arrivals to St.-Louis, eastbound arrivals to Washington airports, Philadelphia, Raleigh-Durham and Charlotte, and southbound to Atlanta and Memphis.

A large permanent military area of airspace sits in the middle of the airspace controlled by the centre and is operated by Indianapolis ATCOs.

Traffic through Indianapolis ARTCC varies in an unpredictable way in its spatial distribution across the centre’s airspace because of the variation of the jetstream position and the need to avoid severe weather.

²

A EUROCONTROL comparative study (2003) carried out during February 2002 and March 2003 by the Performance Review Unit on the request of the Performance Review Commission, with the cooperation of a number of European Air Navigation Service Providers (ANSPs) and the US Federal Aviation Administration (FAA).

Shiftwork features

The basic working day consists of eight consecutive hours and the basic working week consists of five consecutive days (5 days on 2 days off). Shift starting times do not overlap with each other. However, ATCOs in operations can come to work up to half an hour earlier than the official time. This time will be compensated for at the end of the shift. If this compensation is not possible the accumulated time will go to a time account. The standard working week is 40 hours.

Split shifts do not exist and the shifts are permanent over a 12-month period. ATCOs start with evening shifts and moving backward through the day ending with the mid-shift (backward rotating shift). The free time after the shift is eight hours for all shifts (after day or night shifts). The time interval between two working days is 8 hours and the time interval between two shift sequences is two days (48 hours) at least.

The 5/2 shift rotation results in 261 annual working days not counting the sick days, compensation for public holidays or annual leave. Based on shorter availability per day and more annual working days for personnel, overlapping periods between early and late shifts are short. ATCOs from ACC staff are not required for teaching jobs at the FAA academy.

There is an individual roster. Shifts and associated starting times are individually assigned to each ATCO. However, a group of ATCOs follow the same roster cycle for a year. ATCOs which follow the same cycle are part of the same crew.

The Union and FAA at the local level negotiate procedures for employees bidding and assigning to the basic watch schedule. At the request of the Union, bidding and/or assignment within the basic watch schedule is done according to seniority. The basic staff roster is prepared one year in advance, normally in the autumn before the year in question. The roster is valid from 1 March to 28/29 February the year after. The FAA recognizes that changes of individual assignments to the watch schedule are undesirable. Changes between 28 days and 7 days in advance are possible but are minimized. Changes with less than 7 days advance notice are usually avoided because of overtime would apply in such circumstances. Unforeseen circumstances are handled in accordance with staff roster rules and overtime rules. In addition, ATCOs on other duties may be required to work in Operations (OPS) where necessary and if they have a valid rating.

There is generally one collective agreement per each job category. Ground rules for collective bargaining adhere to the Federal Service Labour Management Relations Statute. Collective agreements cannot override rules and regulations contained in the Civil Service Reform Act of 1978. The agreement is made by and between the National Air Traffic Controllers' Association (NATCA), AFL-CIO, FAA and the Department of Transportation. The contract is valid for the period 1998 to 2003.

The NATCA closely watches working conditions and how ATCOs are employed. There are different levels of negotiations: national, regional and local. Bargaining is accomplished at the level appropriate to the issue. All levels are entitled to discuss how "ground rules" for bargaining should evolve but must keep them in line with the current legislation (e.g. Federal Service Labour Management Relations Statute).

NATCA is consulted when working conditions are at stake. In most circumstances FAA managers involve NATCA in the decision-making process from the outset. However, if there is an urgent need to implement a decision that affects working conditions then management does so, even though negotiations may still be in progress.

ATCO staffing levels are negotiated during national collective bargaining at the same time as the FAA/NATCA contract. This negotiation sets the national staffing level for each year of the collective bargaining. Distribution of this staffing level to regions, facilities, and areas/teams is negotiated annually.

Sharing good practice

- ***Individual rosters and teams in place:*** Individual rosters where shifts and associated starting times are individually assigned. However, a group of ATCOs follow the same roster cycle.
- ***Managing traffic variation:*** Breaks: Unless operational requirements do not permit, ATCOs are not be required to spend more than 2 consecutive hours performing operational duties without a break from operational areas. A minimum 30 minutes uninterrupted meal break is also foreseen. There is no daily schedule managing the working times of control staff spent in position and on breaks. The normal break lasts from a minimum of 30 min to a maximum of 60 min.; a break of 30 minutes for lunch or dinner between the 4th and 6th working hour and a break of 15 minutes after the 2nd hour of work at a control position can be claimed. Control staff are allowed to determine the duration of their breaks, provided staff remain permanently available after being relieved.

Controllers are responsible to manage their relief from working positions. Normally the controller returning to work from his/her break relieves the controller with the longest time in position or if requested by the supervisor opens an additional working position. In daily business this means fewer breaks for control staff during peak hours; during times of low traffic additional breaks may be taken. This enables staff to work to full capacity, according to traffic demands.

- ***Staggered starting times:*** Shift starting times do not overlap with each other. However, ATCOs in OPS can come to work up to half an hour earlier than the official time. This time will be compensated for at the end of the shift. If this compensation is not possible the accumulated time will go to a time account. The standard working week is 40 hours.

4.4 Summary

It is evident from the 10 ANSPs in Europe that were interviewed that a number of different shiftwork solutions are practised. Practices vary on the different shiftwork features, such as direction of rotation, length of shifts, individual and team rosters, days off, etc. The differences to some extent may be put down to factors such as size, culture, and legislation. However, there are some general trends towards the development of more flexible solutions to increase productivity. Based on the different changes implemented, some general recommendations can still be made and possibly further developed.

The main contributions and experience from non-European ATM are in the area of individual rostering, fatigue management, managing traffic variation, implementing new shift systems and software tools.

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5. FINDINGS FROM RELATED INDUSTRIES

5.1 Introduction

This chapter outlines experience gained from the following sectors:

- medical,
- police,
- airlines.

5.2 Medical

For the medical industry two case studies based upon interviews are presented. Both are hospitals in Oslo, Norway. The first describes the shiftwork solution applied for medical doctors, whereas the other one describes some experiences with the implementation of a new roster for nurses. In addition to these two cases, three papers are included. These papers are either best practices studies or guidelines within the medical sector from Australia, New Zealand and Denmark.

5.2.1 The Emergency Ward in Oslo, Norway

Oslo Legevakt (<http://www.osolegevakt.no>) or the Emergency Ward in Oslo, Norway, provides medical and social welfare emergency service for the inhabitants of and visitors to Oslo. They offer assistance in case of:

- acute illness or injury,
- acute psychiatric problems,
- violence or sexual assault/rape,
- crises in the family,
- need for follow-up after serious accidents.

The Emergency Ward is one of the biggest of its kind in the world, considering provision of services. Bigger cities typically have smaller units and/or are more specialised, whereas Oslo only has this single one. It is probably also the only place in Norway where medical doctors practise a 24/7 3-shift solution.

Workload varies during the day, the week and the seasons. The daily peak is in the evening, the weekly peak is at the weekend and then at night, and there are also seasonal variations.

The current shift solution was implemented in 2002, resulting in a reduction of sickness leave and a lower turnover of staff. In addition, the staff turnover has gone from an average of 1 year to the current average of 2 years. Based on this, the shift system of the Emergency Ward in Oslo was investigated for the

purpose of best practices. The chief physician of Emergency Ward is responsible for the daily rostering.

Shiftwork features

The shift system is an alternating, continuous 24/7 – 3 shift solution, with an average of 33.6 hours of work per week. The schedule is based upon a 24-week roster, since there are 24 staff. There are special rosters over Christmas and Easter. Forward rotation is practised, although if it is not strictly adhered to. The staff have two one-week periods of free time over the 24 weeks, and alternate between duties, shifts and teams. The staff are only scheduled to have every 3rd weekend free, but, in reality, the demand for staff is higher. Therefore a special practice is used during weekends, where extra resources are bought in.

The priority of the shiftwork system is to “get the job done”, rather than to promote long-term staff health or safety as such. It should be noted that the typical employee is only interested in working there for a few years in order to get valuable professional experience before moving on to other jobs.

The shiftwork solution is guided by Norwegian legislation (the law on work environment – where the health sector has special exceptions), and negotiations with unions and employee representatives in order to ensure satisfactory work conditions.

The system is organized and maintained through a Microsoft Excel sheet.

Good practice experience

- **Flexible application of resources:** The best practice of the emergency unit in Oslo relates to the flexibility of a rather complex system. Flexibility is ensured by the manipulation and the interaction of a number of factors. From a management perspective there is the ability to shift staff on duty from one function to a more prioritized one when needed, for example calling in staff on sick visits, or the possibility of buying in extra staff (off-duty staff). There are direct costs involved with this, but this is accepted and prioritised. Smaller alterations and adjustments will in most cases provide the flexibility needed for daily operations. If there is a four-hour wait or more for the clients, extra personnel can be called in. In addition there are also student workers who increase flexibility.

In addition to the formalized features, a number of “soft issues” would appear to be significant. The shift manager uses the “SMS” function on the mobile phone to give staff advance warning about shift alterations, which would seem to increase acceptance of the alterations. Moreover, a good knowledge of staff members’ personality and situation is considered important, as there will be different needs and thus flexibility associated with each employee. Typically, when there is need for extra staff, or duty swapping, the situation opens for negotiation. Staff might swap shifts between themselves, or ask management to arrange another shift. In addition, management might negotiate with employees. The swapping of

shifts is logged and made official, and there is thus no real difference between the official and the actual schedule.

- **Managing individual difference and individual rosters:** One central factor seems to be both personal character and the mix of personalities. When hiring personnel, a certain “robustness” and flexibility, as well as high intelligence are preferred, owing to the demands of the job. Relatively few professional disputes seem to occur (e.g. between nurses and doctors), which can also be attributed to the constant rotation between teams.

5.2.2 Hospital in Oslo, Norway

The hospital described is located in Oslo, Norway. It provides medical and psychiatric hospital services to several inner city boroughs in Oslo. The shiftwork routine and experiences described here concerns *nurses* at one of the divisions in this hospital. There are about 65 nurses in this division that serve four different departments or functions based on their qualifications. These are the emergency unit, heart surveillance, intensive care, and the night head-nurse. A nurse might rotate between these positions.

One of the nurses at the hospital who had been involved with the planning and implementation of a new roster early in 2004 provided the collected data.

Shiftwork features

The hospital practises a 24/7 continuous alternating 3-shift solution for the nurses. The roster schedule describes a 21-week period (logically: 9+9+3). The staff hold a number of different positions, (e.g. 100%, 75%, 65%, 50%, nights only, weekends only), and are arranged into different units of between 1 and 4 persons that throughout the period rotate in the same direction. The nurses work one out of three weekends, and have one week of holiday within the 21-week period. The day shifts are 8 hours long, evening shifts 7 ½ hours, and night shifts 10 hours. There are 15 night shifts in total – 21 evening shifts – and the remainder are day shifts.

The workers do not have much control over their own schedule. To some extent they are able to swap shifts, either through management, or individually for more urgent changes; in all cases the employer has to approve the change. Workers with, for example, care and responsibility for children will have rosters adjusted to their situation. Workers are able to choose between 3 or 4 consecutive nightshifts depending upon their preference.

The shiftwork solution is not very flexible. Extra staff are frequently required (between 2 to 10 every day). The schedule is organized according to the least possible manning required where holidays, etc. are not planned.

Norwegian laws regarding the work environment govern the shiftwork solution. Norwegian law distinguishes between a “continuous shift system” and “non-continuous system”, where the latter has as more daily than nightly demand

for staff or hours in total. The maximum hours per week are 33.6 and 35.5, respectively, which makes a difference for the employer. The health sector has got a dispensation to have rest period lasting less than 11 hours between shifts, and to therefore have 10-hour breaks as a minimum. The staff representative was involved in the process of making the new roster.

The workers are most pleased with the fact that there are fewer morning shifts following the evening shift, and thus only 10 hours rest. It used to be 9 over 12 weeks, now only 3 over 21 weeks. Previously there was one week off within a 12 week roster, but now only one week off for every 21 weeks. The 2nd week is lost in order to get more rest between shifts. An extra week of holiday has been granted, however.

The management are most concerned with efficiency, i.e. less tired staff. The new shift system was necessary in order to organize and manage evolving needs and issues, such as better distribution of skills, new types of positions, new needs, etc. The new system was a necessity based on these needs.

The rostering is managed through an Excel sheet, as they are not satisfied with available rostering software.

Good practice experience

- **Implementing a new shift system:** The shiftwork solution that was introduced in early 2004, to accommodate the pressing needs for a new system, still has room for improvement. The ability to see the nature of and need for these improvements requires a non-traditional perspective. That is, management's focus primarily on getting the budget right, and on productivity. The roster that is cheapest on paper is not necessarily so in practice. The roster as it is designed lacks flexibility, and there are thus extra costs as a consequence. The schedule is organized according to the least possible manning required. Holidays, etc. are not planned for. E.g. an extra week of holiday has been added, but this last week cannot be used until autumn. With 40 employees taking out one week each during a 20-week period, 2 positions are unmanned during this period. This has not been included in the shiftwork system. A roster that takes into account all real needs and costs might seem more expensive, but is probably cheaper overall. In order to identify the factors that contribute to the total, there is a need to monitor causes and effects for a longer period of time, something that management typically do not focus on. In addition, the rostering system is based upon a profile of nurses that is outdated. Current nurses are a more heterogeneous group than previously, which in turn creates other requirements and needs concerning a shiftwork solution. This analysis was given by the interviewed nurse.
- **Flexible use of resources:** One specific action that has increased the flexibility, and thus probably reduced the cost, is staff training. The training aims to increase competence in order to provide a larger pool of staff able to replace one another. There is a cost of training to be considered, but the workload is reduced as a result.

5.2.3

The Queensland Government, Australia – Queensland health – Rostering Framework – Best Practice Framework for rostering nursing personnel

The Rostering Framework was designed to provide managers and staff with a comprehensive guide to best practice rostering. The document is structured around seven guiding principles, which are designed to apply to any nursing practice setting.

The background for the framework is that a Queensland Health Ministerial Taskforce on Nursing Recruitment and Retention was completed in 1999. The results showed that many focus group participants saw rostering practices as inflexible and inequitable. Individual and organisational issues included:

- problems with self-rostering that lead to unreasonable demands by some;
- perception that full-time employees are disadvantaged in having to work the undesirable shifts;
- requests for fatigue and study leave are often unable to be met as no back-up is available;
- difficulties in replacement of staff in rural and remote locations;
- lack of experimentation concerning different shift lengths;
- lack of organisational rostering principles or guidelines.

The *report* recommended that rostering trials be established at six pilot sites to address this issue. The recommendation was selected as a priority for implementation. The *Best Practice Framework* has been developed as an outcome of these trials and has been designed to provide nursing staff with a comprehensive guide to best practice rostering.

The guiding principles have been based on the “systems” approach to rostering and specify seven principles that underlie the framework. These principles are:

1. Changes to rostering systems are managed in accordance with Queensland Health’s *Change Management Framework*.
2. Rostering systems will take into account fluctuations in demand for labour and match an appropriate supply of nursing personnel to meet anticipated clinical requirements.
3. Nursing personnel are rostered to provide a suitable mix of competence and experience to meet identified service demand.
4. Rostering systems conform to relevant award provisions and accommodate each employee’s leave allowances.

5. Rostering systems take into account the health and safety needs of nursing personnel and their capacity to provide optimal patient care.
6. Rostering systems support work life balance. They ensure employees are rostered in a fair, reasonable and equitable manner while balancing patient, employee and organizational needs.
7. Rostering systems will ensure a direct link between improved patient outcomes and staff inputs.

For each of the seven rostering principles a description is provided on how to meet the outlined demands. As such, the framework is a very structured way to make sure all those aspects thought relevant for rostering are taken into account. It is stated in the document that the purpose is not to dictate the type of rostering method that should be used, but rather to outline the different strengths and weaknesses of different methods, which can be used at different times. Eight steps are suggested for the selection and management of an appropriate rostering method. These steps are:

1. Determine demand and supply requirements for a unit.
2. Analyse the unit's staffing profile.
3. Encourage staff participation and collaboration in selecting an appropriate rostering method.
4. Consider whether conflict management and team building exercises would assist with support for the chosen rostering method.
5. Once the rostering method has been selected, in consultation with the unit's staff develop a set of local (unit) roster 'ground-rules' or guidelines.
6. Provide unit management information to all new starters during their initial orientation period.
7. Provide information and education sessions to staff regarding the unit's rostering system and processes.
8. If you are unsure of industrial awards and/or policies or experience difficulty managing conflicting demands, it is advisable to consult nursing Human Resource experts.

The framework and its associated resource manual are very comprehensive and rich, with examples and tools, and therefore constitute a model for developing shiftwork systems. As such it makes up a roadmap to best practices for nurses.

5.2.4

New Zealand Nurses Organization – Guidelines and standards of best practice for rostering to meet requirements of the nurses & midwives multi-employer collective agreement

The New Zealand Nurses Organization has developed guidelines and standards for rostering. As a rationale the following description is given:

“The delivery of healthcare requires that a continuous service be maintained in most services. For most employees, shiftwork is a job requirement that is not optional. Optimal roster practices need to be a balance between the service needs, the employees’ needs, and Occupational Safety and Health requirements.

It is recognised that shiftwork has a collective impact. Individuals may find that some roster practices, recommended as preferred, will not be ideal for them. This Working Party has identified desirable rostering features aimed at minimising any detrimental effects of shiftwork.”

The New Zealand Nurses Organization (2003)

Central to this guideline is the Roster Audit Tool that specifies a list of survey items meant to investigate that effective and efficient rostering practices are used. The tool is built around four standards. These standards are:

1. Effective rostering practices.
2. Industrial requirements.
3. Clinical/professional requirements.
4. Development and management of a roster.

Criteria for how to meet the standard are listed and will therefore serve to give directions when designing effective rosters.

5.2.5

The NARFE II project, Denmark

In the NARFE II project (<http://hb.homepage.dk>) six hospital wards addressed the inclusion of health and safety issues, ward considerations, and the employees’ social requirements in the management of shiftwork. The effects of the intervention in shift schedules were later evaluated. The original shift scheduling prioritized ward function and social wishes of the employee, whereas health considerations were not given priority.

Six wards were selected for an intervention study. The goal was to develop shift schedules in cooperation with ward employees that to a higher degree than previously took health considerations into account. The **PAR**ticipatory Intervention Method (PARIM) was used in order to lead the discussions on the wards. On each ward a working group with representatives from staff,

supervisors and a scientist was put together. The groups were responsible for arranging discussions on the wards and collection of attitudes and possibilities. Based upon these discussions, principles for scheduling were developed. The principles were tested at ward meetings. Four wards made changes, and the new schedules were tested. The changes implied securing an additional day off after the last night shift, reducing the number of consecutive night shifts, and making the schedules more regular while maintaining a degree of flexibility. A three-shift solution was changed to a two-shift solution.

The staff completed questionnaires before, during, and after the one-year period. In addition, changes in biomarkers of cardiovascular disease and stress were measured. The changes were viewed as positive and a large majority of staff wanted to carry on with the new shift schedule.

5.3

Police

The best practices reported for the domain of police include a shiftwork guide, the results of an audit report and an experimental study.

5.3.1

Decentralised Shift Management (DSM) in the Northrhine-Westfalia Police Forces Germany

The Decentralised Shift Management (DSM) was introduced in the Northrhine-Westfalia police forces because the former rosters did not consider differences in workload and stress, and because the previous rosters produced some 2,600,000 overtime hours per year.

The central features of the DSM are:

- Yearly working time accounts for each officer, which show the *status quo* in relation to the plan, the difference and the overtime.
- Position occupation plans supporting compatibility between demand and resources (which parallels the licensing question in ATCOs); these ensure that at defined times the required number of officers with certain qualifications is on duty; daily (e.g. "disco" times), weekly (e.g. weekend) and seasonal variation (e.g. carnival, tourism, football matches) is considered; the position occupation plans "book" working time from their overall yearly time budget; they also consider handover times; activities outside the routine (e.g. officer on qualification course)
- Flexible working time, which cannot, however, fall short of 28 or exceed 48 hours per week against the will of the employee; if an employee wants, 0 or 48 and more hours are possible.
- Decentralised rostering in each unit; the unit decides on shift cycle, forward or backward rotation, shift length, etc.; small units can build staff pools.

A software program called the “Software SP Expert” is used for rostering. The software offers the following features:

- pre-plans roster on the basis of position occupation plans;
- pre-plans qualification schemes;
- yearly working time accounting;
- prints roster;
- documents times with additional payment (e.g. nights);
- holiday accounting;
- facilitates anonymous controlling for units;
- checks regulation on-line (e.g. warning message if 70 hours per week in two shift cycles are exceeded, then unit head decides) and documents violations of working time regulation;
- one or two training days for unit shift manager;
- longer training for SP-User-Service-Staff (article does not say how long);
- network to payment office is planned.

The time schedule for the implementation of the DSM has been as follows:

- 1993: Tender for expert statement on shiftwork;
- 1994/95: Investigation of seven units;
- 1997/98: Pilot DSM;
- 1998: Northrhine-Westfalia Government decides country-wide use of DSM;
- 1999: DSM software requirement analysis, European tender;
- 2000: Implementation of DSM.

5.3.2 The New South Wales (NSW) Police Service: staff rostering, tasking and allocation – performance audit report

The audit report (2000) addresses the attempts to better match efficiency and effectiveness of the police force by focusing on shiftwork and flexibility through different tools and approaches. The objective of the audit was to investigate the efficiency and effectiveness of staff rostering, tasking and allocation systems, and practices at Local Area Commands (LACs) within the NSW Police Service in Australia. The LACs aim to reduce the crime levels. To achieve this LACs should implement crime prevention strategies, undertake more proactive policing, and gain improved support from information systems. Rostering and tasking systems are seen as critical to the deployment of staff to the proactive policing. Rostering allocates available officers to particular

shifts and duties, whereas tasking allocates officers to specific crime-related activities.

A wide range of information technology and system developments were expected to improve the Service's capabilities to apply intelligence information to the deployment of staff at LACs. When fully implemented this was believed to contribute to the Police Service's ability to be more proactive and provide for better staff deployment. In addition, it was believed that the impact of these developments on the efficiency and effectiveness of rostering and would be further enhanced by attention to gaps in systems and to restrictive staff allocation practices.

The Enterprise Data Warehouse which supports improved measurement and assessment of activities, and the Smart Rostering System (SRS) that replaces manually prepared rosters and existing PC-based links to HR systems were developments to improve the LAC's capacity to better roster and task staff. The SRS should provide benefits to LAC rostering practices but was believed to require further assistance through a more comprehensive recording of proactive policing and improved tasking systems. To achieve the effective utilisation of the increasing number of officers available for proactive duties, the need for an improved integration of intelligence information coupled with flexible rostering and tasking practices was identified. Phase 2 of the SRS was planned in order to integrate an intelligence-based demand model on the 'front-end' of the system. The model applies data from operational systems to predict police activity. This is likely to require more flexible management and staff practices to support increased variability in the lengths of shifts.

The final recommendation included the statement that the Police Service should: "better co-ordinate current initiatives aimed at expanding the recording and assessment of proactive policing. These include improvements to tasking practices at LACs, the SRS, the appointment of specialist roster officers, the COPS/CIDS enhancement project and activity-based management systems. (This could be achieved through a steering committee of representatives from the relevant areas. A task of the committee should be to clarify the definition of proactive policing to facilitate its measurement.)"

5.3.3 UK Police Force – Police Shiftwork Guide

Since 1999 police officers in the UK are covered by Part 1 of the Health and Safety at Work Act of 1974. The Forces have a duty to provide safe systems of work for their officers, including shiftwork, resulting in shift schedules that seek to minimise the adverse effects of shiftwork. For that purpose the UK Police Shiftwork Guide (2004) was developed in order to give sufficient knowledge to assess shift patterns regarding its impact on health and safety, and to present different coping strategies.

As part of the guide, different example schedules, as well as trends and developments are presented, including a discussion of the major developments for the police force from 2003 and onwards. A central observation is that the choice of possible shift patterns that fully complies with

the working time regulation, with police regulations, and with health and safety recommendations for the design of a good shift pattern, is very limited.

In order to monitor the working hours of officers in every department or post, and to assist with managing resources, two Forces have introduced a 'Core' shift pattern, which determines the common (or 'corporate') rest days. The hours worked within the shift pattern are varied to suit the individual needs of departments or posts, but with the same shift lengths and the same 'corporate' rest days. One of the problems, however, is that smaller departments may not have enough officers to be distributed evenly across the same number of teams as needed to operate the 'core' shift pattern of the response function. Even if they do, there is often little resilience when training, re-rostered rest days and annual leave are taken into account.

The solution, according to the author is as follows:

"What I believe Forces should do, is to develop a 'suite' of Working Time and Police Regulation compliant shift patterns based on different numbers of Teams, and allow individual departments to initially select the pattern which they think best meets their requirements. This suite of shift patterns should be strictly monitored and no deviation from it is permitted unless it can be justified. Each shift pattern should have in place a mechanism, which monitors actual hours worked and identifies breaches in the Working Time Regulations.

In developing the suite of Working Time and Police Regulation compliant shift patterns, Forces should pay due regard to the recommendations of shiftwork experts, in order to fulfil their 'duty of care' to staff by minimising the risks associated with shiftwork. It may well be that not ALL the recommendations can be fulfilled. In this case, Forces should consult with their Force Medical Advisor and Force Safety Advisor in order to prioritise those recommendations. In that way, an informed decision can be made as to which recommendations are considered essential to observe and which are less important."

UK Police Force (2004)
<http://web.ukonline.co.uk/bjologie/examples.htm>

5.3.4

Carl Mason – Merseyside Police, UK – "Healthy Nights?"

The report "Healthy Nights?" (Mason, 2000), was submitted as part of the Police Research Award Scheme, which is a scheme open to all police staff designed to encourage and stimulate new ideas from within the service. The report describes a study on the differences in effects two different kinds of shift schedules had when compared. The main focus was number of consecutive nights, and age on a number of variables. As can be expected it was found that high numbers of consecutive nights and higher age had bad effects.

Of more interest, however, are the practical recommendations that the author gives regarding design of shift:

“A national working party should be established to support Forces in their search for safe, healthy, legal and efficient shift patterns: this working party should bring together experts from Human Resources, Occupational Health, Shift Research, Employment Law, Staff Associations, Unions, Work Scheduling and police Management - ideally, the working party would have a large proportion of individuals who have actually worked shifts. This support would allow Forces to meet their own unique goals and Force objectives, whilst accommodating their own different demands.

Each Force may find it useful to appoint a Work Scheduling Unit, to ensure that individual Command Units within their Force adhere to “best practice” in shift scheduling. Of course, training in Work Scheduling should be provided for appointees.

Training of police Managers from the rank of Sergeant upwards, should be revised to include Resource Management, with particular reference to legal liabilities over the organisation of working time and the operational consequences of failing to manage staffing levels.

Each command unit should have a Resource Manager, who would aim to maximise the presence of resources according to demand, minimise the liability of their Area with regard to working time legislation, and maintain adequate and efficient minimum strengths in accordance with Health and Safety Legislation relating to “safe systems of work”, Police Regulations and Support Staff Conditions of Service.

A National Network for police Resource Managers should be created, managed from one point by a Work Scheduling Unit with experience in the field - possibly using an Internet Website, jointly funded by each of the Forces using the system.”

Mason, 2000, p 36

5.4 Airlines

The section below on shiftwork solutions for airlines includes two approaches towards crew scheduling and crew rostering.

5.4.1 Crew scheduling and crew rostering

There appear to be two central problems regarding crew scheduling in airlines. The two problems are the crew scheduling and crew rostering, where the first

is to match traffic needs with crew needs, and the latter is to match individuals to the schedules. A number of papers address these problems and aim to solve them by the development and usage of computer programs.

One approach is described in the paper "Decision Support System for Crew Planning in Passenger Transportation using a Flexible Branch-and-Price Algorithm" (Freling, Lentink & Wagelmans, 2001). The paper describes a Decision Support System (DSS) for airline and railway crew planning, with a focus on the models and techniques that are used in the DSS also taking into account the practical issues. The mathematical background of the system is described, which is outside the scope of this paper. The important aspect to note, however, is what the authors believe is one of the main contributions on a practical level, which is that most of complicating details in practice can be incorporated into the algorithm and thus be solved. The system helps the management in determining:

- capacity needed in order to perform the tasks;
- staffing levels (permanent and temporary) needed to meet the required capacity;
- vacations, standby, etc., for the specific period.

Management and crew wishes are often conflicting, but the system is capable of generating several alternative rosters to choose from, evaluating regulations, policies, etc. satisfying both social and economic criteria. The authors present case studies to illustrate the usefulness of the system. One case is a European airline, where the aim was to build weekly rosters for cockpit crews. In addition to the separate planning for pilot and co-pilot a number of characteristics completed the task. Some of the characteristics were:

- connected network of flights;
- different types of aircrafts;
- crew-specific characteristics:
 - availability,
 - past workload,
 - fixed tasks,
 - licences for types of aircraft and airport;
- different home bases for the individual crew members;
- maximum one layover away from home base;
- no dead headings on flights;
- laws and regulations.

Regarding the case study, the authors conclude on how different mathematical methods give different results as to calculation time and number of staff not scheduled, and that different methods needs to be determined for different applications.

A second paper addressing crew scheduling and rostering is the “Optimizing Crew Scheduling at Air New Zealand” (Butchers *et al.*, 2001). As a response to the two problems crew scheduling and crew rostering, the authors present eight application-specific optimization-based computer systems to solve all the aspects of the planning and rostering process in Air New Zealand. As with the DSS presented above, the system builds on various mathematical models and methods. The systems have supposedly saved NZ\$ 15,655,000 per year, and provided the staff with rosters which take better account of their preferences.

The two papers above are only two samples of a number of studies on scheduling for airline crews, which fall under the area of Operations Research (Thiel, 2004). Other papers include:

- “RosterBuilder - An Architecture for an Integrated Airline Rostering Framework” (Doerner, Kotsis & Strauss, 2002);
- “Airline Crew Rostering: Problem Types, Modelling, and Optimization” (Kohl & Karisch, 2004);
- “Team-oriented Airline Crew Rostering for Cockpit Personnel” (Thiel, 2004).

5.5

Other

In addition to the best practice cases studies, or guidelines presented above that are linked to specific domains, relevant approaches are presented in literature, which should be considered. One example is the use of *risk analyses* in rostering. Another example relates to *national differences in work time preferences and work-life balance*.

The “Rota Risk Profile Analysis” is a computer program that assesses psychosomatic and psychosocial risks of schedules (European Foundation for the improvement of Living and Working Conditions, 2000). Psychosocial features include periodicity (degree of consecutive nights and evenings per week), and weekend recreation (weekends free of work). Based on a risk profile, alterations to the schedule can be made before implementation.

The “Fatigue Management Policy Document for Marine Pilots” (Baker, Fletcher & Dawson, 2000) includes in the guideline both a ‘risk assessment checklist’ and a ‘risk assessment guide’. The purpose of these tools is to identify risks in order to eliminate them, or to counterbalance individual elements by compensating aspects. The checklist is simply asking a number of questions such as: “Are employees regularly scheduled to work more than 10-hour shifts?” with the response options of yes/no. Any ‘yes’ scored indicates a problem. The guide is a table placing elements of work into three

categories (low, medium, high risk). As an example the three categories correspond to: little or no overtime – more than 10 hours overtime – more than 20 hours overtime. In total there are 11 categories like this. The purpose of the scoring is to acknowledge potential risks to the marine pilot companies, the pilots, their families, and the community.

The European Foundation for the improvement of Living and Working Conditions has published the document "Working-time Preferences and Work-life Balance in the EU: Some Policy Consideration for Enhancing the Quality of Life" (2003). The article presents studies about the number of hours that men and women prefer to work, as well as the workers' evaluation of compatibility between their work schedules and their other commitments such as family. In addition, the paper presents an overview of the national working time policies at European and national levels. Although not the main target of the paper, the numbers presented give valuable information on national or cultural specificities relevant for shiftwork. For the purpose of this report it is noteworthy that this kind of information exists and that there are national differences.

5.6 Summary

By approaching shiftwork solutions in non-ATM organizations, a number of interesting findings have been made. Within both the health sector and the police, guidelines and approaches can be found that assist the development of shiftwork solutions. The different airlines are dependent on software programs in order to solve the rather complex task of rostering in this domain. In addition, fatigue management tools have been developed to accompany rostering. Taken together, these findings seem promising for and relevant to the development of European ATM shiftwork solutions.

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6. FINDINGS FROM OTHER SOURCES

6.1 Introduction

In addition to the case study findings described in the previous chapter, the study has aimed to identify additional sources of information. Different Web searches have identified various conferences, journals, software solutions, etc., that add to the findings for the different case studies.

6.2 Web Search

The Web search targeted a number of different resources and was performed for various purposes:

- To find useful information that could provide contacts or provide resources for data collection of best practices.
- To see if the search for best practices in shiftwork has previously been studied, and to identify the conclusions and recommendations emerging from such potential projects. The aim of the search was thus *not* to identify general shiftwork literature (e.g. the health effects of shiftwork – as this is considered a task performed under the literature review), but to gather additional knowledge to complement the literature review by looking at previous attempts on similar research needs.
- To provide an overview of the software tools available for designing rosters.
- The search was also limited to the domains deemed particularly relevant in this report (i.e. police, medical emergency units, aviation).

To acquire a better overview of available literature on shiftwork, a small-scale Web search focusing on identification of journals frequently covering this theme was performed.

6.2.1 Conferences

One particularly interesting finding of the search was links to a series of conferences focusing on best practices in shiftwork. These are not restricted to ATM or any of the domains defined as comparable to ATM. This source is beneficial in terms of providing valuable findings and general lessons learned in designing rosters. In addition to the information about the conferences, a number of best practice reports were found.

Several international conferences, seminars and workshops have been arranged on the topic of best practices in shiftwork management. Annex 2 provides an overview of the main events in this area from 2001 to

2004. It seems evident that the dynamic environments of conferences, seminars and workshops might serve as good opportunities to provide useful knowledge for developing shiftwork solutions for ATM.

6.2.2

Journals

The Web search revealed that some journals are particularly relevant with reference to comprising papers on shiftwork; these should thus be studied in more detail. Journals, which frequently contain papers on shiftwork, are:

- *European Journal of Operational Research* - Publishes papers that contribute to the practice of decision-making directly relevant to the areas of computer science, discrete mathematics, operational research, engineering, management, artificial intelligence, construction, distribution, manufacturing, transport, aerospace and retail and service industries.
- *Journal of scheduling* - Provides a recognised global forum for the publication of all forms of scheduling-oriented research. It covers advances in scheduling research, e.g. the latest techniques, applications, theoretical issues and novel approaches to problems. It incorporates theoretical, experimental and applied research, and covers recent computational and algorithmic advances in the field, addressing the industrial need for scheduling, and includes surveys of techniques. Appropriate to particular subsets of problems such as employee timetabling.
- *Annals of Operations Research* - In addition, several journals have devoted special issues on shiftwork and rostering; For instance, there are:
 - Two special issues on *Annals of Operations Research*:
 - ⇒ Special Issue I: "Staff Scheduling and Rostering: Theory and Applications, Part I", March 2004, Vol. 127, Issues 1-4;
 - ⇒ Special Issue II: "Staff Scheduling and Rostering: Theory and Applications, Part II", April 2004, Vol. 128, Issues 1-4).
 - The *European Journal of Operational Research on Timetabling and Rostering* - Includes several aspects of both theoretical and applied timetabling and rostering research. This feature issue was organised in conjunction with the 4th EURO Working Group on Automated Timetabling Workshop held at the 18th European Operational Research Conference in Rotterdam in 2001.
 - The *Journal of Human Ergology*, Vol. 30 (1/2), 2001 - Comprises proceedings of the 15th International Symposium on Night and Shiftwork. This volume contains more than sixty papers relevant for shiftwork and is organised by topics on:
 - ⇒ innovative strategies and scheduling,
 - ⇒ risk management,
 - ⇒ industrial development,
 - ⇒ sleep/wake rhythms and biological rhythms, and
 - ⇒ well-being and health.

- Journals on nursing also often encompass papers relevant for shiftwork, e.g.:
 - *Journal of Advanced Nursing*,
 - *Nursing Standard*, and
 - *Nursing New Zealand*.

6.3 Insights into Software Tools

Della Rocco and Nesthus (in press) summarize a number of studies into shiftwork in Air Traffic Control (ATC) with the aim of developing countermeasures for the effects of sleep loss and shiftwork. The authors also discuss schedule design, where they address computer-based programs for evaluating schedules. They recommend that: "These could be of great help to ATC schedulers if we could tailor them to the ATC operational environment. Also, schedule design must be carefully considered locally with each facility because of a variety of reasons, including local traffic patterns, geographical considerations which influence circadian rhythms." (p. 29).

A large number of software tools for designing rosters exist and some of them are listed in Annex 3. Within European ATM, especially in the larger units, software tools are used. Either these are in-house developed (majority using Excel) or they consist of off-the-shelf packages customised to needs of the ANSP (e.g. shift logic, SP expert, microster, time care). The majority of these software solutions are used for the rostering of staff and not for optimising staff to workload demand. The tools that do provide optimisation facilities do require expert knowledge to operate these features. Also these tools are expensive in terms of purchase, adaptation to ATM requirements and maintenance costs.

We were also curious to know whether there were other software tool solutions that would provide ANSPs with lower development and maintenance costs and could deal more easily with the area of optimising shift to meet workload variation. The following are some general findings:

- **Center for Sleep Research Tool (Australia).** The Dynamic Roster tool has been developed by the Centre of Sleep Research and the Centre for Industrial and Applied Mathematics. Optimal dynamic rosters are generated by the use of mathematic tools. The rostering system is designed to handle individual employees and fluctuating demands, multiple skill levels, employee leave and special restrictions, employee preferences and changes in demand from day to day, week to week or month to month. The software is for sale and can be purchased along with training courses, etc. (Etzen, 2004). This tool is based on CPLEX software applications as are many of the sophisticated features behind shift logic and SP expert.
- **ILOG Optimization package services** (ILOG, 2003), provider of CPLEX software, offers a variety of technological solutions to optimization and visualization. Different packages support the different phases of optimization projects such as training, analysis, modelling and design. So it

is possible to just buy the software and develop the tool in-house or work with ILOG to develop a prototype, for example. Either solution could probably be cheaper than some off-the-shelf packages and adapted to European rostering needs. Two users of CPLEX in designing a rostering tool for their staff are Air France and SNCB (Belgian Railway). Both users purchased the software and developed their application in-house.

- **Air France** uses CPLEX to develop the applications OPALE and ARCHIPEL that make the crew rostering (medium and long haul crew planning; more than 10,000 crew members and 50,000 tasks to assigned in 3 hours). CPLEX is also used for its PALACE application for aircraft rotation (for all the fleets of Air France), the application Samouraï that make the tail assignment (for the OCC). For ground staff management, Air France has built a prototype to size and schedule the checking and boarding staff of Air France (but this application is not used for the present time). They use CPLEX as a callable library (MIP solver) in many different kinds of applications. However, for all those applications CPLEX is only solving a small part of the overall problem. Air France's applications have been developed in-house by the Operational Research Department. This Department is a group of about twenty people (Engineers and PhD students) who develop real life applications and undertake studies. All of these studies are based on quantitative methods (and as such they use the ILOG tools -- CPLEX and Solver).
- **SNCB** (Belgian Railway) uses CPLEX for a "Shiftwork Scheduling - Holidays" Project, to automate the optimum reconfiguration of work schedules when a public holiday falls midweek. All the work schedules of the 4,500 drivers and 2,500 stationmasters are reviewed three times a year. They are divided respectively into 2,200 and 1,250 duty periods, subdivided into 70-100 sets of 30-50 duty periods. A program initially developed by a VUB spin-off and then by Cap Gemini on the basis of an algorithm proposed by the SNCB team carries out the "optimum" assignment (on the basis of heuristics) of these work schedules. Whenever a public holiday falls midweek, all the schedules have to be corrected: the public holiday in question has to be as similar as possible to a Sunday, the day before and the next day have to be corrected to take account of the constraints set out below, restricting mainly the successive categories of work.

A specific mathematical model was developed making it possible to solve the problem. The algorithm derived from modelling of the problem in the form of a minimum cost flow with multiple commodities. The general solution is broken down into three major parts:

- **Pre-processing generation of valid paths:** By checking the constraints on the successive periods of work (Done in C ++ application), this part generates a linear program for CPLEX on the basis of the data. Essentially, this part checks the individual constraints and the feasibility of the paths in the flow model. The generation of the paths is designed to reduce the total number of paths envisaged in the

linear program. The generation algorithm also needs to avoid exploring too many paths in order to generate this preferential list.

- **CPLEX:** Resolution of the linear program ensuring the general feasibility of the schedule. The general feasibility of the schedule is thus ensured since all the paths valid individually are taken into account.
- **Translation:** Interpretation of the CPLEX solution. The "rough" solution from CPLEX is translated into a more readable version corresponding to the format routinely used at the SNCB to display the work schedule assignments.

Necessary environment

There are few constraints on the compilation and use of the software developed:

- The program is written in standard code C++. In theory there is no constraint if the compiler C++ follows the ANSI standards.
- The program uses simple CPLEX routines. The "CPLEX Callable Libraries", Version 6 or 6.5 of ILOG, are therefore necessary for its compilation and subsequent use.
- UNIX and Windows 95/98/NT platforms can be used.

The findings highlight interesting options which should be explored further to see if they could satisfy the ATM requirements for software solutions to shiftwork.

6.4

Summary

The investigation of additional sources of information reveals a rich opportunity for further investigation. It becomes clear that optimization of shiftwork solutions is a task that is widely addressed by literature, tools and conferences. When seeking additional information the problem is not so much lack of information as it is a challenge of selecting the most relevant and cost effective resources. Regarding insights into software solutions for shiftwork it might be worthwhile to investigate a common and shared approach, between EUROCONTROL and interested ANSPs, to develop a general automated rostering tool including optimisation and at the same offering the possibility to simulate what-if situations within a secure environment.

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7. INSIGHTS GAINED

From the information gathered in ATM, related industries and other sources, a number of insights and lessons learned have been generated to facilitate the MSEA's six areas of interest. These insights are summarised in the following paragraphs.

7.1 ATM and Related Industry Experience

Information gathered from both ATM and non-ATM organizations has been valuable for a number of reasons:

- When aiming to identify best practices in various domains, best practices are not necessarily easy to identify. There is no guarantee that a newly implemented solution should necessarily be considered a very good practice just because it is better than the one it replaced. The example here is the hospital in Oslo, Norway, where a roster was implemented without optimizing all the changes that could make the roster better, at least from one point of view.
- When looking at the different guidelines and frameworks produced (e.g. the Rostering Framework [Queensland Government Australia, 2003], the Guidelines and Standards of Best Practices [New Zealand Nurses Organization, 2003]), these documents appear to be more fully present comprehensive guides to practical rostering. Still, the experiences shared by the Emergency Ward in Oslo, Norway, present another perspective. In this case, the rostering works (e.g. flexibility) because of management's ability to develop a practical system within the framework of the roster. **The lesson learned here is that best practices can be divided into two perspectives, the ability to design good rosters, and the ability to effectively manoeuvre within the system.**
- It seems that a categorization of the relative contribution of the different best practices is both necessary and informative. This categorisation, in turn, serves to structure different aspects of developing good shiftwork solutions, and thus identify an approach for the development of ATM shiftwork solutions. That is, behind every case study, report, guideline, etc., there is a specific focus or lesson to be learned. The following is a suggested classification of good practice experience gathered during this study:

Flexible application of resources

- Flexibility – The Emergency Ward Oslo, Norway
- US FAA
- AirServices Australia

Selecting and adapting shift systems

- AirServices Australia
- Hospital in Oslo, Norway
- The Queensland Government, Australia
- New Zealand Nurses Organization
- UK Police Force
- Merseyside Police, UK

Team/Individual rosters

- Airways New Zealand
- US Federal Aviation Administration

Fatigue management

- AirServices Australia
- Airways New Zealand

Health considerations in roster

- The NARFE II project, Denmark

Specific techniques for developing rosters

- The **PAR**ticipatory **I**ntervention **M**ethod (PARIM) – The NARFE II project, Denmark
- The Smart Rostering System (SRS) – New South Wales Police Service
- Decision Support System for Crew Planning in Passenger Transportation (Freling *et al.*, 2001)
- Optimizing Crew Scheduling at Air New Zealand – software (Butchers *et al.*, 2001)
- Decentralized shift management in the Northerine-Westfalia Police Forces
- Risk analysis:
 - Rota Risk Profile Analysis (as cited in European Foundation for the improvement of Living and Working Conditions, 2000)
 - Risk assessment checklist and Risk assessment guide (Baker *et al.*, 2000)

Cultural considerations

- Working time preferences and work life balance in the EU (European Foundation for the improvement of Living and Working Conditions, 2000)

In addition to the best practice cases and literature reported here, other cases and literature would necessarily expand the list and categories. The same is the case for the identified software tools, and relevant conferences.

If this context differs significantly, the described solutions or techniques need to be evaluated further. This perspective is supported by the experts, who state that there would be several factors unique to the particular workplace, such as individual and contextual factors, that determine the quality of any roster.

7.2 Resources

There seems to be a large amount of information available on the Internet which is of direct relevance to best practice in shiftwork. A fraction of this information was studied in this project.

Resources include journals, as well as conference, seminar, and workshop proceedings, study reports, guidelines, regulations, and more. It is also of interest that the field of nursing typically include papers on shiftwork in their journals. This is of interest since the health sector was identified through the framework as a field likely to share shiftwork challenges with ATM. Another interesting observation is the field of Operational Research that addresses the more technical and mathematical aspects of rostering, something that is of interest when it comes to balancing the different demands of rostering.

A number of conferences, seminars and workshops are regularly arranged around the world with different scopes and purposes regarding shiftwork and rostering. Out of the six conferences, seminars and workshops evaluated, it appears quite clear that both the proceedings and possibly also future attendance would be of great value, and in a lot of cases directly related to the issues identified for the MSEA project.

It therefore seems safe to conclude that both relevant and extensive resources are available on best practices in shiftwork.

7.3 Software Tools

A range of software tools exist which in many cases involving ATM are costly and not completely suited to their needs. The findings highlight interesting options which should be explored further to see if they could satisfy the ATM requirements for software solutions to shiftwork.

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8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The discussions with the *experts* were useful. In general, their comments supported the overall purpose of the study, the approach applied, and they did in addition provide some valuable advice and contacts for a further study.

The development of the *ideal solution* based on the literature review was informative, but was not used to evaluate any of the case studies of shiftwork practices. The aim was to provide a baseline regarding shiftwork solutions based on the latest literature and research, in order to compare the shiftwork practices to the ideal solution. This still seems promising.

The development of the *Framework* in order to select comparable domains regarding shiftwork practices appears useful although there has not been any specific attempt to validate it. There is still a chance that the most relevant cases of best practices in ATM is located in some of the domains not included in the effort. Still, the attempt to classify the domains on shift-relevant aspects should be considered as more valid than any unstructured attempts.

The *data collection* of the *shiftwork practice cases* has been informative to the extent that they have provided useful examples of methodology and guidelines likely to be relevant for ATM shiftwork solutions. Each case study has added to the information obtained in the other cases, which illustrates that a lot can be learned by identifying specific cases. In addition to the specific cases and the interviews, the efforts to identify literature has resulted in both generic and detailed guidelines, as well as specific methods and tools.

The identification of different *resources*, such as *experts, contacts, journals, conferences, software*, etc. appear particularly promising for future research. Owing to the scope of this study, these resources could not fully be investigated, but should be pursued in more detail.

The findings from this study do not point in the direction of any single shiftwork solution for ATM. That is, none of the identified practices can simply be transferred to European ATM. Shiftwork solutions are to a large extent case specific. Each organization will in the end have to develop its own solution. Still, both literature and case studies are rich on considerations, approaches, processes, tools, etc., that together contribute towards a total shiftwork solution.

8.2 Recommendations

Future research on best practices is recommended. There exists a substantial amount of literature, information, and other resources that will be of great use for future research. Future work regarding best practices, however, should

expand on the already established methodology and follow up on contacts, conferences, etc. In addition, more in-depth interviews and investigations should be conducted regarding the identified best cases.

One interesting and central task will be to investigate to what extent specific shiftwork solutions are case specific, and to which extent they are generic. The answer to this is quite important for the development of common shiftwork solutions. A distinction was made between best practices when designing rosters, and best practices when dealing with rosters. Even if the first perspective is in focus here, further investigations of case specific issues might prove valuable. Experiences from implementations of new shiftwork solutions some months or years after implementation should be further investigated. Not only to capture the best practices, but also in order to identify any experiences, thus including what went wrong or could be done better.

Based upon the findings of the study of shiftwork practices one possible solution to managing the different European shiftwork challenges is to develop some kind of 'roadmap'. This roadmap would be based upon the different best practices, lessons learned, etc. and could guide shiftwork designers through the different phases of the design process. Further investigation would be needed in order to find the right structure and format of such a road map.

ANNEX 1 DATA COLLECTION PLAN

1. Introduction

The following text describes the data collection plan that was used for the different case study interviews and that served as a resource for the researchers from ANSPs and related industries.

2. Outline Structure for Data Collection

2.1 Part I: rationale and approach

This first part is about the rationale and approach for the data collection. The actual collection covers four items, referred to as Parts II to V and described below:

- Part II of the interview provides a basic description of the shiftwork solution at the respondent's work place. The items are based upon the questionnaire guide developed for WP3, and should make it possible to compare shiftwork types in ATM and the particular industry on a more detailed level than outlined in the framework for comparison and selection of industries.
- Part III is a free response section where the respondent can describe favourable aspects of their shiftwork solutions without any influence or guidance. The purpose of the section is to allow for new responses and issues to come up that have not yet been considered. It is important to have this session before the respondent has received clues about topics that are of particular interest to the project (Part III).
- Part IV is a semi-structured interview where the respondent is guided to comment on special topics. The listed topics were identified (a) during the WP1 workshop in Brussels (EUROCONTROL, 2004), (b) the literature review on shiftwork in European ATM, (c) essential characteristics of shiftwork solutions used to develop the "framework" for comparison and selection of industries, and (d) key issues outlined in the tender for project.
- Part V is supposed to trigger information about industry networks and contacts that may provide additional knowledge of best shiftwork practices outside ATM. A question on rostering tools is also included here (not before in order to avoid distraction from best practices).

Contents of the survey/interview can be found in the following Sections 2.2 to 2.5. Each section covers an item for data collection, referred to as a Part, and provides the corresponding survey/interview material.

2.2

Part II: basic description of shiftwork solution

- Type of shift (continuous 24/7 or other)
- Alternating or permanent shifts (if continuous)
- Forward or backward rotation (if continuous-alternating)
- Team or individual roster
- Amount of free time
- Workers' control over shiftwork solution
- Flexibility of rosters
- Regulations/guidelines/directives that have to be considered in shiftwork management

2.3

Part III: free response

- Which aspects of your shiftwork solution are the workers and/or the management especially satisfied with?
- Can you describe any features of your shiftwork management practices that other industries might benefit from?

2.4

Part IV: semi-structured interview - topics

- Have you taken initiatives to improve productivity and/or safety by implementing new rosters?
- Do you have specific strategies to reduce health problems due to the shiftwork solution that you use?
- How do you handle conflicting requirements to ideal shiftwork solutions, such as:
 - Coherent, "blocked" free time at the weekend is to be preferred vs. that the length of the shift should not exceed 8 hours.
 - Early shifts are not supposed to start too early vs. night shifts should finish as early as possible.
 - The number of successive night shifts should be as low as possible vs. utilization of permanent night shifts.

- Which initiatives are taken to avoid huge discrepancies between the formal shiftwork solution as accepted by the management, and how shiftwork is really carried out in practice?
 - Is there a gap?
 - Who is responsible for swapping of shifts?
 - Is there a formal system for swapping of shifts that documents the changes made to the original roster?
- How are you able to make the shiftwork solution sufficiently flexible, but at the same time satisfy basic physiological/psychological/social requirements to roster design? For example: Let morning type personalities work more early shifts, and evening type personalities work more late shifts.
- Are you able to use the shiftwork solution to keep the work effort at a reasonable level and, at the same time, satisfy the production demands?
- How do you take strategic teambuilding into account in roster design?
 - For social reasons (who can/should work together on shifts due to personal preferences, personnel conflicts, etc.)
 - For performance reasons (balance rosters in terms of level of work experience, efficient combinations of different competencies, etc.)
- How do you handle situations where your staff requirements are unpredictable?
- Do you have special arrangements for *duty changes* (economically compensated change of shift time on short notice)?
- Are you using software-solutions to design rosters? Describe roster tools.
- What strategies do they use to match staff with workload variation?
- What tools do they use?
- What are/were your procedures for selecting and adapting shift systems?
- How did you, or do you plan to implement new shift systems?
- What is the level of tactic and strategy in your shift management?

2.5

Part V: additional information

- Do you have documentation about advantageous features of your shift management practices that you would like to share in order to contribute to the mutual transfer of knowledge across industries?

- Would you consider taking part in a case-study on shiftwork solutions at a later point in time if this feasibility study becomes a larger research project in the future?
- Do you know contact persons in your industry, or other industries, that could have potentially valuable information about excellent shiftwork solutions?

ANNEX 2: CONFERENCES FINDINGS

Flexible application of resources

- Balancing flexibility for the employer and the employee: a case study of the development of an annualized hours employment contracts
- Improved quality of life and performance within the rostering environment
- An attentive perspective on balancing business needs and quality of life in employee scheduling
- Innovative approaches to effective and flexible fatigue risk management systems
- Implementing flexible rostering systems in your organization

Selecting and adapting shift systems and implementation of a new shift system

- The effects of a roster schedule change from 8 to 12-hour shifts on health and safety in a mining operation
- Reaping the main benefits of switching to an automated, self-rostering scheduling system
- How to align rostering, scheduling, and shiftwork practices with broader corporate objectives
- Developing and implementing a self-regulatory rostering framework
- Moving from a prescriptive to a performance-based approach to fatigue management
- The roster change process

Managing individual differences in shiftwork

- Rosters and lifestyle that reduce attrition rates and absenteeism
- Improved quality of life and performance within the rostering environment
- Social and family costs of extended working hours in a shiftwork environment
- How to balance business needs and quality of life in employee scheduling

- Determining the best ways to decrease employee absenteeism and attrition rates
- Selecting the right employees for shiftwork
- Strategies to improve communication between shiftworkers and their managers
- Achieving best work life balance practices

Team/individual shift systems

- Developing and implementing a self-regulatory rostering framework

Tactical and strategic shift management

- How to achieve improved rates of productivity and employee satisfaction through an automated system
- Designing a flexible roster to reduce fatigue, increase operational performance and improve work life balance
- Optimizing productivity through improved roster design (rotating vs. fixed shifts, assessing the benefits and pitfalls of 12-hour shifts, direction of rotation, etc.)

The boxes below summarize different conferences, courses and workshop on the topic of shiftwork.

Conference: 15th International Symposium on Night and Shiftwork. (Hayama, Japan. 10 -13 September 2001)

Scope and purpose: The Symposium covered a wide variety of areas related to managing night and shiftwork and improving the quality of working life. Special attention was paid to new forms of work organization, risk management, health and tolerance of shiftworkers, coping measures and advances in biological adjustment.

Focus: Exchange of ideas among shiftwork researchers and practitioners.

Domains: Generic. Domain independent.

Input to best practice: A practically oriented session on innovative strategies and scheduling was arranged. Especially valuable papers from the symposium include:

- The Effects of a Roster Schedule Change from 8 to 12-Hour Shifts on Health and Safety in a Mining Operation (Angela Baker, Kathryn Heiler and Sally A. Ferguson).

- Balancing Flexibility for the Employer and the Employee: A Case Study of the Development of an Annualized Hours Employment Contracts (Philip Tucker, Johannes Gaertner and Carl Mason)
- Reducing Night Shift Exposure: A Pilot Study of Rota, Night Shift and Age Effects on Sleepiness and Fatigue (Lawrence Smith and Carl Mason)
- How a Small Enterprise Improved the Conditions of Night and Shiftwork Using Local Resources (Ton That Khai, Tsuyoshi Kawakami and Kazutaka Kogi)
- Support Measures to Improve Night and Shiftwork Conditions in Thailand: A Case Study in a Glass Factory (Chalermchai Chaikittiporn, Tsuyoshi Kawakami and Kazutaka Kogi).

Conference: Duty Rostering & Shiftwork (Sydney, Australia. 30 April and 1st May 2002)

Scope and purpose: Special focus on 'fitness for duty' in a rostering and shiftwork environment.

Focus: Practical and shiftwork management perspective.

Domains: Generic - many domains in Australia represented.

Input to best practice: The conference provided input on the following issues:

- Ensuring efficient recovery time between shifts;
- Improvement of shift handovers;
- Rosters and lifestyle that reduce attrition rates and absenteeism;
- Improved quality of life and performance within the rostering environment;
- Social and family costs of extended working hours in a shiftwork environment;
- The linkage between fitness for duty and fatigue management in a rostering / shiftwork environment.

Conference: Best Practices in Rostering, Scheduling & Shiftwork (Toronto, Canada. 1-2 June 2004)

Scope and purpose: The conference provided methods, techniques and solutions to a number of critical issues surrounding rostering, scheduling and shiftwork, including:

- How to balance business needs and quality of life in employee scheduling.

- Reaping the main benefits of switching to an automated, self-rostering scheduling system.
- How to align rostering, scheduling and shiftwork practices with broader corporate objectives.
- Capitalizing on the corporate benefits of reengineering current shiftwork patterns,
- Determining the best ways to decrease employee absenteeism and attrition rates
- How to develop a fatigue management system that will incorporate work-to-rest ratio regulations.

Focus: Academic, union/management, and practical focus.

Domains: Mainly petroleum/industrial and health services from a Canadian perspective.

Input to best practice: The following sessions provide useful practical insights:

- *How to Achieve Improved Rates of Productivity and Employee Satisfaction Through An Automated System:* With six different types of shifts for almost one thousand paramedics, dispatchers and support staff, devising a system that would incorporate and design schedules for separate groups and their specific requirements was quite a task. Offering permanent and swing employees access to shift times, locations and payroll information has been an enormous development in efficiency and provided numerous cost benefits. The presentation discussed: (a) The time management scheduling system, which allows the staffing department to observe the number of employees working on a given day and to what shifts they have been assigned, (b) the Automated Voice Recognition system that permits workers to call in to a computerized message system that provides details on their next scheduled shifts and location, (c) the overtime call-in system for short of staff/overtime situations, which has also decreased the number of questions and phone calls coming into dispatch and added an unbiased/neutral element to the allocation of scheduled assignments (Wayne Smith, Toronto Emergency Medical Services).
- *An Attentive Perspective on Balancing Business Needs and Quality of Life in Employee Scheduling:* TransCanada Pipeline had to reorganize their modified work schedules to comply with federal Human Resources Development Canada (HRDC) regulations. The presentation discussed: How developing a shift schedule committee to relate priorities concerning quality of life and working conditions increase communication and the overall positive relationship between management and employees, and the challenges of maintaining a business perspective, while still taking into consideration the human factor (Tim Gibson, TransCanada Pipeline).

- *Mid-conference workshop:* How to develop a fatigue management plan that reduces injury rates and absenteeism. This workshop was developed as an introductory tutorial on the concept of the 'fatigue index,' which can be put into practice smoothly and effectively to create a safer environment for employees and reduce injury rates and absenteeism when devising schedules.
- *Panel discussion:* When realigning your workplace environment to better meet corporate objectives and goals, to what degree should underlying factors such as employee sleep patterns, nutrition, and lifestyle play? Some industries demand that these issues be a priority to ensure safety. Other corporations believe that providing a certain level of consideration for their employees increases productivity based on high employee satisfaction. Then there is the group that finds these to be 'soft' issues.

(CD-Rom documentation available for ~290€)

Conference: Best practice for effective and flexible rostering and shiftwork (Sydney, Australia. 14-16 July, 2004)

Scope and purpose: Provide practical insight into rostering and shiftwork strategies that will increase productivity, efficiency, employee safety and satisfaction while reducing fatigue and related risks.

Focus: Mostly a practical focus.

Domains: A wide selection of domains in Australia and New Zealand were represented (e.g. police, steel industry, aviation, mining, and health services).

Input to best practice: The following sessions provide relevant input on best practices in shiftwork management:

- *Innovative approaches to effective and flexible fatigue risk management systems:* Studies into workplace fatigue have provided groundbreaking measurement tools to study the effects of poor roster planning on employees and the workplace environment (Dr Drew Dawson, Centre for sleep research, Australia).
- *Designing a flexible roster to reduce fatigue, increase operational performance and improve work life balance.* Australian Federal Police have developed and implemented a flexible rostering framework that meets surges in service delivery and overcomes the challenges of fatigue and lifestyle management (Stephen Cooke, Australian Federal Police).
- *Developing and implementing a self-regulatory rostering framework:* Hydro Tasmania uses a unique method to roster its 24 x 7 workforce who work as a self regulated team designing their own rostering and shiftwork schedule.

The focus is on the ability of a small team to meet both business and personal objectives (Peter Clark, Hydro Tasmania).

- *Implementing a flexible rostering model to improve service delivery in the healthcare industry:* QEII Hospital implemented a flexible rostering model driven by the staff. The presentation explored how the Queensland health business planning framework was adapted to suit the hospitals demands and improve overall employee satisfaction and service delivery (Shauna Paine, Queii Hospital Queensland, Australia).

Course: Optimizing productivity, performance and roster design in a shiftworking environment (Auckland, New Zealand. 1-2 September 2004, or 6-7 September, 2004).

Scope and purpose: “This intensive two-day training seminar will show you how to get the best out of your people. By strengthening your people management skills, you can optimize productivity and performance and improve staff morale. Find out how to encourage greater cooperation between workers operating different shifts and improve communication between shiftworkers and managers.”

Focus: Emphasis on how management can get the best out of the staff.

Domains: Domain independent.

Input to best practice: Examples of topics discussed during the course are:

- Selecting the right employees for shiftwork;
- Optimizing productivity through improved roster design (rotating vs. fixed shifts, assessing the benefits and pitfalls of 12-hour shifts, direction of rotation, etc.);
- The roster change process;
- Strategies to improve communication between shiftworkers and their managers;
- Fighting fatigue: identification, measurement and management.

Upcoming Conference: Best practice strategies for rostering and scheduling (Singapore, 30 November - 1 December, 2004)

Scope and purpose: Dedicated to rostering and scheduling strategies, and how to ensure a safe and productive environment through an effective rostering strategy.

Focus: Improvement of rostering practices (headline: “an effective rostering system can result in cost savings of 20% and a 75% reduction in operational planning time”).

Domains: Strong focus on health services, but also some focus on aviation. Geographically limited to Australia, New Zealand, Philippines, Hong Kong and Singapore.

Input to best practice: The following sessions may be of particular relevance for best practices in ATM:

- *Achieving Best Work Life Balance Practices:* One of the challenges healthcare organizations face is getting people who are willing to work shifts for 24/7 operations. Shiftwork is generally viewed as undesirable and disruptive to personal life. However, at KK Women’s and Children’s Hospital they have turned adversity into advantage by offering a wide range of flexible work arrangements. With strong management support, they have been able to creatively implement new programs that have enabled them to reduce staff turnover and reduce the absenteeism rate (Pauline Teo, Human Resource Performance Management).
- *Moving From A Prescriptive To A Performance-Based Approach To Fatigue Management:* On the transition from the traditional prescriptive-based approach to a performance-based approach to managing fatigue in the aviation industry (Cary Thoresen, Civil Aviation Safety Authority, Australia).
- *Moving From A Manual-Based System To An Automated Approach:* The traditional paper and pencil method worked, but now you have the latest and best computer technology at your hands. Planning and rostering technology is an essential tool for any organization wishing to minimize labor costs and capitalize on labor resources for the future (Dr. Eric Chan, Hospital Authority of Hong Kong).
- *Implementing Flexible Rostering Systems In Your Organization:* Maintaining a fixed roster pattern is a safe, low maintenance option. Everybody knows the routine and then it will be very busy or exceptionally quiet. Paradoxically, introducing flexible working enables a company to challenge these assumptions and do something about them – enabling a more consistent service (Maria Linda Buhat, Philippine Heart Centre).
- *Workshops:* (a) Automated and optimized staff rostering - A paradigm shift, and (b) Best practice strategies for an effective rostering system.

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ANNEX 3: SOFTWARE TOOLS EXAMPLES

Sumit - designed for roster planners with small teams with 24-hour service, and rather predictable workload <http://www.sum-it.nl/enindex.php3>

Easy schedule maker - an employee scheduling program for Windows <http://www.bykeyword.com/downloads/software-3/download-3418.html>

Scheduler - See Eveborn, P., and Rönnquist, M. (2004), Scheduler - a system for staff planning. *Annals of Operations Research*, 128, 21-45.

Careplan Pro - <http://www.reallyusefulprograms.co.uk/>

SchedulerLite - Staff rostering, employee scheduling and resource booking tool featuring both pictorial and spreadsheet style views of a roster, recording and checking of staff availability, repeat rosters and shifts, parameterizable preview/ printing of reports. <http://www.schedulerlite.com/default.htm>

<http://www.bykeyword.com/downloads/software-7/download-7240.html>

Scheduling employees 2000 - To schedule mostly part-time employees and print out weekly schedules. Track time and labour costs by the hour and week as you schedule. Knows when the employee is available for work. This program is often used in Restaurants and Retail stores. <http://www.bykeyword.com/downloads/software-7/download-7242.html>

Shift schedule continuous excel - Build a roster to your specifications, allocate staff automatically, and generate a printable roster, all at the click of a button. Compact and user friendly with default values for ease of use. Full operational instructions. <http://www.bykeyword.com/downloads/software-7/download-7440.html>

Rotagen - rostering software solutions for business, health and social care <http://www.rotagen.com/>

Rotaplan - assists in the development of shift rota patterns and rosters up to 53 weeks in length.

http://www.dynamic-rostering.com/Modelling_Software.htm

Smart human logistics - The HL Deployment Management module is a rostering tool that creates and allocates rosters for individual employees. It allows you to attach rules to shifts, to ensure suitable staff cover is available at all times. Total flexibility ensures that the system will match your own shift patterns with your changing business demands. <http://www.peopletimeplanning.com/>

Police:

EDP software, Schedule Pro - is designed for use in healthcare (hospital, nursing home, long term care facilities), all law enforcement agencies (including 911 dispatch, the police and correctional facility - jails, penitentiary etc), call centre, utility company, manufacturing facility, fire & emergency departments and many other organizations. <http://spro.homelinux.com/>

Employee schedule assistant 2000 - For businesses that have mostly full-time employees. The program keeps track of vacations, shift assignments and rotations. This program is often used by Corporations, Hospitals and Police departments. <http://www.bykeyword.com/downloads/software-3/download-3568.html>

Emergency:

EDP software, Schedule Pro - (see above) <http://www.edpsoftware.com/>

Employee schedule assistant 2000 - (see above) <http://www.bykeyword.com/downloads/software-3/download-3568.html>

Promis - Originally developed for emergency services. http://www.softent.co.uk/main_hires.htm

Aviation:

Preston aviation solutions - the staff planning, allocation and rostering module is specifically designed for the aviation industry to meet the challenges of rostering a large and diverse 24 x 7 workforce. <http://www.preston.net/products/StaffSolutions.htm>

All Scheduling - Wallchart have provided scheduling solutions for all areas of industry, airlines, broadcasting, communications, information technology, telecommunications and production. Wallchart are able to offer scheduling solutions for automated scheduling, employee scheduling, event scheduling, staff scheduling, project scheduling, resource scheduling. <http://www.allscheduling.com/>

Rotima - particularly relevant for aviation http://www.rostima.com/press_releases/securicor_selects.html

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ABBREVIATIONS AND ACRONYMS

For the purpose of this document, the following abbreviations and/or acronyms shall apply:

AENA	Aeropuertos Españoles y Navegación Aérea (<i>Spain</i>)
ANS	Air Navigation Services
ANSI	American National Standards Institution
ANSP	Air Navigation Service Provider
ARTCC	Air Route Traffic Control Center (<i>FAA</i>)
ATC	Air Traffic Control
ATCO	Air Traffic Controller (<i>US</i>)
ATM	Air Traffic Management
DAS	Directorate ATM Strategies (<i>EUROCONTROL, EATM</i>)
DFS	Deutsche Flugsicherung GmbH (<i>Germany</i>)
DGAC	Direction de l'Aviation civile (<i>France</i>)
DSM	Decentralised Shift Management
DSS	Decision Support System
EATM(P)	European Air Traffic Management (Programme) (<i>EUROCONTROL</i>), today known as the “European Air Traffic Management Performance Enhancement Programme”
EATM	European Air Traffic Management (<i>EUROCONTROL</i>)
ECAC	European Civil Aviation Conference
EDP	Electronic Data Processing
EU	European Union
FAA	Federal Aviation Administration (<i>US</i>)
FAID	Fatigue Management System
FIR	Flight Information Region

FMP	Fatigue Management Plan
HPTE	Human Performance and Training Enhancement
HRDC	Human Resources Development Canada
HUM	Human Resources Management Business Division (EUROCONTROL, EATM, DAS)
IFE	Institutt for Energiteknikk (<i>Institute for Energy Technology, Norway</i>)
LAC	Local Area Commands
Lfv	Luftfartsverket (<i>Sweden</i>)
MSEA	Managing Shiftwork in European ATM (EUROCONTROL, EATM)
NARFE	National Active and Retired Federal Employees Association (<i>Denmark</i>)
NATCA	National Air Traffic Controllers' Association
NATS	National Air Traffic Services Ltd. (<i>UK</i>)
NPP	Nuclear Power Plant
NSW	New South Wales
OCC	Operations Control Centre
OPS	Operations
PARIM	Participatory Intervention Method
SMS	Short Message System
SNCB	Société Nationale des Chemins de Fer Belges (<i>Belgian Railway</i>)
SRS	Smart Rostering System
TCU	Terminal Control Unit
TMA	Terminal Control Area
VUB	Vrije Universiteit Brussel (<i>Free University of Brussels, Belgium</i>)