EUROPEAN ORGANISATION FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

This document is issued as EATCHIP Reference Material. The contents are not mandatory. They provide information and explanation or may indicate best practice.

Proceedings of the Second EUROCONTROL Human Factors Workshop

Teamwork in Air Traffic Services

HUM.ET1.ST13.000-REP-02

Edition	:	1.0
Edition Date	:	30/01/1998
Status	:	Released Issue
Class	:	EATCHIP

EUROPEAN AIR TRAFFIC CONTROL HARMONISATION AND INTEGRATION PROGRAMME

DOCUMENT IDENTIFICATION SHEET

DOCUMENT DESCRIPTION

Document Title

Proceedings of the Second EUROCONTROL Human Factors Workshop

Teamwork in Air Traffic Services

EWP DELIVERABLE REFERENCE NUMBER		
PROGRAMME REFERENCE INDEX HUM.ET1.ST13.000-REP-02	**EDITION :**	1.0
	EDITION DATE :	30/01/1998

Abstract

This report contains the proceedings of the second EUROCONTROL Human Factors Workshop held in Luxembourg in May 1997. The theme of the workshop was ‘Teamwork in Air Traffic Services’. This report includes the presentations of the speakers and summaries of the working groups.

Keywords

Teamwork	Accident/incident (A/I) investigation
Concept	Operational Environment
Selection	System Design
Training	Team Resource Management (TRM)

CONTACT PERSON : D. Van Damme	**TEL :** 3567	**DIVISION :** DED5

DOCUMENT STATUS AND TYPE

STATUS		CATEGORY		CLASSIFICATION	
Working Draft	☐	Executive Task	☐	General Public	☐
Draft	☐	Specialist Task	☐	EATCHIP	☑
Proposed Issue	☐	Lower Layer Task	☑	Restricted	☐
Released Issue	☑				

ELECTRONIC BACKUP

INTERNAL REFERENCE NAME : HF_PROC2.DOC

HOST SYSTEM	MEDIA	SOFTWARE
Microsoft Windows	Type : Hard disk	Word 6.0 PowerPoint 4.0
	Media Identification :	

DOCUMENT APPROVAL

The following table identifies all management authorities who have successively approved the present issue of this document.

AUTHORITY	NAME AND SIGNATURE	DATE
Human Factors Expert DED5	D. VAN DAMME	26/01/1998
Chairman Human Resources Team	C. P. CLARK	26/01/1998
Senior Director Operations and EATCHIP	W. PHILIPP	26/01/1998

DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

EDITION	DATE	REASON FOR CHANGE	SECTIONS PAGES AFFECTED
0.1	09/09/1997	Proposed issue for approval by HRT8	All
1.0	30/01/1998	Released issue	All

TABLE OF CONTENTS

Intentionally left blank

EXECUTIVE SUMMARY

The European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) Human Resources Bureau has initiated the organisation of annual workshops on topics concerning Human Factors (HFs) in Air Traffic Management (ATM).

This report contains the proceedings of the second EUROCONTROL Human Factors Workshop held in Luxembourg in May 1997. The workshop addressed 'Teamwork in Air Traffic Services (ATS)'.

Chapter 1 introduces the background, scope and purpose of the workshops and their relevance for the work of the Human Resources Bureau in EATCHIP.

Chapter 2 of the document includes the text of the presentations given during the plenary session on the first day:

- Introduction to the Workshop (Mr M. Barbarino);
- Teamwork Issues in Air Traffic System Management (Mr K. C. Williams);
- Teamwork for Air Traffic Controllers (ATCOs) (Mr B. Ruitenberg);
- The Pilot's View on Teamwork (Capt. J. Butler and Mr L. Beardsworth);
- Team Resource Management (TRM) Training for ATCOs (Messrs M. Masson and J. Pariès);
- Team Resource Management in CNS/ATM Systems (Capt. D. Maurino).

Chapter 3 provides the summaries of the Working Groups (WGs) held on the second day and presented by rapporteurs on the third day. The themes of the WGs were:

- Teamwork, the Concept;
- Teamwork in the Operational Environment;
- Teamwork and Selection;
- Teamwork and Accident/Incident (A/I) Investigation;
- Teamwork and Training;
- Teamwork and the Design of Air Traffic Systems.

The list of participants is provided at the end of this document as well as a list of abbreviations and acronyms.

Intentionally left blank

1. INTRODUCTION

Within EATCHIP, the Human Resources Bureau is in charge of the integration of human aspects-related knowledge and methods into the current and future ATM system to ensure the overall compatibility with the human operator. Its main activity covers HFs studies, manpower planning, selection, training and licensing.

1.1 Scope

The EATCHIP Human Resources Team (HRT) has initiated the organisation of annual workshops on topics concerning HFs in ATM. The goal is to create a European centre of HFs expertise in ATM. This should encourage HF practitioners and researchers to share their experiences, to exchange the results of current research development trends and practice, and to consider the evolution of new concepts for the changing ATM environment.

The first workshop was held in 1996 on cognitive aspects in ATC.

1.2 Purpose

This report is the proceedings of the second annual workshop entitled ‘Teamwork in ATS’ held in May 1997 at the EUROCONTROL Institute of Air Navigation Services (IANS) with 100 participants from 21 States.

It contains the text of the presentations given during the first day plenary session, the conclusions of the six WGs conducted on the second day and the list of participants.

Intentionally left blank

2. TECHNICAL NOTES

After a short introduction to the workshop, five speakers presented a different point of view on teamwork in ATS. These presentations attempted to give a wide overview of the different issues in teamwork and served as an input for the WGs.

The workshop was chaired by Mr Chris Clark, Head of Human Resources Bureau DED5 - EATCHIP Development Directorate - EUROCONTROL, and Chairman of the Human Resources Team.

2.1 Introduction to the Workshop

Mr Manfred Barbarino - Head of Human Factors Studies Section - Human Resources Bureau DED5 - EATCHIP Development Directorate - EUROCONTROL

Ladies and Gentlemen,

Before we begin with the presentations on our subject ‘Teamwork in ATS’, allow me to give you some background information on why EUROCONTROL has decided to conduct these HFs workshops.

When the Human Resources Domain (HUM) in EATCHIP was set up in 1991, it was found that many ATC-related HFs activities were being carried out in Europe but they were rather local and uncoordinated. Some States even believed that HFs issues were mainly a national concern and had little in common with each other.

The challenge was to define a HFs project which should develop and apply harmonized and integrated HFs principles and methods for the best use of human performance and advanced technology in European ATM. Within this project, one of the most important parts is the establishment of a network for HFs developers and practitioners in Europe. This work includes regular contacts and meetings with European HFs research and development units, data collection on HFs activities, and the conduct of annual HFs workshops.

These workshops have three major objectives:

1. To increase and spread the awareness of HFs-related issues in ATM.

2. To provide a platform for HFs specialists and operational staff to exchange expertise, experience and current activities.

3. To encourage the participants to develop and discuss new ideas on HFs topics in ATM.

Last year in May 1996 we organized the first EUROCONTROL Human Factors Workshop here in Luxembourg with 60 participants from 10 European countries.

The workshop lasted two days and the topic was ‘Cognitive Aspects in ATC’. It consisted of presentations, WGs and panel discussion.

This year the workshop lasted three days and we have almost doubled the number of participants. Altogether I am very pleased that we have been able to accept 106 participants from 23 States, and I am sorry for those we had to reject because this conference room had reached its capacity.

Although the first workshop was regarded as a success by almost all of its participants, we had to learn a few lessons. The main concern was that the discussions were rather theoretical and abstract, and did not focus enough on operational problems and solutions.

This year we have chosen the subject ‘Teamwork in ATS’, which is by nature an operational issue. Our speakers today all have a strong operational background, and that is also true for at least half of the participants.

It is my personal belief that the success and the application of HFs principles in future ATM largely depends on a balanced integration of both scientific and operational inputs.

Before I close this introduction I would like to highlight an important HFs aspect. As I told you before, the participants come from 23 States in and outside Europe and only a few of them use English as their mother tongue. In our experience we have found that our major obstacles in the harmonization process are differences in language, semantics and words used. At the beginning of a harmonization process, people often assume many differences and only few commonalties but, if we allow enough time and patience to overcome these semantic problems, we often find that our problems and concerns are pretty similar.

Increased awareness and understanding of the benefits of communal HFs activities and operational application in the European Civil Aviation Conference (ECAC) area currently constitute the most important progress in this field, and I am convinced that this is the right way to contribute to the challenge of future ATM in Europe.

2.2 Teamwork Issues in Air Traffic System Management

By Mr Keith C. Williams - Director Air Traffic Operations - National Air Traffic Services Ltd, UK

2.2.1 Background

Air traffic is forecast to grow substantially well into the next century, and providing sufficient capacity to meet forecast demand remains the major preoccupation for all air traffic service providers. EATCHIP recognises that increasing capacity in European airspace whilst maintaining a high level of safety is not simply a technical event. The human is an essential and valuable resource in the European air traffic system. Realising the benefits of EATCHIP and the future European ATM System (EATMS) hinges crucially on maximizing the contribution of the human element.

The users of Europe's air traffic system - principally the airlines - believed that ATS providers could produce some rapid results by the more widespread application of best practice techniques for managing human resources practised elsewhere in the aviation industry and in the commercial sector. This resulted, last year, in the publication by EATCHIP of guidance material directed at encouraging ATS managers to actively consider the current human resource issues. Teamwork is one of these issues.

2.2.2 Interactions in the Air Traffic Control Environment

To set 'management of teamwork issues' in some context, there is a need to ensure that the human interactions involved in providing the ATS are understood.

- At the ATC unit level at ACCs and in airport control towers, there are the managers, supervisors, planners, controllers, engineers and support staff working together to provide the operational service to the customers (the flight crews operating the aircraft (a/c) - civil, military and general aviation) as well as working with other elements of the national ATC system and across international borders.

- At the organisational level, the corporate management provides direction to the unit level and the strategic links to customer organisations, government, regulatory bodies, and international ATC organisations.

The scope of the teamwork issues spans the entire breadth of these interactions. This requires a broad and flexible outlook. However, integrated working also hinges on effective communication combined with a clear focus on the issues that are most critical to ATS customers.

This presentation therefore covers the issues relating to all three - teamwork, communication and customer focus. It also considers whether future changes in role of the controller proposed under EATMS might alter the perspective.

2.2.3 Teamwork

The objective should be to enhance teamwork in ATS in order to optimise the safety and efficiency of ATS. Traditionally, people think of teamwork only within their immediate area, but teamwork is much greater when you consider the wider interactions of ATC.

At the organisational level, there is a need to ensure close co-operation and good teamwork between the various ATS elements in order to improve the cohesion of the air traffic system so that the traffic keeps flowing.

This involves the ACCs, airport ATC, flow managers and engineers working together more closely, not only in their day-to-day operations but also in their forward planning.

The ability of everyone in the organisation to work together with mutual respect is equally vital. This means breaking down any entrenched attitudes, demarcations and suspicion of management motives and replacing them by an organisational culture which sits at the leading edge of working practices, employee relations and productivity.

At the ATC unit level, analysis of ATC incidents clearly indicates that failures in teamwork contribute to incidents. Moreover, a survey of controllers revealed that inconsistencies in working practices of colleagues often have a detrimental effect on the performance of individual controllers within the team and can contribute to safety-related incidents and reductions in traffic throughput.

The world's airlines recognise the importance of effective teamwork by flight crews on safety and efficiency of flight operations and have invested heavily in Crew Resource Management (CRM) training. EATCHIP is now doing the same, actively addressing team functioning in ATC through applying a CRM equivalent in ATS - known as ‘Team Resource Management (TRM)’.

In addition to TRM, a key action towards achieving such improvements is introducing training on teamworking into all aspects of ATC training. Formal teamwork training would probably cover topics such as organisational culture, teamworking skills, motivation, leadership and communication.

The key benefit of better teamwork in ATS organisations would be enhanced safety, increased efficiency and improved links between the various ATS elements. Better integration through teamworking also encourages greater employee involvement and creativity, stimulates greater awareness and commitment, and overall provides an enhanced quality of working life.

2.2.4 Communication

The role of communication is about dialogue, teamwork and involvement. The objective is to ensure that an effective system of communication exists within ATS organisations which will enhance performance and facilitate change. Good communication is the lifeblood of every successful organisation and is everyone's responsibility.

The task of managing effective professional relationships within the organisation lies with its leaders. The leadership and communication style they adopt will ultimately influence the average employee's outlook, glue the organisation together on common issues and set the whole culture of the organisation. A rounded relationship and a well-thought out communications strategy will ensure everyone understands the benefits of communicating effectively.

At the day-to-day level, managers and employees need to be equipped with good communication skills and style in order to assist interpersonal contact, encourage dialogue and recognise sensitivities. Managers need to be equipped so that they can establish a trusting relationship and feel comfortable in debating difficult issues. Employees need evidence that communication is indeed 'two-way' - they need to feel that their views are valued and that their ideas are acted upon.

ATS organisations should be committed to establishing and maintaining effective communication between all levels. This includes establishing an effective strategy which underpins the desired organisational culture, and defining communications processes which deliver timely and co-ordinated messages and minimize the impact of the 'grapevine'. Training in communication would promote teamwork through the development of communication skills, effective style and interpersonal contact.

2.2.5 Customer Focus

The driving force behind the present-day operation and future development of Europe's air traffic system must be meeting the requirements of customers - i.e. the airspace users. There is a clear responsibility on the 'team' at the front-line delivering ATS to understand the needs of their customers.

Much closer links with customers are essential - both at a strategic level and on a day-to-day basis - if ATS organisations are to better understand customer needs. Developing a customer-oriented culture within the ATS organisation is vital to increase customer awareness amongst managers and employees so that the organisation's efforts are directed towards meeting those needs.

ATS organisations should work closely with customers to ensure that they are fully briefed on progress with developments and current issues so that they can plan accordingly. This should lead to a more 'educated' customer who understands the problems and works in partnership with ATS managers to resolve them.

This constructive, teamworking style of relationship builds a much better understanding of each other's operating problems.

For effective customer dialogue, a formal customer consultation process should be set in place at the strategic level. It is also important to establish informal contacts at unit level to ensure that day-to-day operational issues are addressed by those directly responsible for the service. Customer service targets should be set by ATS organisations against which improvements in performance can be measured, and customer surveys should be conducted periodically to assess their perceptions of performance. Establishment of formal customer awareness training for managers, supervisors and employees would help develop their understanding of customer requirements and commercial awareness of the airline industry.

The key benefit of embracing the customer service concept at all levels within the ATS organisation is the ability to work as a team in partnership with customers to address issues, target capacity improvements and reduce delays. Increased customer awareness at the operational level provides the impetus for managers and employees to find effective and lasting solutions.

2.2.6 Future Role of the Controller

The key element of the current ATC system is the 'Tactical Controller' who mentally creates a picture of the traffic situation in order to identify and deal with problems in their airspace sector. Since there is a limit to the number of flights the controller can handle, additional capacity is provided by resectorising or simplifying procedures. However, this continued reliance on further sectorisation, more controllers and better procedures as a means of bringing extra capacity on stream is simply not sustainable in the longer-term. Continuing to slice-up the airspace would result in sectors becoming too small and the co-ordination workload would escalate. Clearly, new methods of operating are needed in the future if workload constraints are to be overcome and ensure that further capacity can be provided cost effectively in line with ever-growing demand.

EATMS envisages that additional capacity will be achieved through enhanced, multi-sector planning of flight trajectories, using advanced ATC systems and supporting computer assistance tools, to design out conflicts in advance. The role of the tactical controller will switch to managing the execution of the plan and intervention by exception, such as when unplanned events occur.

It follows that these new methods of operating will increasingly rely on the system 'holding the mental picture', not the controller. This conclusion has huge implications, not only for system design, architecture and certification, but for the human element. With a future air traffic system operating at capacity for prolonged periods, the role of the human in ensuring the safety and resilience of the system remains extremely important. Technology must not become a barrier to human interactions and relationships.

Great care over teamwork, customer focus and communication needs to be taken as the role of the human in the air traffic system changes. Development work needs to be done in conjunction with operational staff and customers who, as ultimate users of the systems and tools, must be convinced that they are worth implementing and can be safely introduced. Any failure to gain controller or customer acceptance of new operating methods would mean that Europe's air traffic system could no longer keep pace with growth in traffic demand. A return to the capacity crisis and the appalling delays of the late 1980s may then become inevitable.

These new challenges demand even greater teamwork at all levels into the future.

2.3 Teamwork for Air Traffic Controllers

By Mr Bert Ruitenberg - Human Factors Specialist - The International Federation of Air Traffic Controllers' Associations (IFATCA)

2.3.1 Introduction

The notion of 'teamwork' is not new to Air Traffic Control (ATC). When I first became interested in a career in this profession, which must have been around the late Sixties to early Seventies, the job-information sheets that were sent to me already mentioned that 'ATC is teamwork' and therefore one of the attributes expected from candidate applicants was 'the ability to work in a team'.

Apparently this observation does not historically apply for the pilots' profession. This is illustrated by a number of findings from the USA's National Transportation Safety Board (NTSB) accident investigations from the late Seventies and early Eighties:

- A crew, distracted by the failure of a landing gear indicator light, failing to notice that the automatic pilot was disengaged and allowing the a/c to descend into a swamp;
- A co-pilot, concerned that takeoff thrust was not properly set during a departure in a snowstorm, failing to get the attention of the captain with the a/c stalling and crashing into the Potomac river;
- A crew failing to review instrument landing charts and their navigational position with respect to the airport and further disregarding repeated Ground Proximity Warning System alerts before crashing into a mountain below the minimum descent altitude;
- A crew distracted by non-operational communications failing to complete checklists and crashing on takeoff because the flaps were not extended;
- A breakdown in communications between a captain, co-pilot and ATC regarding fuel state and a crash following complete fuel exhaustion;
- A crew crashing on takeoff because of icing on the wings after having inquired about de-icing facilities. In the same accident, the failure of a flight attendant to communicate credible concerns about the need for de-icing expressed by pilot passengers (source: Wiener, Kanki and Helmreich, 1993).

From these and other examples it is evident that the notion of teamwork did not come to the cockpit naturally. Only after what we would now call aviation psychologists and HFs experts had pointed out to the pilot-training community that there existed a serious deficiency in teamwork skills among professional pilots, the industry, to its credit, responded by introducing CRM training, which previously stood for Cockpit Resource Management training.

2.3.2 About Crew Resource Management

CRM initially was met with scepticism but it rapidly gained recognition and acceptance from the pilot community, especially after a number of events became known where good CRM evidently paid off. One of the more notorious examples of such events is the case of United Airlines 232, also known as the Sioux City DC-10. For a description of it, I quote from the book ‘Cockpit Resource Management’, edited by Wiener, Kanki and Helmreich (1993):

> ‘On June 19, 1989, a DC-10 crashed during an attempted emergency landing at Sioux City, nearly 45 minutes after a catastrophic, uncontained failure of the fan disk in the centre engine severed lines in all three hydraulic systems, resulting in a total loss of the a/c's hydraulically powered flight control systems. Fatal injuries were sustained by 110 of the 285 passengers and by 1 of the 11 crew members aboard the crippled a/c. In its report on this accident, the NTSB commended the crew for its performance, noting that the pilot, co-pilot, flight engineer, and a DC-10 flight instructor who had been riding in the passenger cabin managed to devise a crude but workable method for partially controlling the control-less a/c. Working together as a highly integrated team, this flight crew salvaged much of what could have been a total disaster. Because of their performance, 185 people survived an otherwise not survivable situation’.

The captain of flight UAL 232, captain Al Haines, has since appeared at numerous seminars or other pilot gatherings to express his belief in the value of CRM, thus adding to peer acceptance of the concept.

After more and more airlines voluntarily introduced CRM training in the curriculum for their flight crews, it was even mandated by ICAO. This means that now every commercial airline of a certain size is required to have a CRM-training programme for its pilots. CRM has undergone a subtle change by the way: the acronym now stands for ‘Crew Resource Management’, for it was recognised that resources are not necessarily restricted to the confines of a cockpit. Indeed, some airlines have taken to designing training scenarios in which a full (or nearly full) aircrew takes part: pilots, flight engineer, cabin crew, and sometimes even representatives from airline operations.

I guess therefore it is safe to say that CRM training for flight crews has become a success. And as a direct result of that success of course, a tendency developed to export CRM to other sectors, both within aviation (maintenance, dispatch, ATC) and outside of it (hospitals, in particular surgical theatres). But can CRM be exported as easily as it seems?

2.3.3 Crew Resource Management for Air Traffic Control

In an attempt to answer that question, I suggest we look at the ATC sector as a potential target. For starters, here are some differences between flight crews and ATC crews:

Flight Crews	ATC Crews
In the cockpit, the role of each crew member is strictly defined: pilot flying, pilot not flying, and (in specific types of a/c) flight engineer. Each member normally stays in his or her role from the beginning of the flight till its completion. The work for each crew member is designed to complement that of the other(s). Overall responsibility is clearly designated to the captain of the flight. On long-haul flights, extra crew members are usually available for relief, but the size of the active team remains the same.	In ATC, it is common to find that the role of a team member is determined by the physical working position (workstation) where he or she sits. Activation of positions depends on the traffic situation: the more complex or busy it gets, the more positions become active. By activating more positions, the workload is shared between the team members, who work to supplement one another. Each controller is responsible for all the traffic in his or her area. In the course of a working day, a controller may work at different positions. Although the formal overall responsibility may be designated to a supervisor, team members work most of the time without over-the-shoulder supervision. Indeed, the supervisor may be working a certain operational position himself/herself during busy periods.
Because the tasks of aircrew members are strictly defined, it is possible for pilots who have never met before to fly an a/c successfully from A to B in good co-operation, provided they belong to the same company. By adhering to company procedures and using checklists, they share the mental model required for the job.	Within most ATC units, such company procedures and checklists are non-existent. The controllers share a mental model of their job, adjusted to the specific situation of their unit, but there may be surprisingly large differences in the individual ways of working. In fact, trainees are often encouraged to develop their own style. Knowing the style of one's colleagues is important to be able to closely co-operate with each other.
Pilots receive recurrent training, usually on high-fidelity flight simulators. Airlines not owning simulators rent time from other companies.	Few controllers receive recurrent training. Few facilities own high-fidelity ATC simulators. Facilities not owning simulators cannot easily rent time from other companies because of lack of equipment compatibility.

Figure 1: Differences between Flight Crews and ATC Crews

Flight Crews	ATC Crews
Pilots are physically involved in their work. If a problem occurs, they have a strong personal interest to see the a/c return safely to the ground.	Controllers are more detached from the problems that may face them. They are hardly ever in any physical danger during their work.
In their normal work, pilots ideally should encounter no problems: the a/c is airworthy, scheduled departure and arrival times are met, and the weather is fit for flying. In case one of these items turns out to be less than ideal, the crew has a problem that they are expected to solve. Since several of such problems have been anticipated to occur, pilots are trained to handle them and checklists are provided to assist in the solving of these problems.	The work of a controller almost exclusively consists of problem-solving, in trying to accommodate the traffic safely, efficiently and in an orderly manner in the available airspace. This is less dramatic than it may sound, since it is exactly what they are used to. Controllers are trained to solve these problems themselves without consulting checklists or colleagues. Yet there can be additional (non-routine) problems as well for controllers, such as a/c with an emergency, breakdown of ATC equipment, communication failure, etc.

Figure 1 (continued): Differences between Flight Crews and ATC Crews

I submit that these and possibly other differences will significantly determine the exportability of airline CRM programmes to ATC. Note that I said *programmes* - the *concept* of team training may be exportable, but it will involve the development of new programmes almost completely from scratch. This in itself should not be too much of a revelation, because in airline CRM it is an accepted fact that CRM programmes for one airline are not successfully transferable to another airline, not even if that airline is from the same country as the first. But it may imply that the effort required to get team-training programmes for ATC in place on as wide a scale as CRM for airlines will be considerable.

2.3.4 Lessons Learned from Crew Resource Management Development

Yet perhaps we in ATC can benefit from lessons learned by the CRM developers over time, in order to avoid making the same mistakes. I have already mentioned the discovery that CRM programmes do not readily export to other airlines, not even nationally. This is a direct result from the fact that the most successful CRM programmes are permeated with the corporate culture of the airline for which they were developed. Professor Bob Helmreich of the University of Texas, who has done an impressive range of research into CRM, describes corporate culture as ‘the way we do things around here’. It is easy to see that, if a programme is designed to closely fit the culture of one company, it will not easily fit that of another company, because people in that company will simply be used to doing things differently.

A second lesson is that it is best to base training scenarios on real-life examples that are relevant to the target audience. A scenario involving problems with a/c in mountainous terrain could be appropriate for Swiss or Austrian controllers, I am sure my Dutch colleagues would seriously question its value. Or, even more obviously, scenarios for ACC crews are probably unsuitable for TWR crews and vice versa.

The third lesson I would like to mention is that CRM scenarios or exercises should be developed by line-instructors, with the professional assistance of HFs consultants. Scenarios developed only by psychologists are simply not realistic enough to be accepted by the target audience.

Perhaps a further lesson can be found in the current state of CRM. As mentioned, the USA's Professor Helmreich is probably the most prominent researcher into this field. In a recent presentation (International Civil Aviation Conference (ICAO) Seminar on Flight Safety and Human Factors, Abidjan, Ivory Coast, November 1996), he identified five different generations of CRM. Each generation has its own clear attributes that distinguish it from the others:

1st	1980-1986	Focus on management styles and interpersonal skills
2nd	1986-present	Focus on concepts (e.g. situational awareness, stress management)
3rd	1993-present	Focus on specific skills and behaviours. Integration with technical performance. Emphasis on evaluating HFs
4th	1994-present	Focus on cultural issues (organisational and national)
5th	1996-..(emerging)	Focus on managing human error

Figure 2 : CRM Generations

So, where are we with the development of CRM or team-training programmes for ATC? Are we using the lessons from the ones who went this road before us? Well, maybe we are, but then again maybe not to the fullest possible extent.

2.3.5 Air Traffic Controllers Team-Training Initiatives

Initiatives are under way on a national level, where management has told the training community to develop team training for certain units. The trainers have turned to operational instructors for help, but my impression is that together they are now looking around for guidance on what exactly to develop. Maybe it is time to bring in the HFs consultants there. On a supranational level, a TRM training programme for ATC is being developed under the aegis of the EATCHIP HRT. Again, I express a personal impression when stating that I fear that, in this development, the operational input is perhaps less than it should be. In other words, I think that this TRM development might be delegated too much to the scientific community. Perhaps the national and supranational initiatives should meet in order to strike a balance?

A question that also needs to be addressed is which generation of CRM we are hoping to emulate when introducing team training for ATC. My feeling is that most of the current efforts are aimed at Dr. Helmreich's third generation, where the focus is on specific skills and behaviours, integrated with technical performance, and with emphasis on evaluating HFs. But can we do that? Can we just skip two generations, or should we allow for an incremental process where each new generation can build on the achievements of the previous one(s)? And, if we agree we can indeed skip earlier generations, why not include some of the more salient good points from the later generations too?

For example, Dr. Helmreich's emerging fifth generation, where the focus is on managing human error, to me is the mother of all aviation HFs efforts. Aviation for far too long has been a domain in which officially no errors were made, and if no errors are made nothing needs to be done about them.

Slowly the realisation is dawning that aviation is as error-prone as any other activity that involves human beings. Our aim as aviation-safety professionals should not therefore be to <u>avoid</u> human error but rather to <u>manage</u> it, to keep errors from turning into accidents, and what better place to begin with this than in training?

Earlier on, I mentioned that the effort required to get team-training programmes for ATC in place on as wide a scale as CRM for airlines will be considerable. Now, whenever in today's business-oriented environment it becomes apparent that considerable effort may be associated with the possible acceptance of a new proposal, the quick management solution is to call for a cost-benefit analysis. I do not intend to take that bit of fun away from our managers, but I am going to take a few hesitant steps in that general direction, if I may.

2.3.6 Is Team Training for Air Traffic Control the Only Solution?

Let me remind you of the list of NTSB findings I presented at the beginning of this paper. Those were findings from accidents where lack of flight crew co-ordination was the main factor. Would it be possible to make a similar list of incidents and/or accidents where lack of ATC-crew co-ordination was the main factor? Well, I will be the first person to admit that I may be professionally biased, but I could think of only one such accident: the Zagreb-midair, and I am not even sure it is a correct example. If a team is reduced to effectively having only one player in the field, are we then talking co-ordination failure or organisational failure? In my view, it is the latter, which leaves the list empty.

That may seem oddly surprising at first sight, but is it really? Remember how also at the beginning of this paper I explained that historically ATC has been regarded as teamwork? Admittedly, most ATC-training programmes are aimed at improving technical skills at the individual level, but in the On-the-Job Training (OJT) part, trainees are made very familiar with co-ordinating with other positions, be it in the same sector or TWR, between sectors or between units. Working in a team thus becomes a second nature to ATCOs or ATC crews in general. Which leads me to a somewhat crucial question: what exactly are the expected benefits from introducing team training for ATC?

I do not have the answer to that question. The workshops here during the following days may be excellent platforms for finding it, hopefully together with many more answers to as many questions. But I would like to conclude this paper by suggesting that perhaps there are other solutions and/or improvements for ATC possible than introducing team training to enhance flight-safety in general, and I am going to offer two of those alternatives.

2.3.7 A first Alternative Improvement

CRM has evolved from ‘Cockpit Resource Management’ to ‘Crew Resource Management’, thus reflecting that the concept of who exactly are the players in the team also has evolved.

The flexibility of the acronym could even be further exploited if it were also used to indicate ‘Controller Resource Management’, but for EATCHIP usage the phrase ‘Team Resource Management’ (TRM) was decided on. Yet it all comes back to the point of who exactly are the players in the team. I submit that rather than looking for optimal training for two *separate* teams, training programmes should be developed based on the thought that in a lot of situations pilots and controllers are part of the *same* team. In other words, controllers should become an integral part of the pilots' resources.

This is how that might work. Traditionally, pilots are trained to solve problems ‘in-house’, and only after reaching a solution inform ATC of their intentions and requirements. Traditionally, controllers are trained to wait for that information from the pilots and then try to accommodate the request as well as possible. If ATC is to become an integral part of the pilots' resources, it means that pilots will have to communicate at an earlier stage with ATC and that their requirements need to be described in more general form, and that controllers will have to be prepared to help develop solutions. For example, in the traditional situation a pilot could request an immediate approach to Runway 08 at a specific airport, but in a consultative situation the pilot would inform ATC of the need to land as soon as possible, and ask suggestions as to the most suitable runway - maybe the airport has more runways, maybe there are other airports or landing-strips closer to the position of the a/c. And even if an airport has only one runway, it can still be used in both directions!

2.3.8 A Second Alternative Improvement

The second alternative I am offering is to structurally establish ATC recurrent training programmes across the industry. It may come as a shock to those of you in the audience who are not intimately familiar with ATC organisations that in many countries, including those who are considered ‘developed’, recurrent training for ATCOs is non-existent. I submit that, if controllers were subjected to regular training programmes where rarely-used skills or new procedures can be practised, this would enhance their general performance more than just a dedicated team-training programme would.

I wish you two days of fruitful and enjoyable workshop.

2.3.9 References

Helmreich, R. L. and Foushee, H. C. (1993). Why Crew Resource Management? In E. L. Wiener, B. G. Kanki and R. L. Helmreich (Eds.). *Cockpit Resource Management*. San Diego, California: Academic Press.

Helmreich, R. L. (1996). The evolution of CRM. *ICAO Western African Region Second Regional Human Factors Training Seminar*, Abidjan, Ivory Coast, 5-8 November 1996.

Ruitenberg, B. (1995). CRM in ATC - is it feasible? In B. J. Hayward and A. R. Lowe (Eds.). *Applied Aviation Psychology* (1996). Aldershot, England: Avebury, Ashgate Publishing Ltd.

Ruitenberg, B. (1997). Human Factors Issues in ATC. *The Ninth International Symposium on Aviation Psychology*. Ohio State University, Columbus, Ohio, 27 April - 1 May 1997.

2.4 The Pilot’s View on Teamwork

By Captain Jeremy Butler - Chairman IATA Human Factors Working Group and Mr Louis Beardsworth - British Airways Safety Services - Human Factors Manager

2.4.1 Background

Until the mid 1970s, accidents involving HFs in an aeroplane were usually classified as pilot error. This led to a tendency on the part of accident investigators and airline managements to write off pilot error accidents as being solved. It also led to a defensive attitude on the part of the pilot group in attempting to deal with these problems.

The International Air Transport Association (IATA) 20th Technical Conference held in Istanbul in 1975 made the clear recognition that, with very rare exceptions, pilot error accidents are due not to negligence or deliberate misbehaviour by the crews, but rather the bi-product of a series of circumstances which put the crews in a position where the probability of making an error was extraordinarily high.

Airlines, governments and pilots then started to ask the critical question ‘why such errors were made?’. There was a move away from the previously held concept of ‘blame the pilot if things went wrong’ to look at underlying circumstances from causes.

At about the same time, a number of high profile accidents occurred, in which there had been no technical failure in the aeroplane, but there had been a breakdown in the crew responses to the situation in which they found themselves. Accidents such as those in the Everglades at Portland and Pensecola in the United States were major drivers in the re-examination of flight operational philosophies, policies, procedures and practices. In the United States this was led by United Airlines who unfortunately had suffered a number of the quoted accidents, and it is greatly to their credit that they started the re-examination of the reasons for error and techniques for accident prevention. This formed ‘Cockpit Resource Management (CRM) programmes, essentially exercises in teamwork, which have been developed and expanded worldwide. They are now endorsed by ICAO, and there is wide-spread acceptance by Regulatory Agencies, and they are now to be included in the Joint Airworthiness Requirements-Operations (JAR-OPS) of the Joint Aviation Authorities (JAA).

2.4.2 Introduction

To facilitate further discussion of teamwork, the paper will be divided into four areas:

Firstly, a look at the data, statistics and academic research to teamworking, to consider how the subject has been approached in a generic sense. This is of value to both Flight Operations and ATC, since although our needs will be different in the application of the subject since people are the primary focus, there will always be broad swaths of similarity. Often, even though the environment changes, the people do not.

Secondly, the pilots' view of teamwork will be examined. This will look at the drivers which led to the dramatic changes in thinking about what is needed from the men and women who fly a/c, and the work that was done to define what effective teamworking is, on the flight deck.

The third segment is to describe how this theory is put into practice. The example of the application is that currently being used in British Airways. In the late Eighties in British Airways, the ground was being laid which has led to this work, i.e. CRM. However, CRM largely deals with increasing the awareness and understanding of human behaviour, with only a small element of acquiring behavioural skills and applying these in the flying environment. The important step then is to take this subject of teamwork and make it a measured skill.

The final segment to be covered is looking at the wider team from the pilot's perspective and of course in the context to this seminar, that includes our partners in ATC. There is a saying that 'no man is an island'. In aviation this is a truth for all individuals or organisations, and that is also true of global industry operating within a more and more congested environment. Again, looking at some of the historical background, you will be given a flavour of the collaborative work that has been undertaken in the last few years between the United Kingdom National Air Traffic Services (NATS) and British Airways.

2.4.3 Data Statistics and Research

So, let us now look at some of the recent data and statistics. There has been a wealth of data available from a/c manufacturers, international organisations, regulatory authorities and operators which have indicated that in a now overused phrase '70% of a/c accidents are caused by human error'. This term is now regarded as rather unsophisticated - it is more of a slogan, and requires detailed analysis. The Boeing Airplane Company has introduced the concept of strategies for accident prevention, and this different way of 'slicing the cake' indicates that a large proportion, about 40% of accidents, centre around non-compliance with Standard Operational Procedures (SOPs).

These studies have been carried out on 2 or 3 crew a/c, so it is legitimate to ask why at least 2 people in a cockpit have not complied with the procedure, i.e. where was the teamwork?

There are of course a number of possible answers. Complacency, boredom, unawareness, misunderstanding, high workload and distraction. These might be termed passive failures. One could have deliberate violations, no adherence to SOPs, failure to follow instructions - possibly from ATC, failure to manage the cockpit resources, a gross lack of appropriate vigilance (e.g. all crew members reading the newspapers). These might be termed active failures.

A third category could be a proficiency failure, in which there was inappropriate handling of the a/c or its systems. It can include misjudgement, making incorrect decisions, and may be exacerbated by a lack of experience, lack of training, or incompetence. Whatever the reasons, the data gives cause for concern.

The IATA jet safety report focuses upon these issues. In 1995 there were 18 total hull losses to western built jet a/c over 20,000 tons in operational service. The number of sectors flown was 17.2 million. In 1996 there were 19 operational hull losses in 17.5 million sectors, 11 of these 19 accidents have been assessed as having some measure of human failure (active 4, passive 3, proficiency 10 - some accidents had more than one classification).

IATA has an objective of a 50% reduction in the world accident rate by the year 2004. Unless the human failures on the flight deck can be reduced, this target is unlikely to be achieved.

As can be seen, one of the major components to continue to address is that of teamwork.

Now, let us examine the area of teamwork from the academic view - what it is that we are looking at, and what we are looking for. Teamworking has occupied the minds of many leading management thinkers. The most common point of focus with a management expert has been building the team to produce an effective outcome for the organisation. As we all recognise, although we in aviation are constrained by the same economic factors that affect other industries, we have some more obvious outcomes from the failure of teams than in many other industries, i.e. accidents, which have a high profile in the media and amongst the population at large.

Two researches to be discussed, if only briefly, are Adair and Belbin. Dealing with Belbin first, the contribution that we should recognise from his work is the idea of composition of teams. From the pilot’s perspective the names Belbin used to describe the components of the team may not appear to have any context, neither are the number of players available. However, the lesson that we should draw on is that, depending on the outcome, we required different components in our team to be available. This is not easy when, with a very limited team, perhaps 2, they will need to have all the skills available amongst just themselves.

The work of John Adair is recognised primarily for his focus on leadership. The reason that he is drawn into discussion on teamwork is readily demonstrated by an example of Adair’s model. The model most clearly shows that teamworking does not stand on its own. It is inter-linked with the individual and the task.

The model describes a dynamic situation in which the team, and by implication teamworking, are affected by the other elements. The other and critical point that Adair makes is that teams do not happen by accident. Leadership is about teamworking and creating teams. Teams tend to have leaders, leaders tend to create teams.

2.4.4 Focus on Teamwork

In posing the question ‘So why are pilots now so focused on teamwork?’ It may be asking anyone to state the obvious. The trigger for change in aviation that has led the domain of the pilot to its position of focus on teamwork has clearly been the evolution and the understanding of why accidents occur, and the recommendations and how they can be prevented.

As previously mentioned, the statistic that 70% of accidents attributed to HFs - some of which we related to teamwork - is far too easily used without consideration. It is not that these accidents are the significant percentage that should be the absolute concern. What is of concern is that we already have many of the tools to fix the problems that create them.

Leaving aside the number of events, it has become clear that we have a problem on our flight decks that is associated with ineffective crew operation teamworking. This presented the industry with a dilemma which was focused upon how pilots were trained and assessed. In short, the parameters for the training and measurement of a pilot’s skills were designed around the operation of an individual, and to compound the dilemma, they were technical by nature. Almost without exception everything else that reflected on success or failure of an individual within the crew was addressed with the unmeasured scales of airmanship and crew co-operation.

Richard Hackman of Harvard University (Teams, Leaders and Organisations; New Directions for Crew-Oriented Flight Training) studied 300 crews on 10 a/c types of 10 operators, 6 in the USA and 4 outside. He emphasises that when incidents occur more often than not, it is because the team broke down, because members somehow ‘lost the music’.

Helmreich (1991) in reviewing the causes of accidents and reportable incidents concluded that in the great majority of cases the a/c was mechanically capable of flying out of the situation, all crew members were well trained and in good health, and yet the crew got itself into trouble. It is the team, not the a/c or individual pilot that is at the route of most accidents and incidents.

Hackman emphasises that team skills critical to crew performance cannot be assumed to be present. People are not born with them, nor are they necessarily developed at flying training school. He points out that CRM programmes which concentrate upon behavioural styles rather than skills may teach that certain styles are better than others for promoting team effectiveness, but the changes in style learned in the classroom may not generalise to the cockpit, especially under stress. To Hackman, there is no better alternative than Line Orientated Flight Training (LOFT) with crews operating as a real team in a realistic flying setting.

2.4.5 Application

With this background and the essential need to address an area that as yet was undefined and certainly not measurable, a programme was undertaken by

National Aeronautics and Space Administration (NASA) and the University of Texas. The outcome of the comprehensive research is the list of attributes and actions that are the NASA team skills markers. Currently, these are the best known and most widely used list of skills that go to make up effective teamworking on the flight deck. It should be said, however, that these are not considered the definitive list. Research is going on within Europe to develop a list of markers that have the influence of our own culture and environment.

Given that we now have a list of team skills markers, the next stage assuming that they are accepted and to define the elements of the effective team, is to incorporate them into our way of working.

Incorporation of these non technical measures into what is a technically-based culture, requires not a leap of faith that some might describe, but a well-crafted plan and it is here that our approach may have some translation for ATC as you approach TRM. The essential truth is that non technical skills enhance the technical operation and as such must be integrated at the fundamental level. This level is the only appropriate one to aim at, so that in all aspects of the technical operation of the a/c the two parts become indivisible. To achieve this in British Airways all flight crew trainers, simulator and line training pilots are being put through a three-day course known as advanced trainer skills. The course is essentially one of the giving additional skills to a group who already excel in their chosen profession. The skills can be broken down with respect to teamworking as recognising effective and ineffective operation, de-briefing teamworking and then enabling the flight crew under test or training to increase their skills level.

Flight crew as a group are conservative; new concepts need careful introductions. They are focused on the technical, and suspicious of the less easily defined behavioural skills. They distrust ‘psycho babble’. The great key to the acceptability of these markers is that they are able to deliver a clear and shared vocabulary, teamworking and crew co-operation that effective instructors have always understood. If we then link this back to the ‘why’ of why we as pilots interested in teamworking, we can now see that the loop can be closed. The flight instructor now possesses a language and a means of scaled assessment for the skill areas that have been identified as relevant in accidents and incidents. This, however, moves our profession down a new road where we will require different skills to achieve the new outcome now required. It is logical to extrapolate that the assessment, selection and training processes that are used for flight crew will need to recognise the paradigm has been broken and adjust accordingly.

Having put these changes in place in training and assessment of flight crews in response to deficiencies detected in accidents, and addressed them in a simulator, the last part of the cycle is to ascertain if we have changed operation on the line. One would not expect to measure the effectiveness of training by the presence or absence of the type of incidents that first lead to the development of changes in how teamworking is approached. What we have, however, is a reporting system which, as part of its structure, is able to provide feedback to the training mechanism. This is the confidential reporting programme within the family of British Airways BASIS safety systems, namely HFs reporting. Although this system deals with the broad subject of all HFs affecting the operation of the a/c, it has within its structure of descriptive key words the core of the team's skills. If reports received from flight crew describe effective or ineffective teamworking, it is possible to encode this into the database which can then be interrogated for trends.

2.4.6 Teamwork with Air Traffic Control

Now to the fourth element. Within the pilot's view this is the wider team. In this case teamworking with ATC. It is true to say that pilots always work with ATC, without there being anything that in any sense can be adversarial. Do we always work together? This question should not be misunderstood. Our individual disciplines within aviation have developed in complexity which has meant that it is more and more difficult for either group of professionals to have a comprehensive understanding of the others' needs and capabilities within their function.

Drawing on the experience of British Airways and NATS in the United Kingdom, it would appear that air traffic agencies are taking the most active steps to close the gap. To illustrate this there are three examples where British Airways and NATS work together to address perceived needs are given.

The first part established approximately five years ago was an airline familiarisation course for junior ATCOs. This was specifically designed to give the new entrant to the profession a view of how the customer operates in commercial pressures to which they are subject. Although the course goes well beyond the area of the flight deck, it includes familiarisation flights as part of the programme. The success of this course led to a request to extend and develop the content so that it would be suitable for groups of senior ATCOs. Both courses, although the teamworking may not have been addressed directly, provide an opportunity to improve understanding through knowledge.

The third collaborative venture is in the area of training for controllers in the handling of emergency procedures. Here, a series of videos have been produced which address a variety of emergency scenarios. In the way that a picture paints a thousand words, the videos demonstrate the essential effects of good teamworking from the pilots' perspective. The safest possible outcome.

2.4.7 Conclusion

One must briefly mention that teamwork exists within the organisational context. It is vitally important to recognise that its success for application requires the support of the organisation and management. The work of Professor James Reason, in highlighting the importance of latent conditions as pre-cursors to active failures, emphasises the organisational factors in aviation safety.

Safety must be viewed in a systemic way such that managerial philosophies are reflected in the developed policies and procedures and can be measured in the operational practices. Only with this level of support can teamwork be maximized.

2.5 Team Resource Management Training for Air Traffic Controllers

By Mr Michel Masson, Project Manager, and Mr Jean Pariès, Managing Director, DEDALE S.A.R.L. - Paris - France

The information, observations and interpretations presented in this article are DEDALE views on ATC work and TRM. They do not represent in any way the official viewpoint of EUROCONTROL.

2.5.1 The Needs

ATCOs work in shifts within operational units such as Aerodrome Control Towers (TWR), Approach Control Offices (APP) and Area Control Centres (ACC). Until now, a proper management of all available resources (people, information and equipment) within ATC teams has been mainly viewed as being embedded in the ATC environment, and individual capacity for teamwork has been mainly perceived as a natural skill.

The increasing complexity of the ATC task and the increasing demand for safety now call for a more structured approach through a tailored training. Within the frame of the EATCHIP, EUROCONTROL has undertaken to introduce and validate had hoc training techniques into the ATC environment.

2.5.2 The EUROCONTROL Answer

A EUROCONTROL Task Force including experts in ATM and HFs from several ECAC States was first established in 1995, and developed ‘Guidelines for Developing and Implementing Team Resource Management’ (EATCHIP, 1996) in ATM. At the end of 1996 a competitive call for tender allowed for the selection of DEDALE Company as a consultant for developing a prototype courseware based on the aforementioned guidelines.

The objective of the current project is to provide EUROCONTROL with a Prototype Team Resource Management Courseware (PTRMC) for ATCOs. The prototype courseware will constitute the framework on which national WGs will build their own national tailored courses.

TRM will be a training tool for operational ATCOs having a professional experience. The courseware will build on their experience. It will refer to practical and realistic examples, including actual incidents or accidents. It will be designed to be facilitated by qualified controllers specially trained for this purpose.

The primary purpose will not be to teach academic knowledge about HFs as such, but to improve ATCOs' awareness about TRM needs and practical solutions. However, the courseware will include, when necessary, a ‘refresher’ presentation of the main relevant concepts with limited emphasis on theory. The TRM courseware will also be designed as a component of a continued training process for ATCOs; it will include possible connections with *ab initio* training, as well as potential extensions towards recurrent training: simulator training and/or OJT.

National differences will be dealt with in two steps; the prototype TRM course core will be based on shared features of national cultures, training systems, ATC structures, job organisation. The course will then be customised and implemented on the national level by adding specific outer layers under the management of TRM national WGs.

2.5.3 The Example of the Airline Industry

It so happened that the Seventies were marked by the occurrence of several accidents 'instigated' by good crews (experienced, properly qualified, well considered) flying 'good condition' a/c (without any failure or only minor ones). The 1972 Eastern Airlines crash into the Everglades swamp is prototypic of these accidents.

During the night of 29th December, a Lookheed Tristar was approaching Miami International Airport, when the crew suspected a nose landing gear malfunction. After executing a missed approach, the a/c climbed on a westerly heading, while the crew attempted to check the gear position indicating system. Shortly after reaching the two thousand feet assigned safe height, the altitude hold autopilot mode disengaged for unknown reasons, and the Tristar began a gradual descent which was not detected by the crew, and crashed, killing ninety-six passengers and five crew members. NTSB determined that the probable cause of the accident was the 'failure of the crew to monitor the flight instruments during the final four minutes of flight, and to detect an unexpected descent soon enough to prevent impact with the ground'. The nose gear indicator light bulb was the only actual malfunction on the a/c.

The concept of Crew Resource Management (CRM) emerged in the late Seventies because such accidents were not understandable within the framework of the then current safety model, which could be stated as follows*: pilot competence plus technical reliability equal flight safety*. A slow safety paradigm shift then took place over the last twenty years. It has progressively changed the focus of accident causality from front line operators skills to the aviation system intrinsic failures (e.g. Pariès, 1996).

The question was: *'How can skilled operators perform so poorly that they kill themselves and their passengers?'* A first generic answer to this question emerged as follows: a crew or a team is not an addition of individuals but an interaction between individuals. So personalities, attitudes, lack of communication skills can lead to poor interaction. Pilots should therefore be informed about personalities, attitudes and co-operative behaviours that are considered desirable. This was the objective of the first CRM generation. It was sometimes resisted and rejected by pilots as psychological 'claptrap'.

Aggressive questioning of personalities was abandoned in most of the cases, and further issues were progressively tackled both from an individual and from a team perspective:

– updating of situational awareness, decision-making strategies,
– crew/a/c interaction with a special mention to automation,
– error management (prevention, detection, correction),
– interaction with the other teams (cabin crew, ATC, ground staff),
– coping with the environment (time pressure, stress, etc.).

So the focus has shifted from affective aspects of co-operation to management of all available resources, from *crew* resource management to crew *resource* management.

TRM will definitely benefit from the CRM history lessons (e.g. Helmreich et al.,1995; Pariès and Amalberti, 1995). But controllers are not pilots. Their jobs do present some similarities, but also major differences concerning teamwork, cognitive demands, decision-making, workload management and so on. TRM must be based on a relevant understanding of ATM job (e.g. Herschler, 1991). The following section therefore describes some of the main specificities of teamwork in ATM.

2.5.4 Some Important Features of Teamwork in Air Traffic Management

2.5.4.1 Team Structure

Controllers work as a team and work in shifts. The typical team is a long- lasting team. Long-lasting means that controllers typically keep belonging to the same team throughout their career. Controllers from the same team work together, eat together and also often share leisure activities, holidays. This leads to a strong team identity, with proper culture and habits. Members of a team would strongly resist leaving their team or watch to join a different one.

Long-lasting teams typically lead to the same basic team structure which is a ‘clanic’ structure. A clan is a self-organising structure in which everyone has her/his place, in which roles and status are defined accurately but through internal tacit rules of functioning, enforced through ‘peer pressure’ (see for example Gras et al., 1994). Everyone must be fair to the team and accept its functioning, or will be rejected. Trainees pick up the team culture and habits when they are trained by their colleagues. Such a team is very aware of the strengths and weaknesses of its members. For example, the team will not allow a ‘weak’ controller to take a difficult position during a peak workload situation. However, everyone is declared to be ‘a (good) controller’ towards the outside world.

Although many variations can be observed either on a national basis or even on a local basis, this generic structure is shared by most of the ATM structures in the EUROCONTROL sphere. Some countries do not use long-lasting teams, but the smaller overall size of the staff at major control centres leads to a similar effect.

This typical team structure has implications regarding several domains of team synergy: leadership, communication, decision-making are affected, among others.

2.5.4.2 Leadership and Command

A ‘clanic’ structure facilitates the emergence of leaders: strong individuals easily ‘set the tone’. In the case of ATC teams, leadership is based on competence and expertise, as well as capability to personify and express the collective interest of the team, to arbitrate between individual interests. This influences the relationship between the controllers and their official team hierarchy (supervisors).

In some countries, the team supervisors are selected by the authority of the ATM organisation with reference to seniority. There is no specific assessment process nor specific training (for communication and leadership skills).

In other countries, the supervisors are selected and qualified on the basis of technical and personal capacity, as well as motivation and attitude towards the job and towards the organisation.

However, contrary to what could be expected from these differences in the selection process or from (national) cultural features, the command style is currently rather comparable. The team supervisor is not (necessarily) recognised by the controllers as the control room boss. Even if she/he is legally responsible for the decisions taken, the supervisor does not usually exercise her/his authority over the controllers firmly. Depending on the traffic situation, she/he delegates most of her/his authority to controllers, and mainly acts as a monitoring and backup resource. Technical decisions, including bandboxing and splitting of sectors and real time sector staffing, are actually often taken by controllers on sector, with tacit approval from the supervisor. Supervisors mainly plan and organise staffing, schedule work, deal with individual requests (resting time, rostering, days off, etc.), and perform paperwork. Only if necessary (e.g. in case of an emergency) would a supervisor behave as the actual room boss and decision-maker. Conversely, the physical distance between the supervisor and the controllers in the room is an indicator of the situation demands and of the quality of control.

2.5.4.3 Communication

Communication between Controllers of the Same Unit

Communication between controllers of the same unit is heavily influenced by the high level of mutual knowledge that prevails within a long-lasting team. Visual information backs up verbal information and vice versa. Actions taken locally naturally inform the others about the intentions and the strategy of their authors. Silent communication continuously takes place between controllers who share a common representation of - at least part of - the traffic. Tacit communication takes place through understanding of the situation and intent recognition (see for example Masson, 1996, for a short literature review). Verbalisations are mainly used to reduce uncertainty. Example: ‘This Lufthansa over there, I'm gonna turn it to the left’, meaning: ‘I know you can expect me to turn it another way’ and/or ‘This control action may impact the situation on your sector’. Verbal (non professional) communication is also mainly used to maintain a friendly atmosphere and team spirit.

Communication between Controllers of Different Units

Communication between controllers of different units is purely verbal, as it uses the telephone. As controllers of different units do not see each other, and do not necessarily know each other, this communication is intermediate between intra-unit communication between controllers and communication with pilots. It is a one-to-one communication, but no visual feedback is provided (except through radar screen, the a/c squawk being a common reference). Conflicts often arise at the interfaces between sectors assigned to different control units, because of communication failures and because control styles can vary pretty much between units. Different local or national cultures also influence the reliability of communications (see the paragraph about cultures below). Here are examples of attitudes towards other control units:

– ‘You know how they are: single-minded and disciplined!’
– ‘In that unit, they work like at school: funny!’
– ‘We are the best! We are working the right way!’
– ‘Controllers of that unit can sometimes be unfair.’
– ‘You cannot expect the people from that unit to be rigorous...’
– ‘You can ask such thing to all units but this one.’

Such attitudes are rather resistant to change; they really operate as *stereotypes,* and each unit is globally convinced to behave in the proper way.

> *‘While we invariably extend a fair measure of tolerance to the errors and quirks of the gauche and eccentric foreigners, it is still the foreigner who appears gauche and eccentric, not us.’* (Johnston, 1993).

Communication between Controllers and Pilots

As communication with pilots is only verbal, no visual feedback is provided - except by monitoring the a/c plot and control parameters on the radar screen (heading, Flight Level (FL), speed). But this is a slow response feedback. Communication follows a one-to-many pattern: the pilots receive all messages sent through the air and are mainly (but not exclusively) receptive to the ones which concern their flight. Consequently, a strong component of any message is its ‘address’. Communication is strongly structured through the standard phraseology (normal and emergency) and through ‘hearback/readback’ cycles. Errors are frequent and may be critical.

Roughly half of all communications by pilots and controllers include at least one error (Wilson, 1996). The main errors are confusions of call signs, confusions between call signs and FL, deviations from standard phraseology (e.g. Koenig, 1997), omissions and mutual misunderstandings. Routine expectations also lead to communication failures: a typical situation is a pilot acting upon the ATC clearance he was expecting (due to habit, wish, hurry up, etc.), while the controller did not (or not immediately) identify the erroneous readback. Standard phraseology is a good protection against this, but it also has some drawbacks which facilitate deviations: it is constraining; it is depersonalised and therefore may be felt as boring or frustrating; it can hardly support special information requests.

2.5.4.4 Decision-making

Decision-making in ATC is both an individual and a collective process. Decisions made by controllers include micro and macro-decisions.

Micro-decisions are tactical decisions. They concern issues like:

- Selection of a conflict resolution strategy;
- Issuing clearances: change of FL, heading, speed;
- Questioning information received from colleagues and pilots: e.g.: 'This pilot called me "Maastricht" instead of "Frankfurt"...Why? What does it mean? Should I ask him to confirm? Is there any problem behind? Or can I save time?';
- Switching to emergency phraseology.

Macro-decisions are strategic decisions. They concern issues like:

- Sector staffing, splitting and bandboxing;
- Monitoring colleagues after shift handover or bandboxing;
- Accepting traffic load, asking for assistance;
- Triggering an emergency plan.

As all human decisions, ATC decisions are made according to technical criteria, and result from problem-solving, but they also include emotions, affects and feelings (Damasio, 1995; Hopkin, 1995). Among such factors are team pressure (not losing pride in front of colleagues or pilots), motivation and job satisfaction. For instance, late decision to split a sector can induce incident-prone situations. Such a decision can be driven by a wish to maintain competence, to get job satisfaction and to maintain a valuable position in the team. Asking for splitting can indeed be interpreted by the others as a weakness, a 'tender foot' action. The fear to 'lose face' can motivate inadequate decisions. This is typically the kind of attitude that TRM will have to tackle and, ideally, to modify...

2.5.4.5 Situational Awareness

In order to make decisions and implement actions, controllers must have a proper understanding of the situation, a good 'situational awareness' (see for example Sarter and Woods, 1991, for a definition). The 'process' to be controlled is a dynamic process, which evolves in part according to control actions taken by ATCOs and in part in an autonomous way.

Controllers have to deal with multiple tasks like maintaining a proper understanding of the global traffic situation, identifying conflicts, finding out resolution strategies, implementing resolution strategies, co-ordinating with adjacent sectors and instructing trainees. All these tasks mutually compete for catching attentional resources, in a context where controllers are randomly interrupted by 'blind' communications from pilots and colleagues from adjacent units.

Controllers rely on two main visual information systems providing two external analogical representations of the traffic, the radar and the (paper) strips:

- Visual information provided by the radar are 2D while monitoring, control, planning, scheduling and decision-making activities concern a 3D world. The vertical dimension on the radar is purely digital. Reconstructing the third is based on mental imagery and integrates knowledge of sectors' geography (airways, flight profiles, departure and arrival patterns, etc.).

- Strips are mainly used to structure the mental representation and to plan (identifying incoming a/c and their planned flight path, pre-identify conflicts and resolution schemes), to take note of actions and a/c evolution (e.g. climbing), to refresh traffic representation (scanning the strip board), to provide a backup when radar information is downgraded.

Working memory is facing strong demands: controllers have to memorise a lot of features during the course of action, and to schedule and monitor activity. Under acute situation pressure, this process becomes error-prone (e.g. Reason, 1990).

Different resolution strategies are used according to traffic requirements and resources available, at the level of the individual, the sector or the team. The two extreme situations are anticipative control (being ahead of the traffic) and reactive control (falling behind the traffic). The ultimate version of reactive control is mere anti-collision, which is felt as a very negative experience by controllers.

Practice is critical in ATC. Practice allows for the development and maintenance of visual, auditory, control, monitoring and communication skills. And these technical skills are quickly impoverished when not practised. Even highly experienced controllers for example feel uneasy when they go back from holiday.

2.5.4.6 Cultural Aspects

No nation can nowadays consider its ATC services independently of the others. ATC is now part of a worldwide service network. Many nations around the world are now facing similar HFs problems in ATC, because of technical advancements regarding traffic control, a/c equipment, traffic growth, and future air/ground integration requirements (Hopkin, 1995).

But, as Johnston (1993) noticed about CRM in airlines, if flight safety and efficiency are now shared objectives across the international aviation community, there are wide differences in definitions, understandings and choices to achieve these objectives in the best possible way; this might be due to the fact that there is no single best way to achieve safety and efficiency as soon as cultural differences are acknowledged. This calls for a necessary customisation process, which will be tackled in the TRM in a forthcoming adaptation phase.

The following figure plots scores on the two Hofstede's dimensions 'Power distance' and 'Individualism' for eighteen European countries (Hofstede, 1980, 1991). Germany and Great Britain, for example, score as small power distance - high individualism countries, while France differs by a larger rating on power distance. There is some evidence that these dimensions do have influence on the captain - first officer relationship in cockpits (see for example Redding and Ogilvie, 1984, Johnston, 1993, and Merritt, 1994).

Small Power Distance High Individualism Great Britain, Norway Netherlands, Switzerland Denmark, Germany Ireland, Finland Sweden, Austria	***Large Power Distance High Individualism*** Italy Belgium France Spain
	Large Power Distance Low Individualism Turkey Greece Portugal Yugoslavia

Figure 3: Power Distance x Individualism
for 18 European Countries (derived from Hofstede, 1983)

Unfortunately, cultural studies are less developed in the ATM domain.

According to our observations and interviews with controllers, cultural factors could lead to different attitudes, behaviours or practices in the following issues:

- attitudes towards errors;
- attitudes towards female controllers;

- selection and training requirements;
- work/vacation time balance, attitude towards pleasure and life enjoyment;
- attitude towards risk;
- attitudes towards leadership and command;
- team structure, team functioning and team spirit;
- attitude towards ATC institution and authorities;
- attitude towards other national and foreign units.

2.5.4.7 Relationship between Workload, Safety and Job Satisfaction

Typical Incident-prone Situations

Typical incident-prone situations involving the team are:

- Insufficient staffing;
- No or late splitting decision, in order to get more fun (traffic load is a source of excitation for controllers) or not to 'lose face' in front of colleagues (peer pressure);
- Shift handover without proper briefing;
- Leaving the position without proper briefing: either the whole task context is not properly transmitted or it is but with some omission (an a/c for example);
- During a bandboxing operation, providing a sector without monitoring its integration by the receiving sector;
- Unsuitable tacit assumptions concerning colleague actions or interpretations, within the team or between control units ('I thought you would know/you would have understood', etc.).

In their daily practice, controllers are very sensitive to incidents. Incidents are perceived as strong signs of professional failure and are quite always experienced as 'traumatisms', mainly because controllers easily imagine the incident could have turned into a disaster. Incidents are a strong source of stress, which sometimes requires psychological support. Stress has therefore to be properly managed, both at the individual and at the team level. This is another benefit expected from TRM.

Relationship between Workload and Incidents

Incidents can occur in any workload situation, but we hypothesise a kind of 'U-shaped' relation between workload and incident frequency.

Under Extreme Workload

Extreme workload situations are particularly incident-prone. Anticipation is no more possible, controllers strive only to act in a reactive way, performing mere anti-collision. Activity becomes strongly disorganised, sometimes up to the breakdown. Overload situations are feared by controllers mainly because they endanger safety, and also because controllers fear loss of face (loss of pride): both self-image and the way the person is viewed by the team are affected where failure to cope with the traffic occurs.

These situations are pretty rare. They are mainly due to:

- no or late splitting,
- undue bandboxing,
- very high traffic conditions (above system capacity), which creates:
- anticipation or control failures.

Under High or Medium Workload

High or medium workload situations require to pay a high degree of attention to the task, but controllers are very efficient in managing such situations in a reliable manner. Here is a comment made by a supervisor of the Approach Unit in Frankfurt: ‘If you have a lot of a/c on the air, you're just too busy to make mistakes!’.

Under Low Workload

Quoted from a controller: ‘Only 2 a/c at the same FL can be tricky and is thus incident-prone!’ Low workload situations are indeed tricky because it is prone to insufficient concentration on the task, controllers being attracted into side-activities, like discussing with colleagues, reading newspapers. Monitoring is then reduced (the chair is moved away from the position). Or hypovigilance may be induced.

Dynamic Aspect

Controllers are trained to work within a ‘comfort window’, which corresponds to a reasonable amount of traffic (i.e. not too high and not too low). They tend to stay within this window using workload management strategies. They may face difficulties when these workload management strategies are overburdened.

Human operators - including controllers - are bad at coping with rapid changes in their workload. The risk of incident increases drastically when a low workload phase follows a high workload one, because of attention release and distraction associated to recovering from high concentration and fatigue. The risk of incident also increases when a workload peak follows an underload phase because of the difficulty to mobilise resources. This can be observed at the scale of a working day, and also at the scale of weeks and seasons: incidents tend, for example, to increase in summertime.

Relation between Workload, Safety and Job Satisfaction

Controllers are not supposed to be paid for getting fun! But what makes this job satisfactory? Doing things efficiently - in other words accepting a high workload - is part of the answer. So, even if cultural differences can be felt, controllers globally appreciate high traffic situations, mainly because they allow to maintain competence and skills, they provide fun in the course of action and satisfaction afterwards (there is a kind of challenge or surfer spirit: controllers appreciate and enjoy nice control actions in dense traffic).

Suppressing the pleasure dimension from the job through a strict workload control could well lead to boredom, and paradoxically have negative effects on safety. On the other hand, 'playing with traffic' is also 'playing with risk'. So every time risk is controlled successfully, it is great. But when it fails, it is an incident!

Risk is actually high when attention scanning and monitoring level are not meeting the demand of the situation. The demand is closely related to workload. Attention scanning and monitoring level are in turn controlled by the perception of risk, which is related to the traffic demand, and to psychological factors (peer pressure, fear to lose face, memory of prior near miss experiences, fear to kill people, stress, etc.) and to situational factors (instruction on sector, formal examination, etc.). Finding the proper level of risk-taking and job satisfaction is a matter of balance. And TRM may contribute to help the controllers to find the proper balance, in favour to safety.

2.5.4.8 On-the-Job Training

Instruction on sector is a normal situation in ATC. But on the job training is incident-prone, as statistics demonstrate. Coaching a trainee sets extra demand on the instructor.

It requires creating and maintaining a second mental model regarding the trainee's situational awareness and actions to assess the quality of the trainee's strategy and to take over in case of necessity.

How does a qualified instructor know when to take over? It is a subtle decision, depending on the balance between overconfidence and lack of confidence. Setting the proper confidence level is a whole process in itself. Assessing actual trainee performance allows to set a proper confidence level. Confidence does not evolve in a linear way. Failures are needed to calibrate confidence properly. Too few or (too many) opportunities induce overconfidence or lack of confidence.

2.5.4.9 Procedures and Practices in Air Traffic Control

As most of front line operators, controllers are facing a paradox: they are requested to stick to procedures, while, at the same time, requested to be 'intelligent', adaptive and flexible. Indeed, a big deal of procedure interpretation is needed. As quoted from one controller: 'Procedures cannot describe all situations faced; they provide only generic task and role allocation principles! By the way, if you stick to procedures, you are not always able to deal with all the traffic...'.

Procedures and regulations are seldom fully and correctly known by controllers. It is not rare to meet two controllers with different opinions about what is prescribed and what is not! ATCOs seem to behave more on the basis of an 'oral tradition', sticking more on rules of thumb than to written instructions and regulation. However, this is once again a matter where cultural differences are important.

ATCOs are far less referring to written procedures, methods and regulations than cockpit crew. One reason is that their activity is mainly a mental one. It is impossible to specify cognitive processes the way action sequences are specified. Another reason is that, in the ATC world, it is generally not possible to set down specifications - because of its high level of flexibility and autonomy.

Procedures will never substitute to background knowledge and skills. Particularly, control activity is mainly based on technical and social skills acquired through intense practice. But procedures do provide a common reference. Deviating from procedures does not imply an immediate accident. However, team synergy is impaired when some controllers stick to procedures while some others do not, because of possible discrepancies in expectations and actions. High risk situations may then occur.

2.5.5 Contents and Structure of the Course

2.5.5.1 Contents

The PTRMC contents will cover all the topics recommended by the 'Guidelines for Developing and Implementing Team Resource Management'. The development process will build on the ATM job specificities as described in Section 2.5.4 above, and address the following issues:

- introduction,
- situational awareness,
- decision-making,
- communication,
- teamwork,
- leadership,
- stress,
- conclusion.

2.5.5.2 Courseware Structure

The TRM training program will be implemented in the form of a three-day seminar. Each of the topics listed above will be addressed in a specific training module.

The training method will build on the trainees professional experience, to diagnose safety-related problems in professional situations relevant to each module.

These situations will be presented using a variety of tools such as realistic videos showing controllers at work (to be specifically shot for this purpose at a national level), case studies, role-playing, interactive presentations based on transparencies (data projection). Professional experience will be elicited through debriefing sessions.

Further on, the HFs knowledge required to provide an interpretation of the problem will be brought about. Theoretical aspects will be introduced when necessary, but not systematically emphasised.

Existing solutions to problems will be acknowledged and revisited, and innovative solutions will be derived whenever possible. Practical implications for behaviour and attitudes will be discussed.

Reinforcement of positive behaviour and attitudes will be sought where necessary using additional videos or other training materials (practical exercises). The following diagram shows the typical structure of each module:

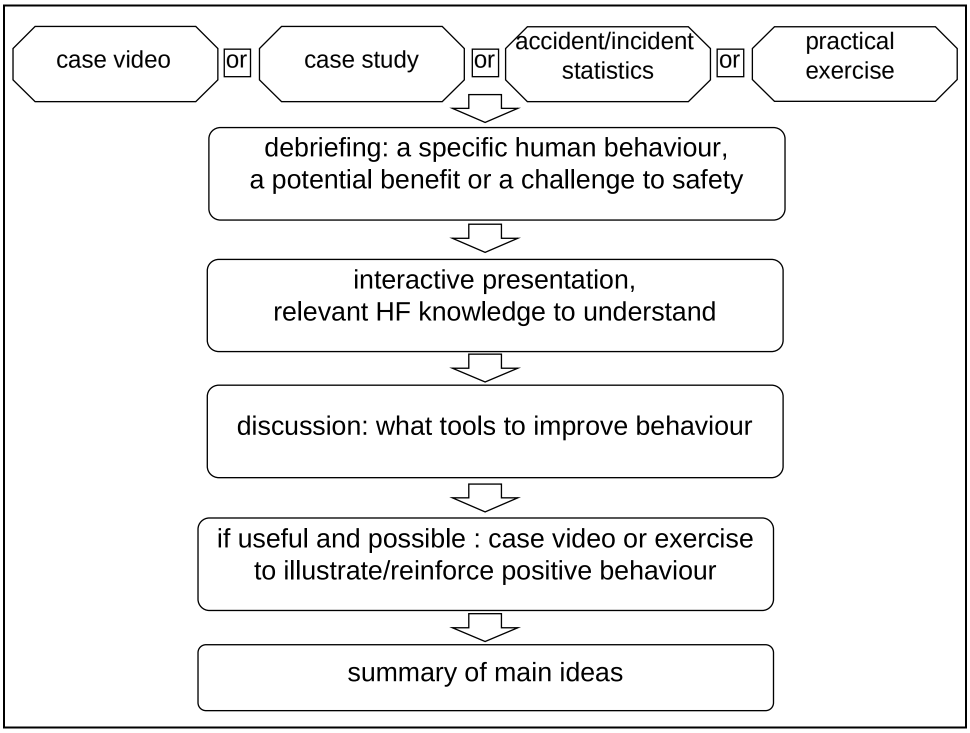

Figure 4: TRM Modules Structure

2.5.6 Conclusion

Controllers are a key component of aviation safety. They can contribute to improve or maintain it against major modern challenges. They work within a system which controls their training, working tools and procedures, their work schedule, and a lot more. But they still have several degrees of freedom to monitor and control their performance and reliability.

They work as a team and work in shifts. They are used to a strong team identity, with its proper culture and habits.

They are used to an environment where roles and status are defined accurately through internal tacit rules of functioning and 'peer pressure'. They are communication professionals, and have a lot more team membership professional skills. TRM will build on that, and will further clarify the conditions and tools needed for a highly effective and reliable teamwork.

2.5.7 Acknowledgements

The authors express their acknowledgements to the members of the TRM Task Force at EUROCONTROL for their participation to the TRM development.

Many thanks also to Patrick 'Max' Bareau from the CENA for his professional support during the visits of Air Control Centres in France, Germany and the United Kingdom between January and March 1997.

And last but not least, the authors would like to thank the controllers met during these visits for their technical contribution and kindness.

2.5.8 References

Damasio, A. R. (1995). *L'Erreur de Descartes : la raison des émotions*. Paris: Odile Jacob Sciences (Eds.).

EATCHIP (1996). *Guidelines for Developing and Implementing Team Resource Management* (HUM.ET1.ST10.1000-GUI-01). Brussels: EUROCONTROL.

Gras A., Moricot C., Poirot-Delpech S. L. and Scardigli V. (1994*). Faced with automation. The pilot, the controller and the engineer*. Paris : Publications de la Sorbonne.

Helmreich, R. L., Wiener, E. L. and Kanki, B. G. (1995*).* The Future of Crew Resource Management in the Cockpit and Elsewhere. *ICAO Asia and Pacific Region First National Human Factors Training Seminar*, Hong Kong, September 1995.

Herschler, D. A. (1991). Resource Management Training for Air Traffic Controllers. In J. A. Wise, V. D. Hopkin and M. L. Smith (Eds.). *Automation* *and System Issues in Air Traffic Control*, NATO ASI Series vol. F73, 497-503. Berlin: Springer-Verslag.

Hofstede, G. (1980). *Culture's consequences. International differences in work-related values*. Beverly Hills: Sage Publications.

Hofstede, G. (1991). *Cultures and Organisations: Software of the Mind.* Maidenhead, UK: McGraw-Hill.

Hopkin, V. D. (1995). *Human Factors in Air Traffic Control.* London: Taylor and Francis Inc.

Johnston, N. (1993). CRM: Cross-Cultural Perspectives, In E. L. Wiener, B. G. Kanki, R. L. Helmreich (Eds.) *Cockpit Resource Management*. London: Academic Press.

Koenig, R. L. (1997). Excess Words, Partial Readbacks Score High in Analysis of Pilot-ATC Communication Errors, Flight Safety Foundation. *Airport Operations. Vol 23, n°1*, Jan-Feb. 1997.

Masson, M. (1996). Réflexions sur les systèmes adaptatifs d'assistance aux opérateurs. *Le travail humain*, *tome 59*, *n° 3/1996*, 227-298.

Merrit, A. (1994). Cross-Cultural Issues in CRM Training. *ICAO Flight Safety and Human Factors Seminar,* Amsterdam, May 1994.

Pariès, J. (1996). Human Factors training initiative that first emerged in the 1970s has reached maturity. *ICAO Journal,* Oct. 1996.

Pariès, J. and Amalberti, R. (1995). *Recent trends in aviation safety: from individual to organisational resources management training* (Risoe I - series). Roskilde, Denmark: Risoe National Laboratory.

Reason, J. T. (1990). *Human Error*. Cambridge: Cambridge University Press.

Redding, S. G. and Ogilvie, J. G. (1984). Cultural Effects on Cockpit Communications in Civilian Aircraft. *Flight Safety Foundation Conference.* Zurich Washington: Flight Safety Foundation.

Sarter, N. B. and Woods, D. D. (1991). Situational Awareness: a critical but ill-defined phenomenon. *International Journal of Aviation Psychology, 1*, 45-57.

Wilson G. (1996). Readback. A key factor in ATC Communications between pilots and controllers. *Airliner.* Oct.-Dec. 1996.

2.6 Team Resource Management in CNS/ATM Systems

By Captain Daniel E. Maurino - Co-ordinator, Flight Safety and Human Factors Programme - International Civil Aviation Organization (ICAO) - Montreal, Canada

2.6.1 Introduction

This paper comprises two parts. The first part argues that a close relationship exists between safety and training, and asserts that the prevailing safety paradigm shapes training development and contents. TRM is no exception to this. The paper briefly reviews the relationship between safety and training and links three possible safety paradigms with the most likely approaches to TRM training associated to each of them. The second part discusses the evaluation of the effectiveness of TRM, challenging the value of such evaluation if based on data from accidents and incidents - the traditional source of feedback in aviation. The paper critically reviews this practice, and suggests an alternative way to move forward in the evaluation TRM's contribution to aviation safety and efficiency as an error management tool.

2.6.2 On the Relationship between Safety and TRM Training

Safety is partly an objective process based on techniques and supported by data, but it essentially develops from attitudes. Safety deals with the identification of hazards and the perception of the risks such hazards might generate. It deals with the allocation of resources to avoid damage to property and therefore with the value of human life. Neither hazards nor risks are objective or inherent to artefacts or activities but rather subjective constructs developed based on experience and beliefs. Such constructs are different in different parts of the world because of culture-induced beliefs. This inevitably leads to the fact that the value of human life and allocation of resources to cancel hazards and deny risks will vary across the global village. Safety is not the fully objective process asserted by tradition, but a subjective process of risk evaluation and acceptance.

Training, on the other hand, is one means to cope with deficiencies which were unforeseen or ignored when the system was designed. At its bottom line, training is a moderator of systemic failures. As such, consciously or unconsciously, training is linked to the prevailing safety paradigm. Effective training must therefore build upon a relevant safety paradigm as well as upon an understanding of systemic deficiencies (what the *real* problems are).

Predominant beliefs about safety across aviation can generically be grouped in three distinct paradigms, and it is possible to link each of these paradigms with an associated approach to TRM training.

2.6.2.1 The Individual Paradigm

The first link is based upon the most widely held safety paradigm and comprises the following premises:

- *Safety is a universal value.* Safety is considered a culture-free value with universal definition. Safety problems, their causes and solutions are the same across the world.

- *Accidents are caused by individuals*. Accidents are caused by individuals who deviate from professional practices, exhibit lack of discipline or disregard training they have received.

- *Human error as a cause*. Accident investigations backtrack events until the point in which operators' actions or inactions produced an outcome other than the one desired; human error is then pronounced and the process of investigation closed. Accident investigation is oriented towards finding guilt and apportioning blame.

- *Reaction*. Safety is a reactive activity entirely focused on the outcome regardless of the quality of the process: if, at the end of the shift, the number of landing clearances a controller has issued equals to the number of takeoff clearances, safety has been accomplished (even if ten near misses and twenty losses of separation occurred in the process).

TRM training associated to this paradigm would probably look as follows:

- *Universal solution*. TRM is a solution of universal application, with minor changes. It is ‘cosmetically’ tailored after CRM training programmes and it does not need to be based on data collected from the organization where it will be implemented.

- *Focus on individual performance*. TRM is largely ‘leader's training’: its objective is to make supervisors more responsive to fellow workers inputs.

- *Prevention strategy aimed at the outcome*. The objective of TRM is to avoid accidents by inhibiting ‘bad’ human performance.

- *Training intervention narrowly focused.* TRM attempts to fix supervisors with the ‘wrong stuff’, essentially those who are not team players.

- *Prevalence of consultants*. TRM is considered to deal with ‘soft’ instead of ‘real’, technical issues, and is therefore designed and delivered by consultants (who, most of the times, have no clue of how the aviation system can fail). These programmes are most likely a ‘translation’ of existing CRM programmes.

2.6.2.2 The Social Paradigm

The second link is based upon a paradigm which started to gain terrain in the late Eighties, and which can be summarized as follows:

- *Safety is a social value.* Safety problems across the industry may exhibit similar symptoms, but they encode different causes and therefore require culturally-calibrated solutions. Exporting solutions which worked in one context to another will likely address visible symptoms while leaving causes largely untouched.
- *Accidents are caused by work groups*. These work groups may be an ATC team, a flight crew, a maintenance shift, or an entire airline, maintenance, manufacturing or regulatory organization.
- *Human error: cause or symptom?* Human error is considered a symptom rather than a cause, an indication of deeper deficiencies somewhere in the system, just as fever is the symptom of illness rather than its cause.
- *Reaction and pro-action*. Accident investigation remains the focus of prevention activities, but there is increasing interest in the investigation of incidents. Confidential reporting systems proliferate.

TRM training associated to this paradigm would probably look as follows:

- *Context specific solution.* TRM is designed based upon data collected about the organization and therefore reflects local values. Corporate culture issues are integrated into TRM training design.
- *Focus on individual performance but interest in the work group.* TRM focuses on human performance issues such as stress management, improved situational awareness, decision-making in naturalistic environments and so forth.
- *Prevention strategy aimed at the process.* TRM aims at improving the quality of the process. Unit-specific case studies include those where controllers averted potentially worst outcomes, or where bad outcomes occurred in spite of good processes.
- *Training intervention broadly focused.* TRM starts with ‘console’ solutions, but it expands to include upper hierarchies within the ATC organization.
- *Consultants supported by operational personnel*. As TRM addresses operational issues, controllers become actively involved in its delivery. Consultants' participation is limited to training design, with controllers supporting them.

2.6.2.3 The Organizational Paradigm

The third link bridges a dawning safety paradigm with what TRM might look in the future, and can be summarized as follows:

- *Safety is a corporate value.* Safety practices consider the organization's particular ‘way of doing business’ as well as corporate's possibilities and constraints. What works well for one organization does not necessarily work equally well for others.

- *Accidents are caused by system flaws.* The failures observed at the ‘front end’ of aviation operations are considered symptoms of deficiencies in the architecture of the aviation system.

- *Human error as a symptom*. Error is accepted as normal component of human performance, unavoidable but manageable. Procedures and design aim at making the consequences of error visible and without catastrophic consequences beyond recovery, rather than at error-free performance. Human error is a clue which indicates where the safety investigation process must begin rather than end.

- *Pro-action.* Attention is focused on the processes incurred by the aviation system, regardless of the outcome of these processes. Prevention endeavours concentrate in process monitoring, through operations quality control and assurance.

TRM training associated to this paradigm would likely look as follows:

- *Dedicated solution*. Consideration of cultural issues include the professional controller culture and the subcultures of the different controller groups.

- *Focus in the organizational context*. TRM training becomes an organizational development, an organizational mandate on how to conduct operations rather than a fix for the ‘wrong stuff’.

- *Broad prevention strategy*. TRM is considered a strategy for error management in the ATC environment rather than business management training adapted to aviation.

- *Broad training intervention.* TRM provides controllers with further knowledge to contain the adverse consequences of system deficiencies unforeseen or ignored at the time of system design, and which periodically penetrate system defences.

- *Operational personnel supported by consultants*. Controllers are actively involved in training design rather than simply in its implementation. Controllers are also actively involved in research in a support role.

2.6.3 The Evaluation of TRM Training Effectiveness

2.6.3.1 'Accident-induced' Design?

Most attempts to measure the effectiveness of training strategies use to some extent accident data as important source of feedback. However, accidents provide limited opportunity for feedforward. Accidents belong in the past, and while accident scenarios may present similar circumstances, they are never the same. In socio-technical systems - and contrary to conventional belief - accidents never repeat themselves. The general scenario might look the same, but contextual differences make each accident scenario unique. The statistical probability of exact duplication of sets of circumstances is indeed very small. Furthermore, since humans design, manufacture, operate, maintain and manage the aviation system, human error will always be a high priority suspect (and probably a foregone conclusion) in most accident reports. The lessons we may learn from accidents are limited. We might be able to define generic accident-inducing scenarios (i.e. CFIT). We might identify external manifestations of error, its types or frequencies, or whether a particular training deficiency is more conspicuous than others. This, however, provides only a tip of the iceberg perspective. Such analysis concentrate on failures, and what we need to better understand are the success stories, to see if we somehow can 'bottle' their mechanisms and export them widely.

Furthermore, when retrospectively analyzing human performance in accidents, analysts know that the behaviours displayed by participants in such events were 'bad' because the bad outcomes are a matter of record. This is a benefit the participants obviously did not have when they selected what they thought were 'good' or 'reasonable' behaviours. It is also appropriate to remember that human decision-making in operational contexts is a compromise which demands a balance between production and safety; between production-oriented behaviours and decisions, and safety-oriented behaviours and decisions. This is indeed a complicated as well as delicate balance, and humans are generally very effective in applying the right mechanisms to successfully achieve it, although they occasionally fail.

To sum up, accidents yield data about the mechanisms which failed to achieve the desired balance about failed compromises. What we need to capture - through systematic analysis - are the mechanisms underlying successful compromises so that we can turn those coping strategies into training interventions. This can only be obtained by monitoring normal operations.

2.6.3.2 Incident Reporting: *avante ma non troppo*

A step forward in this direction is the proliferation of incident reporting systems. However, it is not enough. It is accepted wisdom that incidents are precursors of accidents, and that *N*-number of incidents of one 'kind' take place before an accident of the same 'kind' eventually occurs.

Most safety practitioners would agree that incidents are more reliable indicators of system safety than accidents, if for no other reason because they signal weaknesses within the system *before* the system breaks down. However, there appears to be no evidence of any formal endeavour to establish a statistical relationship between accidents and incidents which would withstand the so-called burden of proof. On the other hand, there are limitations to the value of the data from incident reporting systems. First, because accidents are unique set of circumstances which seldom duplicate, so it is questionable whether a solid case could be built about how rigorous this accepted relationship between similar 'kinds' of incidents and accidents really is. Second, because incidents are reported in the language of the trade (i.e. aviation), and therefore capture only the external manifestations of errors. In order to understand the mechanisms underlying errors in operational environments, flaws in human performance captured by incident reporting systems should be considered as symptoms of mismatches at deeper layer of the system. This mismatches might be deficiencies in training systems, flawed person-technology interfaces, poorly designed procedures, corporate pressures, poor safety cultures and so on.

Incident data is not enough to understand how the aviation system fails and the human contribution to these failures. It is better than accident data, but the real challenge is to take the next step: it is essential to move beyond the visible manifestations of error when attempting to evaluate training interventions. If such interventions are to be successful in modifying behaviours, errors must be considered as the point of departure, as the symptom which suggests in which direction to look further. In making a medical analogy, error would be just as fever: an indication of illness and not its cause. It is the beginning rather than the end of the diagnostic process. In extending the analogy, it is suggested that accident investigation is the *post-mortem* of the system, and there is not much that can be done about it; incident investigation is like going to the doctor to check symptoms (possibly serious, possibly not), while normal monitoring is like the annual physical - checking the system pro-actively before it 'gets sick'. The value of the data generated by incident reporting systems is that it identifies areas of concern, but it is suggested that such data does not capture the concerns themselves.

2.6.3.3 'Normal' Design

While the analysis of A/I databases will provide *some* answers to questions about human error in operational environments, it is unlikely that it will answer the fundamental question to understand the role of human error in aviation safety: to what extent successful coping strategies employed by controllers, to what extent successful TRM strategies contributed to avert incidents and accidents? In order to indeed dig out the role of human error in aviation safety, in order to prioritize the issues to be addressed by TRM training, in order to eventually reshape TRM training, this is the fundamental question for which a *systematic* answer is imperative.

Training strategies should build upon positive rather than negative outcomes. Normal process monitoring (such as normal operations and simulation observations by expert observers utilizing objective observation tools) will provide meaningful information about positive outcomes, the mechanisms of which could then be identified and shaped into training interventions such as TRM, and later applied to evaluate their effectiveness. Any typical duty shift - a normal process - involves dozens if not hundreds of errors (calling wrong frequencies or altitudes, acknowledging incorrect readbacks, mishandling switches, and so forth), which have no damaging consequences because: (a) controllers employ successful coping strategies, and (b) system defences act as contention net. It is about these strategies and defences that we must learn to then shape training strategies, and not about those which were unsuccessful.

A second and highly desirable level should include monitoring of the normal processes that aviation organizations incur while pursuing their production goals; processes such as communicating, budgeting, financing, training, monitoring, allocating resources and so on. These are all processes over which organizations in aviation (both airlines and regulatory) have a direct measure of control. Downsides in these processes are inevitable and they become 'latent conditions' which eventually foster errors at the tip of the arrow which in turn penetrate the system defences and generate incidents and accidents. The fundamental point is that the latent conditions which are going to foster human error are *already* present in the system, hence the importance of normal process monitoring to anticipate human error.

2.6.3.4 Postscript

When approaching prevention through training strategies, it is essential to remember that error is a normal component of human behaviour. Regardless of the quantity and quality of training humans may receive, error will continue to be a factor in operational environments because it is the downside of human cognition. Error countermeasures - including training - should not attempt to avoid error, but to make it visible, and trap it before it can produce damaging consequences. Human error is *unavoidable* but *manageable*. As an afterthought, it is important to stress the difference between errors (product of human limitations) and violations (which have a motivational component). While we must accept error as the inevitable downside of human intelligence and flexibility, and we must learn to live with it, violations are not to be condoned.

2.6.4 Conclusion

A disquieting tendency has been developing over the last year or so. The foundations for TRM's 'father', CRM, were laid in the late Seventies, and further, broader-oriented HFs endeavours multiplied across the international aviation community during the Eighties. All these interventions have been justified in the so-called '70% factor', and they have all been attempts to reduce the incidence of human error in aviation operations.

However, statistics seem oblivious of these efforts, and 1996 has in particular been a very unmerciful year in terms of the human contribution to safety breakdowns. The fact that the industry has apparently not been able to reduce the incidence of human error in spite of its efforts (and considerable allocation of resources), combined with the poor 1996 safety statistics have led some quarters to speculate about the safety value of HFs in general and CRM in particular.

It is a very human tendency to look for scapegoats when things do not go the way we would like them to go. HFs and CRM/TRM are simply tools which contribute to improve - *not to generate by themselves* - system safety and efficiency by better interfacing humans with humans, humans with the technology they use to achieve the system's productions goals, and humans with the organizations to which they report. HFs and CRM/TRM are only part of the prevention process. It is this process and its sustaining paradigm which are in serious need of reconsideration and reshaping, and not simply one of the 'modules'. Because we seldom look at the normal processes, there is no way we can statistically score, beyond anecdotal evidence, the number of 'saves' CRM/TRM and the application of HFs knowledge in aviation have contributed over the years. If we would, the figures would rise more than one eyebrow in surprise. It would indeed be regrettable if HFs and CRM/TRM - for all perceived shortcomings, real or otherwise - become the scapegoats of the aviation system's collective failure to tackle the real safety issues as they come.

2.6.5 References

Cacciabue, P. C. (1996). Organizational factors in prevention and investigation of air safety. In International Civil Aviation Organization (Ed.). *Proceedings of the Third Global Flight Safety and Human Factors Symposium.* Auckland, New Zealand, 9-12 April 1996 (pp. 67-73). Montreal, Canada: Author.

Harle, P. G. (1994). Organizational and management factors: A case study. In International Civil Aviation Organization (Ed.) *Report of the Seventh ICAO Flight Safety and Human Factors Regional Seminar.* Addis Ababa, Ethiopia, 18-21 October 1994 (pp. 75-86). Montreal, Canada: Author.

Helmreich, R. L. (1996). Cultural issues in Crew resource Management training. In International Civil Aviation Organization (Ed.). *Proceedings of the Third Global Flight Safety and Human Factors Symposium.* Auckland, New Zealand, 9-12 April 1996 (pp. 141-148).Montreal, Canada: Author.

International Civil Aviation Organization (1993). Human Factors Digest No. 10*: Human Factors, Management and Organization.* Circular 247-AN/148*.* Montreal, Canada: Author.

Johnston, A. N. (1996). Blame, Punishment and Risk Management. In C. Hood, D. Jones, N. Pidgeon and B. Turner (Eds.) *Accident and Design* (pp. 72-83). London, UK: University College Press.

Klein, G. A, Orasanu, J., Calderwood, R. and Zsambok, C. E. (1993). *Decision making in action: Models and methods*. Norwood, New Jersey: Ablex Publishing Corporation.

Maurino, D. E, Reason, J., Johnston, A. N. and Lee, R. (1995). *Beyond Aviation Human Factors*. Hants, England: Averbury Technical.

Maurino, D. E. (1997). Building a bridge to safety. *Airline Pilot, Vol. 66, Number 2*. February 1997 (pp. 18-21). Washington DC, USA.

Maurino, D. E. (1997). Safety philosophy. *ICAO Journal, Vol. 52*, *Number 2*. March 1997 (pp 21-22). Montreal, Canada.

Merritt, A. C. (1994). Cultural issues in CRM training. In International Civil Aviation Organization (Ed.). *Report of the Sixth ICAO Flight Safety and Human Factors Seminar.* Amsterdam, The Netherlands. 16-19 May 1994 (pp 326-243). Montreal, Canada: Author.

Pariès, J. and Amalberti, R. (1995). Recent trends in aviation safety: From individuals to organizational resources management raining. In Risoe National Laboratory - Systems Analysis Department (Eds.). *Technical Report (Risoe I series*). Roskilde, Denmark: Author.

Reason, J. (in press). *Organizational accidents*. Hants, England: Averbury Technical.

Woods, D. D., Johannesen, L. J., Cook, R. I and Sarter, N. B. (1994). *Behind human error: Cognitive systems, computers and hindsight*. Wright-Patterson Air Force Base, Ohio: Crew Systems Ergonomics Information Analysis Center (CSERIAC).

Intentionally left blank

3. SUMMARY OF THE WORKING GROUPS

Six WGs were held in parallel. The WGs have been run according to a structured method.

The texts below present the conclusions of the WGs which took place during the second workshop day and which were presented by the rapporteur of each group at the conclusion session on the third day.

3.1 Teamwork, the Concept

Facilitators: Anne-Laure Amat and Michiel Woldring
Rapporteur: Nigel Sylvester-Thorne
Authors of the Conclusions: Anne-Laure Amat and Michiel Woldring

3.1.1 Introduction

The text below reflects the issues discussed by the WG dealing with the concept of teamwork in ATS. Many aspects were mentioned but, due to time constraints, checks on completeness and prioritisation have not been set up.

For definitions and the EUROCONTROL concept of teamwork, we recommend the EUROCONTROL publication (HUM.ET1.ST10.1000-GUI-01): *Guidelines for Developing and Implementing Team Resource Management.*

3.1.2 Main Results

3.1.2.1 Overview of the Concept

The WG defined safety and efficiency as main objectives for teamwork in ATS. Group development, individual development and attitudes were clustered as main elements of the concept.

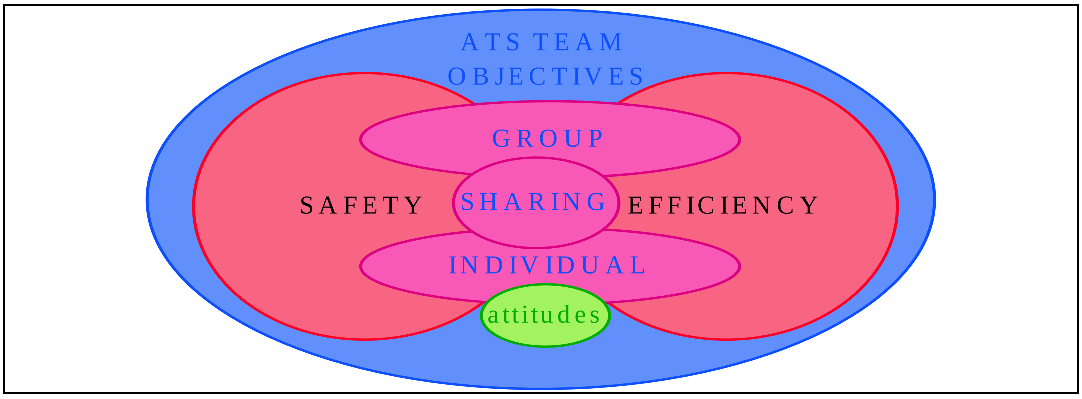

Figure 5: Teamwork, the Concept

3.1.2.2 ATS Team Objectives

The role of the ATS team is to provide safe and efficient services to the aviation community. Reliable hardware and software, regulations, procedures and training are the solutions most frequently brought forward. Yet organisation of the work and collaboration with the wide circle of aviation team members is also of primary importance. Teamwork is indeed a major contributing factor to safety and efficiency.

Safety

In the current aviation system, flight safety is mainly jeopardised by human error. Teamwork, because it implies good communication, co-operation, structural checks in the team and sharing of information contributes to error avoidance, error recovery and error management. Indeed, teamwork reduces the errors stemming from communication problems within the team. It increases the chance of identifying an error made by a member of the team and makes it possible to reduce its impact.

Efficiency

When working as a team, the performance of a group of people is superior to the sum of the individual performance. Two controllers working as a team are more efficient than two controllers working in their own sector and focusing on their own part of the task, with no consideration of the need and task of the other. Teamwork goes beyond the arithmetic rules and states that 1+1>2.

When working as a team, people can support each other, anticipate the needs of their colleagues, contribute to the regulation of the group workload, collaborate in the management of the situation, make decisions considering different viewpoints (holistic approach) and implement these decisions more efficiently because they are not imposed on the group but established by it.

The fact that one can also learn from the way one's colleagues work, also stimulates creativity; new and more efficient solutions can thus stem from teamwork.

3.1.2.3 Teamwork and the Individual

A team is composed of individuals having a common overall objective. In order to form a proper team and do good teamwork, each individual must also consider him/herself as a team member and adopt teamwork attitudes. This requires some openness towards the others and might 'cost'; yet it is worth trying to be part of the team as teamwork also contributes to individual development.

Teamwork Attitudes

The will to co-operate with the other links of the chain is fundamental for good teamwork in ATS. The first step is therefore to join the team on a voluntary basis.

In an operational environment, one might face situations where individual and team priorities are in conflict. The team member must then be able to establish a relevant balance between individual and team interests.

The notion of feedback is also crucial for the cohesion of the team (and contributes to individual development). Capacity to receive and provide both positive and negative feedback is required from a good team member.

As each individual has his own characteristics, it is not always possible to ask and expect the same performance from each team member. A good team worker has the ability to accept human limitations, emphasising his strengths and minimizing his weaknesses. Moreover, it is important to remember that the good team member always looks for the best solution based on a positive-thinking attitude.

Individual Development through Teamwork

Teamwork increases job satisfaction, motivation, self-confidence, knowledge of other tasks, mutual understanding and respect. It also provides a common reference for self-evaluation and consequently a better professional knowledge and individual efficiency.

3.1.2.4 Teamwork and the Group

The WG found that teamwork stimulates group development by means of the establishment of common values and norms, and a common understanding of the approach to objectives. An appropriate leadership contributes to the ability of the team to solve its conflicts. Feedback and training also contribute to group development.

3.1.2.5 The Keyword: Sharing

Teamwork, and thus individual and group developments are achieved by sharing common objectives, task responsibilities, stress and fun.

All this improves the situational awareness of both the group and the individuals.

3.1.3 Conclusions

The WG concluded that shared objectives, group and individual elements form a team like different ingredients form a recipe.

3.2 Teamwork in the Operational Environment

Facilitators: Cees Niesing and Michel Pistre
Rapporteur: Jörgen Jörgensen
Author of the Conclusions: Cees Niesing

3.2.1 Introduction

The main question to be answered in this WG was:

‘What do we have to do to improve teamwork in the operational environment?’

The group felt that the main clusters of ideas properly addressing the question should aim at:

- defining the team roles,
- improving mutual understanding,
- getting a change of attitude,
- establishing some team rules,
- improving communication.

3.2.2 Main Results

3.2.2.1 Defining the Team Roles

The group considered the wide variety of teams or team compositions possible within the operational environment, e.g. controllers, pilots, engineering and systems staff, and management.

It was stressed that one ATS unit, itself composed of various teams, could be considered as one large team from micro (the single team) to macro (the totality of teams) as it were. It is, however, of utmost importance that all team members are completely aware of their roles within their team and the interactions they have with other teams.

Defining a team is based on the goal to be achieved in a particular situation. This can vary from minute to minute, from hour to hour, but it is important that one is always a member of a TEAM.

The group considered that the roles within a team should be identified and defined, as are the interactions with other teams. Furthermore, every person should be aware of each team member role, as well as have a good knowledge of the procedures directing or steering this role.

3.2.2.2 Improving Mutual Understanding

The group considered that, once the team roles were properly established, the improvement of mutual understanding and maintaining them would be of paramount importance. This could be achieved by:

- Using simulators to train controllers in more than one area, e.g. APP/ACC, or at least give them an idea, with some practical exercises, of what another team is doing, thus improving the interaction between both.

- Using realistic scenarios, including teamwork models.

- Exchanging roles between partners.

- Exchanging knowledge about other groups, in that way building up the greater team.

- Visiting other units regularly.

  Visits to other units should preferably be of a duration of not less than one complete working day and include the possibility of social activities.

- Having regular familiarization flights.

- ‘Twinning’ pilots and controllers.

  Towns and villages in the various European countries are twinning with each other, exchanging information on organisational and cultural issues and organizing mutual visits from time to time. An idea for controllers and pilots? If so, it should be made attractive for pilots to visit their ‘twins’ in the ATS environment, as well as for ATM staff to visit pilots in their environment.

3.2.2.3 Getting a Change of Attitude

The group identified a need to develop and establish a feedback-culture by:

- Reducing the fear-factor.

  A climate should be created where it is not seen as a defeat to admit an error and where it becomes normal to discuss the day-to-day errors made by everybody in the daily working environment. This would identify weaknesses in the work practice and/or procedures, and serve as a continuous feedback to improve both, even in the early stages.

- Developing error-analysis.

  In line with the above remark, an error-analysis method should be developed to which the whole team can contribute.

- Having all team members participate in the investigation process.

The group strongly felt that, if errors lead to incidents, all team members should be involved in the investigation process. Although in a well-functioning team an error or sequence of errors leading to an incident is felt as a team responsibility, the question of personal accountability must also be addressed.

- Identification of situations where teamwork succeeded or failed.

  This identification could be used for motivation and course material.

- Training individuals to accept and give criticism.

  An open communication between the team members themselves and to others beyond the team should improve their awareness of the daily workload while maintaining a safe and efficient performance.

In doing so, the 'John Wayne Attitude' could be changed. The change of attitude is one of the most important elements in accepting this new way of co-operating; working in teams with a common responsibility, even though the team composition may vary.

3.2.2.4 Establishing some Team Rules

There must be a balance between team, individual, machine and procedure.

Therefore models should be developed to create team rules which keep the balance as mentioned before by:

- Making use of the ATCO-mental model.

  Use the mental process whereby controllers recognize, analyse and evaluate information about themselves, the traffic, the procedures and the operational environment to arrive at the intended models.

- Practising teamwork, where the flexibility of equipment and procedures makes it possible.

  In this context, a good knowledge of the procedures must be reiterated. In daily practice controllers will create deviations from the procedures to improve the result of their work. These deviations should be communicated, firstly to establish whether they are not too far away from the procedures, and secondly to indicate that the procedures should perhaps be adapted.

- Considering the partnership between the controller and the system.

  The question was brought up as to how far the machine or the system could be considered as a partner in the team. Overall it was felt that a machine is a machine, and cannot be seen as an equal partner next to a human being. Nevertheless, it was felt that, in view of emerging new technologies where machines can semi-intelligently interact with people, this subject should be re-addressed in the near future.

- Using the system to assist co-ordination only.

  It was stressed that, however far functions are automated, e.g. the automated co-ordination/handover to other sectors, the human must always have the possibility to override the system and, as in this example, to perform verbal co-ordination.

- Allowing different styles of communication.

  Different styles of communication can lead to the same results. It is therefore not necessary to develop a 'standard' style. Allowing different styles implies acceptance of different personal and cultural backgrounds. Awareness of what in the end the result should be is the important thing.

- Thinking OPSroom with teamwork in mind.

  The opinion of the group was that building or re-building OPSrooms should be done in a manner such that teamwork is made possible as a primary function.

Once the models are developed, explain these models by:

- Making controllers understand the system and relations between them.

  Awareness of where you stand yourself gives you a better understanding towards other teams/environments.

- Informing others about different tasks.

- Knowing the dynamic of the whole system.

- Analysing the relationship between the team quality and its performance.

  It should be established what 'quality' is in this respect, and clear indicators should be mutually agreed for proper monitoring.

- Emphasising awareness of the consequences of the actions taken.

Once everybody is involved in the rule-making process, commitment is enhanced, creating a common motivation for each team member.

A clear commitment between managers and staff should be the result.

3.2.2.5 Improving Communication

Communication can be divided into two areas:

- Interpersonal communication:
  - assertiveness,
  - social events,

  - solving problems between generations.

- Operational communication:

  - standard phraseology,
  - de-briefing,
  - common vision on performance,
  - awareness of individual differences.

As communication takes place in every interaction between human beings, communication skills are most valuable. It must therefore be learned in a most progressive way. It should be emphasized that 'standard phraseology' must be used in air/ground and ground/ground communication.

Overall the group considered it important that management should take the lead in improving communication with the 'workers'.

3.2.3 Conclusions

Noting the importance of the above and seeing that the process of improvement will be continuous, management should support training with time, money and involvement.

It was considered worthwhile to emphasize special training for:

- Developing communication skills;

- Stress management within a team;

- A training curriculum for ATCOs in which potential skills can be identified for future positions like training officers, supervisors, team leaders.

The main benefit of pursuing the teamwork model is to improve the safety and the efficiency of the service provided by coping with the individual differences at team level.

Although not mentioned during the workshop, by developing, defining, describing and establishing the above-mentioned model, a context is created in which it becomes easier to adhere to a standard like the ISO 9000 standard, thus also serving the customer interests!

3.3 Teamwork and Selection

Facilitators: Björn Backman and Zvi Golany
Rapporteur: Carl Dean
Authors of the Conclusions: Björn Backman and Zvi Golany

3.3.1 Introduction

The objectives of this WG were to promote awareness and understanding of the role of teamwork in selection issues.

The main question to be answered in this WG was: What are the teamwork issues to be considered in selection?

3.3.2 Main Results

After an initial discussion on different topics, such as whether selection is an instrument to create teamwork or working teams and what kind of different teams should be considered (e.g. pilot-controller, controller-controller), the WG decided to focus on teamwork in the context of *ab initio* screening.

The question of whether teamwork assessment should exist was by and large answered positively. The question asked how much weight teamwork ability should be given in comparison to other ability assessments. Experienced selectors among the WG could not recall a single case where a candidate was rejected mainly on the basis of insufficient teamwork skills. The WG then broadly discussed how *ab initio* candidates should be screened for teamwork. There was a general consensus that selection of *ab initio* trainee controllers should include ability tests, personality evaluation, team skills evaluation and background evaluation (e.g. previous experience).

The WG identified some team skills such as listening, acceptance of group goals, speaking one's mind, communicating in a clear and structured manner, accepting and following rules and/or instructions, giving and accepting assistance not as a sign of weakness but as a normal reaction to overload in air traffic, and last but not least behaviour flexibility.

The WG discussed some selection tools available worldwide for *ab initio* trainee controllers for teamwork or interaction with team members. Some definitions used in aviation psychology to describe anti-social behaviour were also mentioned in this context. The possibility of using ATC behavioural scales to assess 'wrong' or 'good' teamwork behaviour was discussed. The situational interview technique and the possibility to assess social attitudes were also discussed.

Traditional exercises to assess social behaviour included in assessment centres were addressed. In this context, the WG decided to do a short exercise itself assessing teamwork such as one which may be found in an assessment centre.

Two groups of individuals of different cultural backgrounds and professions actively worked together as teams producing a number of greetings cards, while being observed on teamwork scales. The WG compared the team skills assessed in the exercise with the team skills required in actual ATC situations and concluded that other specific teamwork exercises and assessment scales needed to be developed for the selection of *ab initio* trainee controllers.

Some lengthy discussion was devoted to the question as to who should assess teamwork. Should it be only psychologists, or only controllers, or a joint team of controllers and psychologists? There was no clear meeting of minds in this respect. No agreed consensus has yet emerged, nor is ever likely to.

Other important questions, which, due to lack of time, were left open, included: Is teamwork a skill or an ability? How can the reliability of teamwork assessment be increased? Does an assessment centre pay? Some clear differences between a European and an American point of view on this issue were identified.

3.3.3 Conclusions and Recommendations

The WG concluded that there is too little knowledge on teamwork assessment available at present. The key message was that combined efforts are needed to reinforce research and development of team skill assessment, while taking into account different cultural requirements.

Teamwork was regarded as the glue that holds us together (this was the chosen slogan). Anyone who claims to understand this glue thoroughly cannot be in possession of all the facts - as Winston Churchill said of another matter.

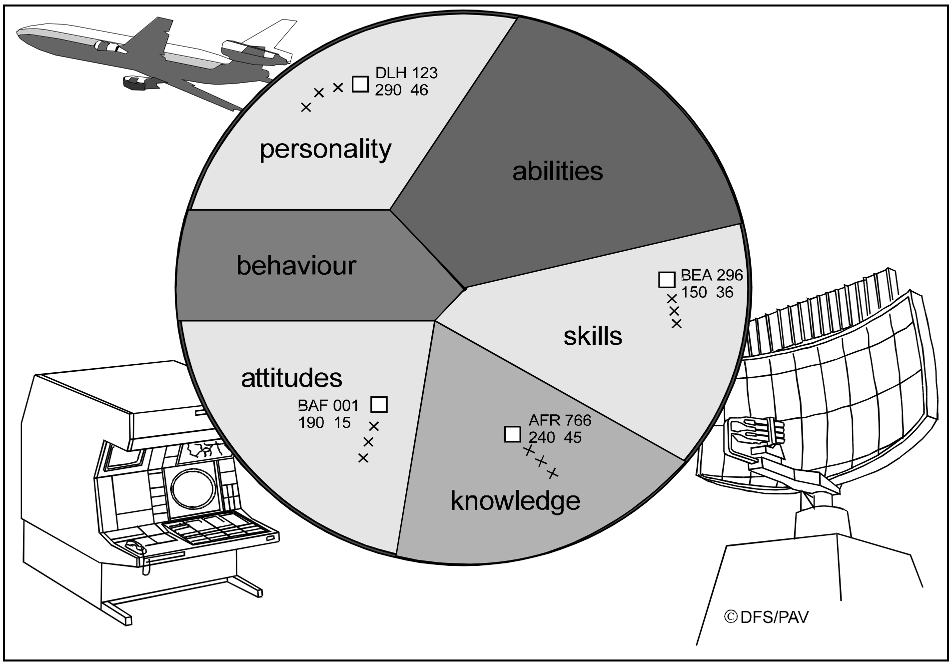

Figure 6: Team-related factors to be considered in selection

3.4 Teamwork and Accident/Incident Investigation

Facilitators: Manfred Barbarino and Dominique Van Damme
Rapporteur: Kathia Defrancq
Authors of the Conclusions: Manfred Barbarino and Dominique Van Damme

3.4.1 Introduction

The objective of this WG was to identify teamwork aspects that can play a role in the occurrence of accidents and incidents and the way to investigate these aspects.

The question which served as a basis for the discussion was: 'Which aspects do we have to consider for the investigation of teamwork-related failures in A/I?'.

3.4.2 Main Results

The following main areas were identified at the end of the working session:

- definitions,
- investigation methods,
- investigation content,
- investigation results.

3.4.2.1 Definitions

In order to define the scope of teamwork-related aspects and the way we can investigate them, it is necessary to find a common agreement on the terms themselves and to give a clear answer to set questions, for example:

- Concerning the term 'teamwork' :

  What do we mean by teamwork? Who is part of the team? Is ATC teamwork or is it done by well supported individuals? Is management part of the ATC team?

- Concerning the term 'incident':

  To what kind of incident should we extend the investigation? Is an error without consequences considered as an incident? Do we have to consider only effective consequences or should potential consequences of failures also be considered in the decision to investigate?

3.4.2.2 Investigation Methods

Prerequisite Conditions and Philosophy

A few ideas were expressed about the prerequisite conditions and the philosophy that should support the investigation process:

- The intention of the investigation should be established and be clear to everybody;
- The investigator must have a good understanding of ATC operations;
- He should also have a sufficient knowledge about HFs in ATC and have a formal training to enable him to investigate these aspects.

An important question was raised about the way to report an incident should it be done anonymously or confidentially. In encouraging incident reporting, anonymous reporting seems to be very effective while, for the interest and the ease of the investigation, confidentiality seems more suitable. It allows the investigator to make contact with the reporter in order to clarify any points and to go deeper into the investigation.

3.4.2.3 Data Sources

In order to investigate an incident, a set of information is usually available or needs to be collected. This includes:

– recordings: radar screen, Radio/Telephony (R/T),
– interviews of the controllers in all the units involved,
– personal data (e.g. experience),
– opinions from peers.

The collection and analysis of the facts should be oriented towards the understanding of what happened, in what context and why it happened.

3.4.2.4 Investigation Content

Teamwork is only one of several HFs areas which needs to be fully integrated in the overall investigation.

The WG identified the detailed list of categories presented below. A list of questions that can be used by the investigators is attached at the end of this chapter.

The investigation can focus on:

- Team characteristics;

- Team organisation;
- Team relationship;
- Training level of the team as a whole and the team members as individuals;
- Communication.

3.4.2.5 Investigation Results and Feedback

The results of the investigation should be issued in a report describing the relevant facts that led to the incident and suggesting recommendations in order to avoid similar occurrences.

Feedback should be provided to those who were involved in the incident but also to people who were not involved and who can learn from the incident.

3.4.3 Conclusions

There is room within the investigation of accidents and incidents for a better understanding of what has happened in relation to teamwork aspects.

The difficulties experienced in investigating them stem from the data collection because teamwork aspects can cloud some of the facts and there are no tools that can record the informal aspects. Nevertheless, giving particular attention to them by interviewing people can help to identify teamwork-related facts that could have led to an incident. The attached list of questions could be used.

The group agreed that some questions remained open:

- What is an incident? And what should not be considered as such?
- Which type of incident should be investigated?
- How can team roles and responsibilities be better defined?
- What is the right level of confidentiality in the incident reporting system?

The group also agreed on the following recommendations:

- Introduce briefings within ATC operations: The introduction of briefings in ATC was suggested because it can help to build the team spirit at the beginning of every shift.
- Establish a reporting system which issues recommendations: The investigation of incidents is most useful if the reports contain recommendations for avoiding similar occurrences.
- Install a HFs training programme for investigators: From the participants' point of view, investigators, who generally have good expertise in A/I investigation and in ATC, could improve the investigation of teamwork

aspects by being more aware of the HFs that can play a role in the occurrence of an incident . This could be achieved by training them on HFs in A/I investigation.

- Provide the means to reach a better understanding between pilots and ATCOs about each other's job: A better understanding of the specific objectives and constraints of each other's job appeared to be a first step in improving the relationship between pilots and ATCOs, and, in the same way, improving teamwork spirit and safety.

LIST OF QUESTIONS FOR THE INVESTIGATION OF TEAMWORK-RELATED ASPECTS

The following list of questions was issued at the end of the WG. As it could be useful for those who have to investigate teamwork-related aspects, the entire list is reproduced here.

Team Characteristics

- How long has this team been working together?
- Has this team been involved in A/I before?
- Do they feel, think and behave as a team?
- Do they blame one team member for the incident?
- Could the same have happened with another team?
- Has each team its own characteristics?
- How was the balance between risk, safety and job satisfaction?
- How was the team balance broken?
- Why did it happen?

Team Roles and Organisation

- Are the task, role and responsibility of each team member clearly defined?
- Is every team member aware of his or her role in the team?
- Is there a team leader?
- Is he a formal or informal team leader?
- What is his role?

- Was all information available and obtainable by the controller?
- Where was the error/failure?
- Who should/could have noticed the error(s)?
- What would have been the right way to act?
- Was the team size appropriate for the task?
- What was the workload and task demand at the time of incident, and just before?
- Was any particular team member overloaded?

Team Relationship

- Did the team members get on?
- Was there any conflict of personality?
- Did the team leader ask for input from the others?
- Was there a chance to challenge the decisions?
- What was the relationship between the various teams involved?

Training Level of the Team and Team Members

- Have the team members an adequate skill level and experience?
- Have the team members proper qualifications?
- Was TRM or team building training provided and accepted by the team members?
- Did each team member have a good knowledge and the same understanding of the procedures?

Communication

- How was the communication (style and content) and co-ordination amongst the team members?
- Was there any chance to talk about conflicts?
- Was there a breakdown in the tacit understanding?

- Were the controller and pilot communicating with and understanding each other properly?

3.5 Teamwork and Training

Facilitators: Eoin Mc Inerney and Hermann Rathje
Rapporteur: Ulf Harborg
Author of the Conclusions: Hermann Rathje

3.5.1 Introduction

The objectives of this WG were to study how teamwork should be trained and how it could be integrated within the whole training plan. The question to answer was: 'How can we foster teamwork in training?'

3.5.2 Main Results

3.5.2.1 How Can We Foster Teamwork in Training?

The group was well aware of the fact that fostering teamwork in the training environment requires:

– clear goals/aims to be achieved in training,
– teamwork-related knowledge, skills and attitudes to be changed,
– specific methods and tools to be developed and applied,
– evaluation exercises to be conducted and experience to be fed back.

In addition, one of the tasks is to get convincing messages across in the organisation as a whole and in particular to management in order to obtain full support and exercise optimal impact. These relationships are visualised in the figure below.

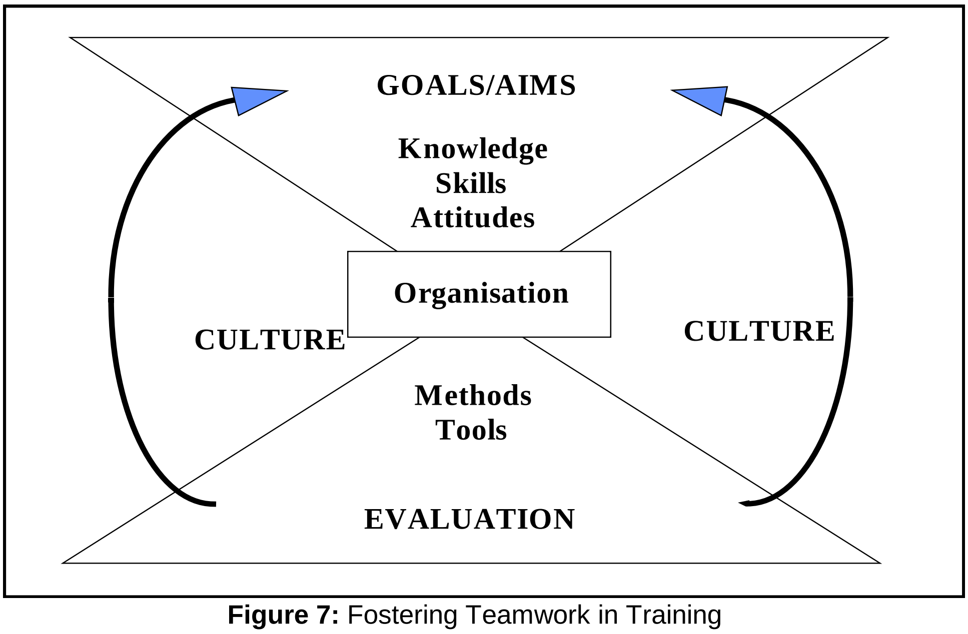

Figure 7: Fostering Teamwork in Training

Aim

Teamwork in training needs a common aim: teamwork is about communication, decision-making, co-operation, tolerance for others as being different people, and respect for them and their contribution to the work.

Training must relate to organisational aims and the existing needs.

Three Key Messages

The group felt strongly about three key messages that were formulated towards the end of the discussions but which could lead into the issue in a more focused way:

1. In order to promote teamwork in training we need to address the knowledge, skills and attitudes of people in three areas:

   – personal and group behaviour,
   – interpersonal relationships,
   – communication,

   with clear aims of **what** should be promoted.

2. Management needs to lead and drive the initiatives pro-actively.

3. In training people in teamwork we need to use the appropriate methods and tools:

   – active rather than passive training,
   – practical exercises,
   – closed loop instruction.

These issues were discussed in more detail. The important points are given in the following sub-chapters.

3.5.2.2 Behaviour for Promoting Teamwork

Personal Behaviour: Responsibility

The aim of teamwork training is not to 'do away' with personal responsibility but to strengthen it. Professionals in ATS should act professionally by following valid rules and methods, and demonstrate the sense of responsibility which is connected to the profession.

Members of a team should take up this personal responsibility. However, it is necessary for them to realise that they are part of a team working towards a common goal. Teamwork thus becomes a duty.

This has a direct impact on day-to-day teamwork: it helps to develop the ability to understand other people's situations better and to show respect for the job others are doing. Increased (self-)perception helps to detect errors earlier (cross-checking) and to correct them. The ability to admit errors and to change (erroneous) decisions is an important aim in teamwork training, especially in ATS.

Personal Behaviour: Role Awareness

‘Good’ team players pay attention to the personal steering mechanisms of behaviour.

One of the key questions in this respect is to ask: How do I perceive myself and how do others perceive me in my role in the team? This will help first to know oneself and to understand that this perception is individual. Second, it evokes sensitivity to the differences between people which need to be understood in order to act as a ‘good’ team player. To consider perceptions from others can be surprising but it is a necessary step towards common understanding.

Part of this understanding is to be aware of the role of others and role conflicts.

Group Behaviour: Leadership/Management

Teamwork training should embrace managers, supervisors and other leaders at all levels of responsibility to ensure that the enthusiasm for teamwork comes from the top. Management should be ‘seen’ to support this programme and should show interest in TRM, for example.

The leadership style which is most effective in this respect is ‘leading by example’; managers should act as role models open to changes in an open culture.

Group Behaviour: Communication

‘Communication’ is one key concept in teamwork training and practice. The open style communication should be promoted. Even more important than talking is active listening.

The sharing of knowledge is essential in ATS. There is no room for holding back important knowledge for one’s own benefit and letting others make mistakes. In fact, good teamwork can suppress errors before they appear.

Another important feature in communication is feedback, both positive and negative. Positive feedback is rare. To give feedback means to communicate one’s own objectives, share information and give one’s own perceptions. It is not personal criticism.

Good feedback should be behaviour-oriented.

Group Behaviour: Interpersonal Skills

The interpersonal (team-oriented) skills to be strengthened and/or developed are: to support others, to respect their roles and to tolerate differences. In order to co-operate with others efficiently, the 'us and them' attitude needs to be broken down. Again, the focus should be given to the positive outcome of good co-operation, not only to A/I happening or to errors made.

There will always be some conflicts in teams. Teamwork training should provide a means of handling conflict and stress, and correcting conflictual behaviour. One of the issues in TRM should concentrate on how to reduce problems or conflicts between colleagues.

3.5.2.3 Training for Teamwork

Instructors

Instructors for teamwork training should be selected for this work. The profile of instructors who could act as good role models is important.

Teamwork training instructors need to be trained. Teamwork training should be given by experienced people who have the right knowledge, skills and abilities.

Training Design

Teamwork training is active training and active learning - not only talking about teamwork. Using practical exercises (e.g. team building, role-play) is strongly recommended. Events like workshops and seminars help to promote ideas on teamwork training and give a higher profile to the issue.

The training design should ensure that skills are provided which can be used in a multitude of different situations, and in different teams.

Training designers need to be aware of different learning- and problem-solving styles of trainees. This and the design of teamwork training for different levels (e.g. *ab initio*, managers) will almost certainly lead to different approaches in the training to be adopted.

Evaluation

As with any other training, teamwork training needs to be followed up and evaluated, and validation studies should be carried out.

3.5.3 Conclusions

The final message of the WG stressed the importance on putting into practice the considerations previously stated.

Management, supervisors and more senior controllers, coaches and instructors need to act as role models to keep teamwork alive in practice.

3.6 Teamwork and the Design of Air Traffic Systems

Facilitators: Alistair Jackson and Johan Kjær-Hansen
Rapporteur: Peter Goillau
Author of the Conclusions: Johan Kjær-Hansen

3.6.1 Introduction

This WG explored a substantial and wide range of teamwork concepts related to the design of air traffic systems. The WG was professionally well-balanced and in a good position to approach the subject with five participants from an operational background, four participants involved with software engineering and six HFs experts.

The WG addressed the topic through a number of group sessions to cover the concepts associated with teamwork and the design of air traffic systems, the requirements and guidelines to follow when designing for teamwork, and the recommendations for further research in the domain.

3.6.2 Main Results

3.6.2.1 Teamwork Elements

The WG identified significant elements of teamwork covering:

- Teamwork stakeholders: such as air, ground and others (managers, Operators (OPRs), scientists).
- Co-ordination: Pilots - ATCOs, Executive Controller - Planning Controller, Executive Controller - Pilot, Planning Controller - Pilot, civil - military.
- Personal contact: including aspects such as culture, language and background. The availability of a common vision (picture) and the understanding of objectives.
- Communications medium and bandwidth: including the non-verbal and emotional content.
- Teamwork commitment: providing the proper leadership style and recognising teamwork aspects.
- Visibility of task allocation: distributed system architecture supporting a balanced workload, skills requirement and responsibility.
- Team interaction: using colleagues as a safety net to maintain situational awareness and keep the picture.

- Teamwork analysis and design: a good representation of teamwork (preferably graphical), modelling information organisation and display.

- Supportive measures: such as handover procedures, teamwork education, and training providing the proper internal team qualifications.

3.6.2.2 Teamwork in Design vs. Designing for Teamwork

An important distinction between *teamwork in design* and *designing for teamwork* was made. The former related to aspects concerning the team that produce the design, while the latter was concerned with the factors which would support and even promote teamwork in a particular design. Due to the limited time available for the WG, it was decided to concentrate on the design for teamwork, which is approached in the following sections.

3.6.2.3 Designing for Teamwork

The WG identified some significant factors in the design life-cycle, such as:

- The **assumptions** held about the design cycle;

- The **prerequisites** for performing a human-centred design;

- The **concepts** on which to base the design;

- The **system properties** perceived as essential for the support of teamwork aspects;

- The **practice** to employ in the design for teamwork in ATS;

- The **evaluation and validation** of teamwork aspects of ATS.

The individual factors or design phases are elaborated in the following subsections.

Assumptions

As the design of new work systems always has the danger of ‘re-inventing the wheel’, the WG advised learning from history, either from the history of ATS design itself or from experiences gained in design for teamwork in other areas. One research domain, Computer Supported Computer Work (CSCW), was identified as contributing some insight into teamwork design and groupware.

Techniques should be employed for establishing a good knowledge of the work processes, such as detailed task analysis and the study of existing procedures. Other techniques might help in changing the boundaries between humans and technologies. A global approach should be applied in order to avoid sub-optimisation of the system.

Prerequisites

An important prerequisite for teamwork was considered to be the organisational learning process employed in the adoption of the concept and the prevailing 'social culture' established. An important part of the learning process was to establish a common understanding of the concept and what it means in an operational context. The potential negative reception of changes in the organisation should be minimized through preliminary agreements within the team, and through teamwork education and other measures for increasing the staff's qualifications.

Concept

The importance of the teamwork concept was stressed. This concept may have several interpretations whether it is addressed in an operational context or in a transition phase. An understanding and definition of the 'path of concepts' should form a basis for the design process.

The change process should identify the focal points for design and implementation and address the functionality of new technologies (such as increased automation assistance) or new working methods.

System Properties

A number of system properties were highlighted as essential for supporting teamwork, such as flexibility, transparency and consistency. The system should maximize the quality of the communication and richness (termed 'bandwidth').

The status of the system should be visible and transparent in terms of control structure and work processes. The functions of the system should be properly distributed and interfaces intuitive.

Design Practice

The suggestions for design practices to employ in the support of teamwork were many:

- To apply a goal-oriented approach, and choose of a good design method for teamwork and user-centred design;
- The notion of participatory design should be introduced through timely involvement of all interested parties in the system;
- To apply a multi-disciplinary design approach with design teams mixing technological background, operational background and HFs specialists;
- To design systems with a flexible allocation of tasks between humans and machines. Special attention should be provided to Human-Computer Interaction (HCI);

- The choice of technology and control strategy should be appropriate. The control strategies could range from manual control, ‘hero’ tools (see all, know all), computer-supported co-operative work/groupware tools or full automation;

- Openness in the design process was highlighted as being very important as well as honesty over problems during design, as this saves time later. The process should provide feedback to all involved parties, and should define goals, intentions and roles;

- To have a good understanding of what the ‘system’ looks like and of the influences on the system, (ground, civil-military air components, computer hardware, software, single persons, team of people, procedures, organisation, etc.).

Evaluation and Validation

The first question to approach when addressing system evaluation and validation is how to ‘measure’ teamwork. Although no satisfactory solution was identified, it was agreed that the deployment of technology should be done in close collaboration with the team, which has to work with it. The evaluation of teamwork design should be iterative, and modifications should be made with the involvement of the whole team.

Some important terms are:

1. Verification (building the system right).
2. Validation (building the right system - ask the team members, users).
3. Evaluation (is the teamwork design any good?).

3.6.2.4 Some Research & Development Activities and Recommendations

The WG sessions revealed some of the complexity of this area. While acknowledging the complexity, the WG participants suggested the following actions to be taken and recommendations for further study:

1. Investigate the legal responsibility in teamwork.

2. Establish the limitations of technology to support teamwork.

3. To establish the kind of outcome required (theory, Research & Development (R&D) agenda or practical recommendations).

4. How to assess the risk and value of teamwork solutions?

5. How to ensure design for teamwork supports ‘fail-soft’ (‘graceful degradation’)?

6. Investigate the effectiveness of substitutes for interpersonal communications in human-centred ATS.

7. Explore alternative team structures for next generation ATM system concepts.

8. To develop a coherent R&D programme to support inter-operability and meet the increased demand for teamwork in 2000+.

9. To identify which existing tools and techniques could support R&D in team concepts.

10. To encourage interdisciplinary exchanges.

11. To make surveys in other applications and industries for candidate teamwork models/concepts.

12. To investigate the implications of the recent European Union (EU) pronouncements on teamwork concepts.

13. To survey the effectiveness of existing teamwork research.

14. To research the added value of teamwork, and look at implications for future concepts programmes, such as Future Air Navigation Systems (FANS) and EATMS, and to develop techniques, practices and systems exploiting teamwork.

3.6.3 Conclusions

The findings of the WG may be summarised as follows:

- The need to address planning for teamwork, whether it is the present operational architecture or the (short-/medium-/long-term) future systems;

- The design life-cycle was described from 'assumptions' to evaluation;

- The importance of flexible, multi-disciplinary teamwork within the development process and flexible methods was underlined;

- A listing of desirable system properties, assumptions, prerequisites, especially co-ordination and communication.

Although the WG revealed some significant aspects of design for teamwork, the complexity of the subject was fully acknowledged. It was agreed that further work in this area is needed.

LIST OF THE PARTICIPANTS TO THE WORKSHOP

ABREU GUERRA Antonio Manuel ANA, ATCO Training Co-ordination 118, Rua C Aeroporto de Lisboa P-1700 LISBON PORTUGAL	Tel: +351 1 841 3500 Fax: +351 1 847 9333
AMAT Anne-Laure EUROCONTROL Human Resources Bureau - DED5 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: +32 2 729 4764 Fax: +32 2 729 9149 E-mail: anne-laure.amat@eurocontrol.be
ANDERSSON Stig Senior Air Traffic Controller Swedish ATS Academy Box 52 S-230 32 MALMO-STURUP SWEDEN	Tel: +46 40 613 1330 Fax: +46 40 613 1319
ASSENOV IORDANOV Emil ATSA BULGARIA ATCO Human Resources Dept. Sofia Airport BG-SOFIA BULGARIA	Tel: +359 2 000 42 Fax: +359 2 718 095
BACKMAN Björn Selection and Manpower Planning Expert EUROCONTROL Human Resources Bureau - DED5 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: +32 2 729 4728 Fax: +32 2 729 9149 E-mail: bjorn.backman@eurocontrol.be
BALDWIN Rodney Director BALDWIN INTERNATIONAL SERVICES 34, Dellegaass L-7651 HEFFINGEN LUXEMBOURG	Tel: +352 872 11 Fax: +352 879 785 E-mail: rodbaldwin@compuserve.com or rb65@tutor.open.ac.uk
BARATI Ferenc Hungarian Military Liaison Officer EUROCONTROL - DEI2/5 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: +32 2 729 4723 Fax: +32 2 729 9196 E-mail: ferenc.barati@eurocontrol.be
BARBARINO Manfred Head of Section Human Factors EUROCONTROL Human Resources Bureau - DED5 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: +32 2 729 3951 Fax: +32 2 729 9149 E-mail: manfred.barbarino@eurocontrol.be
BARDUCCI Lucilla ENAV – International Affairs Office 716, Via Salaria I-00138 ROME ITALY	Tel: +39 6 816 6443 Fax: +39 6 816 6555 E-mail: gcarlo.enav@interbusiness.it (c/o Giampiero. CARLO)
BAREAU Patrick CENA – Human Factors Studies 1, rue Champagne F-91200 ATHIS-MONS FRANCE	Tel: +33 1 69 57 79 29 Fax: +33 1 69 57 79 34 E-mail: bareau@cena.dgac.fr

BASELEY Doreen		
Principal Scientific Officer		
DERA MALVERN ATC SYSTEM GROUP		
St. Andrews Road	Tel:	+44 1684 894 214
GB-WR14 3PS	Fax:	+44 1684 894 109
UNITED KINGDOM	E-mail:	baseley@atc.dra.hmg.gb
BAUDEL Véronique		
ATCO		
CRNA/NORD (ATHIS-MONS)		
9, rue Champagne	Tel:	+33 1 69 57 67 05
F-91200 ATHIS-MONS	Fax:	+33 1 69 57 66 42
FRANCE		
BEARDSWORTH Louis		
Human Factors Manager		
BA Safety Services	Tel:	
	Fax:	
	E-mail:	
BENES Ivan		
ATC Controller ACC		
ANS CZECH REPUBLIC		
4, Smetanovo Nabrezi	Tel:	+420 2 2037 4386
CZ-11800 PRAGUE	Fax:	+420 2 2037 4250
CZECH REPUBLIC		
BIERWAGEN Thomas		
Manager Simulation Exercises		
DFS - Deutsche Flugsicherung		
Flugsicherungsakademie		
Postfach 1243	Tel:	+49 6103 707 794
D-63202 LANGEN	Fax:	+49 6103 707 741
GERMANY	E-mail:	bierwagen@se.dfs.de
BOHDAL Jaroslav		
ATS and Systems Planning		
ANS CZECH REPUBLIC		
4, Smetanovo Nabrezi	Tel:	+420 2 2037 2024
CZ-11800 PRAGUE	Fax:	+420 2 2037 2006
CZECH REPUBLIC	E-mail:	bohdal@ans.cz
BOIDE Bruno		
ADP/ROISSY - CDG,		
Aéroport de Roissy Charles de Gaulle	Fax:	+33 1 48 62 24 78
FRANCE		
BOUILLIER-OUDOT Jean		
ATS Expert		
EUROCONTROL - DEI3		
96, rue de la Fusée	Tel:	+32 2 729 3298
B-1130 BRUSSELS	Fax:	+32 2 729 9066
BELGIUM	E-mail:	jean.bouillier@eurocontrol.be
Capt BUTLER		
Chairman Human Factors Working Group		
IATA		
Dormers		
Hall Lane		
Waltham St Lawrence		
GB-Reading, Berkshire RG10 OJD	Tel/Fax:	+44 173 434 3391
UNITED KINGDOM		
CALIMAN Ioana		
Aeronautical Inspector		
CAA ROMANIA		
Km 16.5, BUC-PLOIESTI	Tel:	+40 1 230 3750
RO-BUCHAREST	Fax:	+40 1 230 2942
ROMANIA		
CARSTENSEN Peter		
Laboratory Research Scientist		
RISO Nat.		
P. O. Box 49	Tel:	+45 46 775 145
DK-4000 ROSHILDE	Fax:	+45 46 755 170
DENMARK	E-mail:	peter.carstensen@risoe.dk

CASALE Guglielmo Project Manager ALENIA Km 12.400, Via Tiburtina I-00131 ROME ITALY	Tel: Fax: E-mail:	+39 6 4150 3650 +39 6 4150 3709 gcasale@lti.alenia.it
CEBIS Patrik ATC Controller TWR/APP ANS CZECH REPUBLIC 4, Smetanovo Nabrezi CZ-11800 PRAGUE CZECH REPUBLIC	Tel: Fax:	+420 2 2037 4548 +420 2 2037 4250
CLARK Chris Head of Bureau/Chairman HRT EUROCONTROL Human Resources Bureau - DED5 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: Fax: E-mail:	+32 2 729 3398 +32 2 729 9149 chris.clark@eurocontrol.be
DAWSON W.g. U.K. CAA Dep. Hd. ATS Investigation 1E, Aviation House GB-Gatwick, West Sussex RH6 OYRK UNITED KINGDOM	Tel: Fax:	+44 1 293 573 647 +44 1 293 573 974
DEAN Carl Manager Air Traffic Staff FAA 27, bd du Régent B-1000 BRUSSELS BELGIUM	Tel: Fax: E-mail:	+32 2 508 2680 +32 2 230 0642 carl.dean@faa.dot.gov
DEFRANCQ Katia Captain BAE146 ABPNL 23/1, Lakensestraat B-1853 GRIMBERGEN BELGIUM	Tel: Fax: E-mail:	+32 2 267 8344 +32 2 267 8344 KatiaDefrancq@compuserve.com
DE STANSKI Christian CRNA/NORD (ATHIS-MONS) Quality Unit 9, rue Champagne F-91200 ATHIS-MONS FRANCE	Tel: Fax:	+33 1 69 57 66 41 +33 1 69 57 66 42
DEUCHERT Inez, PAV DFS - Deutsche Flugsicherung Flugsicherungsakademie Postfach 1243 D-63202 LANGEN GERMANY	Tel: Fax:	+49 6103 707 270 +49 6103 749 67
DONOHOE Laura Senior Human Factors Analyst NATS/U.K ATMDC Bournemouth Airport GB-Christchurch BH236DF UNITED KINGDOM	Tel: Fax: E-mail:	+44 1202 472 121 +44 1202 472 236 hfactors@atmdc.nats.co.uk
DROZ Jacques ATCO SWISSCONTROL Case Postale 796 CH-1215 GENEVA SWITZERLAND	Tel: Fax:	+41 22 417 4040 +41 22 417 4511
EGGERT Walter ATCO SWISSCONTROL Case Postale 796 CH-1215 GENEVA SWITZERLAND	Tel: Fax:	+41 22 417 4040 +41 22 417 4511

EISSFELDT Hinnerk		
Aerospace Psychology		
DLR		
54A, Sportallee	Tel:	+49 405 130 96 31
D-22335 HAMBURG	Fax:	+49 405 130 96 60
GERMANY	E-mail:	hinnerk.eissfeldt@dlr.de
ELEFTHERIADI Anna		
ATCO		
CAA GREECEe	Tel:	+30 1 894 7193
GR-16604 ATHENS	Fax:	+30 1 894 7101
GREECE		
FASSERT Christine		
SOFREAVIA		
3, Carrefour de Weiden	Tel:	+33 1 41 23 46 83
F-92441 ISSY-LES-MOULINEAUX	Fax:	+33 1 46 48 32 80
FRANCE		
FIGAROL Sylvie		
CENA - Human Factors Studies		
7, Avenue Edouard Belin	Tel:	+33 5 62 25 96 40
F-31055 TOULOUSE	Fax:	+33 5 62 25 95 99
FRANCE	E-mail:	sfigarol@cenatls.cena.dgac.fr
FOURNIE Alain		
Head of Training CEU		
EUROCONTROL - CFMU1		
96, rue de la Fusée	Tel:	+32 2 729 9780
B-1130 BRUSSELS	Fax:	+32 2 729 9028
BELGIUM	E-mail:	alain.fournie@eurocontrol.be
GALUSHKA Joe		
Engineering Research Psychologist		
FAA		
Atlantic City International Airport	Tel:	+1 609 485 7376
USA-08405 ATLANTIC CITY	Fax:	+1 609 485 6218
UNITED STATES OF AMERICA	E-mail:	joeg@hfl.tc.faa.gov
GOILLAU Peter J.		
Senior Scientific Officer		
DERA Malvern ATC Systems Grp.		
St. Andrew's Road	Tel:	+44 1684 894 250
GB-Malvern, Worcs WR14 3PS	Fax:	+44 1684 894 109
UNITED KINGDOM	E-mail:	goillau@atc.dra.hmg.gb
GOLANY Zvi		
Selection and Manpower Planning Expert		
EUROCONTROL		
Human Resources Bureau - DED5		
96, rue de la Fusée	Tel:	+32 2 729 3509
B-1130 BRUSSELS	Fax:	+32 2 729 9149
BELGIUM	E-mail:	zvi.golany@eurocontrol.be
GRASS Gérard		
Instructeur régional		
DAC/SUD - Direction Aviation civile Sud		
B. P. 100	Tel:	+33 5 62 74 64 43
F-31703 BLAGNAC cedex	Fax:	+33 5 62 74 64 09
FRANCE		
GRUNWALD Georg		
Expert Implementation		
EUROCONTROL - DEI3		
96, rue de la Fusée	Tel:	+32 2 729 3041
B-1130 BRUSSELS	Fax:	+32 2 729 9066
BELGIUM	E-mail:	georg.grunwald@eurocontrol.be
HAKANSSON Lars		
Chief of Personnel		
CAA SWEDEN		
Box 54, ATCC MALMOE	Tel:	+46 40 613 1594
S-23032 MALMOE-STURUP	Fax:	+46 40 500 288
SWEDEN	E-mail:	lars.hakansson@ans.lfv.se

HARBORG Ulf Senior Air Traffic Controller Swedish ATS Academy Box 52 S-23032 MALMO-STURUP SWEDEN	Tel: Fax:	+46 40 613 1330 +46 40 613 1319
HERNANDEZ REDONDO Carlos Jefe Division de Control de la Circulacion Aerea AENA c/ Juan I. Luca de Tena, 14 E-28027 MADRID SPAIN	Tel: Fax:	+34 1 321 3317 +34 1 321 3114
HINDSON Gregory ATCO CRNA/S-O (BORDEAUX) rue de Beaudésert F-33700 MERIGNAC FRANCE	Tel: Fax:	+33 5 56 55 61 71 +33 5 56 55 63 68
HINTZ KELLER Mariann Training Expert EUROCONTROL - IANS 31, Bd Konrad Adenauer L-1115 LUXEMBOURG LUXEMBOURG	Tel: Fax: E-mail:	+352 43 60 61 323 +352 43 86 69 mariann.hintz@eurocontrol.be
ISAAC Anne DEDALE 4, Place de Londres F-95727 ROISSY CDG Cedex FRANCE	Tel: Fax:	+33 1 48 62 62 04 +33 1 48 62 62 05
JACKSON Alistair Controller Work Position HMI Team Leader EUROCONTROL - EEC BP15 F-91222 BRETIGNY S/ORGE Cedex FRANCE	Tel: Fax: E-mail:	+33 1 69 88 75 44 +33 1 69 88 73 33 alistair.jackson@eurocontrol.fr
JORGENSEN Jörgen ATCO CAA DENMARK 2, Overdrevet DK-4291-RUDS VEDBY DENMARK	Tel: Fax:	+45 40 583 379 +45 58 263 188
KARAMANOGLU Nur EUROCONTROL - CFMU 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: Fax:	+32 2 729 3566 +32 2 729 9149
KENT Keith ATC Training and Ops. Manager NATS/U.K. Birmingham Airport GB-Birmingham B26 3QN UNITED KINGDOM	Tel:	+44 121 782 1200
KING William EUROCONTROL - IANS 31, Bd Konrad Adenauer 1115 - LUXEMBOURG LUXEMBOURG	Tel: Fax:	+352 43 60 61 506 +352 43 86 69
KJÆR-HANSEN Johan Human Factors Expert EUROCONTROL Human Resources Bureau - DED5 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: Fax: E-mail:	+32 2 729 4773 +32 2 729 9149 johan.kjaer-hansen@eurocontrol.be

KOCHER Bernard Supervisor/ATCO/Trainer SWISSCONTROL Case Postale 796 CH-1215 GENEVA SWITZERLAND	 Tel: Fax: E-mail:	 +41 22 776 4155 +41 22 776 6442 bernard.kocher@swisscontrol.inet.ch
LENFANT Gildas Chief of Quality Unit CRNA/S-O (BORDEAUX) rue de Beaudésert F-33700 MERIGNAC FRANCE	 Tel: Fax:	 +33 5 56 55 61 71 +33 5 56 55 63 68
LUESCHER Paul ATC Controller/H. Instr SWISSCONTROL. CH-8058 ZURICH AIRPORT SWITZERLAND	 Tel:	 +41 1 816 39 47
MARTI Patrizia Senior Researcher UNIVERSITY OF SIENA 14, Via del Giglio I-53100 SIENA ITALY	 Tel: Fax: E-mail:	 +39 57 729 8463 +39 57 729 8461 marti@media.unisi.it
MASSON Michel DEDALE 4, Place de Londres F-95727 ROISSY CDG Cedex FRANCE	 Tel: Fax:	 +33 1 48 62 62 04 +33 1 48 62 62 05
MATOS Ana Paula TAP, Psychologist Lisbon Airport P-1704 LISBON Cedex PORTUGAL	 Tel: Fax:	 +351 1 841 5018 +351 1 841 6188
MAURINO Dan Co-ordinator Flight Safety and HFs Programme ICAO 999 University Street CDN-Montreal, Quebec H3C 5H7 CANADA	 Fax: E-mail:	 +1 514 954 6759 dmaurino@icao.org
MC INERNEY Eoin Instructor Training EUROCONTROL - IANS 31, Bd Konrad Adenauer L-1115 LUXEMBOURG LUXEMBOURG	 Tel: Fax: E-mail:	 +352 436 061 932 +352 436 eoin.mcinerney@eurocontrol.be
MENDOZA NAVAS Montserrat HMI Design Expert EUROCONTROL - EEC BP15 F-91222 BRETIGNY S/ORGE Cedex FRANCE	 Tel: Fax: E-mail:	 +33 1 69 88 73 09 +33 1 69 88 73 33 mendoza-navas.montserrat@eurocontrol.fr
MERRITT Fiona Human Factors Specialist U.K. CAA Aviation House GB-Gatwick Airport RH6 OYR UNITED KINGDOM	 Tel: Fax: E-mail:	 +44 1 293 573 485 +44 1 293 573 995 fiona.merritt@srg.caa.co.uk
MUENSTER Axel Head of Qualification Programmes DFS - Deutsche Flugsicherung Flugsicherungsakademie Postfach 1243 D-63202 LANGEN GERMANY	 Tel: Fax:	 +49 6103 707 202 +49 6103 707 177

MUNOZ Neus Safety Department Expert AENA c/ Juan I. Luca de Tena, 14 E-28027 MADRID SPAIN	Tel: Fax: E-mail:	+34 1 321 3317 +34 1 321 3114 nmunoz@ugdna.aena.es
MUSCAT Michael Head ATC Training Section CAA MALTA ATC Training Centre M-Luqa Airport MALTA	Tel: Fax:	+356 25 900 505/509 +356 23 92 78
NIESING Cees Manpower Planning Expert EUROCONTROL Human Resources Bureau - DED5 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: Fax: E-mail:	+32 2 729 3336 +32 2 729 9149 cees.niesing@eurocontrol.be
NILSSON Ake Management Consultant SWEDAVIA AB 11, Vikboplan S-60179 NORRKÖPING SWEDEN	Tel: Fax:	+46 11 192 543 +46 11 130 711
NOORDAM BOLDING Suzanne Expert ATS Procedures ATC P.O.Box 75200 NL-1117ZT SCHIPHOL Airport THE NETHERLANDS	Tel: Fax: E-mail:	+31 20 406 2201 +31 20 406 3538 bolding@lvb.nl
NORLEN Olof Senior Air Traffic Specialist CAA SWEDEN S-60179 NORRKÖPING SWEDEN	Tel: Fax:	+46 11 192 441 +46 11 192 645
OLANTERA Pekka Planner/ATCO CAA FINLAND ANS-Department P.O. Box 50 FIN-01531 VANTAA FINLAND	Tel: Fax: E-mail:	+358 98 27 71 +358 98 27 72 297 pekka.olantera@fcaa.fi
ORR Brian Architecture Team EUROCONTROL - DED1 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: Fax: E-mail:	+32 2 729 3462 +32 2 729 9083 orr.brian@eurocontrol.be
PARIES Jean Managing Director DEDALE Place de Londres, 4 F-95727 ROISSY CDG Cedex FRANCE	Tel: Fax: E-mail	+33 1 48 62 62 04 +33 1 48 62 62 05 pariesj@worldnet.fr
PECHHACKER Andrea AUSTRO CONTROL Gesellschaft für Zivilluftfahrt GmbH ATS/DEP 11 Schnirchgasse A-1030 VIENNA AUSTRIA	Tel: Fax: E-mail:	+43 1 1703 2011 +43 1 1703 2006 andrea.pechhacker@austrocontrol.co.at
PICHANCOURT Isabelle HMI Design Expert CWP Coe. EUROCONTROL - EEC BP15 F-91222 BRETIGNY S/ORGE Cedex FRANCE	Tel: Fax: E-mail:	+33 1 69 88 76 61 +33 1 69 88 73 33 isabelle.pichancourt@eurocontrol.fr

PISTRE Michel Training Expert EUROCONTROL - IANS 31, Bd Konrad Adenauer L-1115 LUXEMBOURG LUXEMBOURG	Tel: Fax: E-mail:	+352 43 60 61 511 +352 43 86 69 michel.pistre@eurocontrol.be
RADA Ivan Human Factors andTraining Manager ATS CZECH REPUBLIC 4, Smetanovo nabrezi CZ-11800 PRAGUE CZECH REPUBLIC	Tel: Fax:	+420 2 203 732 31 +420 2 203 732 30
RATHJE Hermann Head of Selection & Manpower Planning Section EUROCONTROL Human Resources Bureau - DED5 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: Fax: E-mail:	+32 2 729 3955 +32 2 729 9149 hermann.rathje@eurocontrol.be
RUITENBERG Bert Executive VP Professional IFATCA Appelgaarde, 4 NL-2771 PK BOSKOOP THE NETHERLANDS	Tel H: Fax H: E-mail:	+31 172 212.896 +31 172 214 088 B_Ruitenberg@CompuServe.COM
SCHOLTZE Maurizio ENAV - International Affairs Office 716 Via Salaria I-00138 ROME ITALY	Tel: Fax:	+39 6 816 6474 +39 6 816 6555
SICARD Christian CENA - Human Factors Studies 7, avenue Edouard Belin F-31055 TOULOUSE FRANCE	Tel: Fax: E-mail:	+33 5 62 25 95 80 +33 5 62 25 95 99 sicard@cenatls.cena.dgac.fr
SKOV Finn Head of ATM Section CAA DENMARK 50 Ellebjergvej DK-2450 COPENHAGEN SV DENMARK	Tel: Fax:	+45 36 44 48 48 +45 36 44 03 03
SPRAGG Douglas Head of Operations EAS EUROCONTROL - DEI1 96, rue de la Fusée 1130 - BRUSSELS BELGIUM	Tel: Fax: E-mail:	+32 2 729 3166 +32 2 729 9064 douglas.spragg@eurocontrol.be
SYLVESTER-THORNE Nigel Head Real Time Simulation Operations EUROCONTROL - EEC BP15 F-91222 - BRETIGNY S/ORGE cedex FRANCE	Tel: Fax: E-mail:	+33 1 69 88 76 72 +33 1 69 88 73 52 sylvester-thorne.nigel@eurocontrol.fr
THUER Eveline Management and Personnel Development SWISSCONTROL 61, Schwarztorstrasse CH-3000 BERN 14 SWITZERLAND	Tel: Fax:	+41 31 387 9235 +41 31 387 9402
VAN DAMME Dominique Human Factors Expert EUROCONTROL Human Resources Bureau - DED5 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: Fax: E-mail:	+32 2 729 3567 +32 2 729 9149 dominique.vandamme@eurocontrol.be

V. FERDINANDOVA Marietta Training Courses Organizer Human Resources ATSA BULGARIA Sofia Airport BG-1540 SOFIA BULGARIA	Tel: Fax:	+359 2 000 42 +359 2 718 095
VAN TIEL Hans Training Consultant ATC NETHERLANDS P. O. Box 75200 NL-1117ZT SCHIPHOL AIRPORT THE NETHERLANDS	Tel: Fax:	+31 204 062 179 +31 204 063 636
VERMEIREN Roland Head of the Medical Service EUROCONTROL - HR3/4 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: Fax: E-mail:	+32 2 729 3597/3607 +32 2 729 9107 roland.vermeiren@eurocontrol.be
VIRLAN Gabriel ATS Inspector CAA ROMANIA Km 16.5, BUC-PLOIESTI RO-BUCHAREST ROMANIA	Tel: Fax:	+40 1 230 3750 +40 1 230 2942
WILLIAMS Keith Director ATC Operations NATS Hillingdon House GB-Uxbridge, Middlesex UB10 OTS UNITED KINGDOM	Tel: Fax:	+44 1895 276 006 +44 1895 276 140
WISE John A. Human Factors and Systems EMBRY-RIDDLE AERONAUTICAL UNIVERSITY 600 South Clyde Morris Blvd. USA-Daytona Beach FL32114-3900 UNITED STATES OF AMERICA	Tel: Fax:	+1 904 226 6384 +1 904 226 7050
WOLDRING Michiel Human Factors Expert EUROCONTROL Human Resources Bureau - DED5/3 96, rue de la Fusée B-1130 BRUSSELS BELGIUM	Tel: Fax: E-mail:	+32 2 729 3566 +32 2 729 9149 michael.woldring@eurocontrol.be
YAMI Zvi Deputy Managing Director HRI Ltd P. O. Box 2108 IL-46120 HERZELIYA ISRAEL	Tel: Fax: E-mail:	+972 9 958 5910 +972 9 955 2361 sdover@netvision.net.il
ZIMMERMANN Erik AUSTRO CONTROL Gesellschaft für Zivilluftfahrt GmbH Training Dept. 11 Schnirchgasse A-1030 VIENNA AUSTRIA	Tel: Fax: E-mail:	+43 1 1703 2003 +43 1 1703 2006 erik zimmermann@austrocontrol.co.at

Intentionally left blank

ABBREVIATIONS AND ACRONYMS

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

a/c	Aircraft
ACC	Area Control Centre
AENA	Aeropuertos españoles y Navegación aérea
A/I	Accident(s)/Incident(s)
ANA	Aeroportos e Navegaçao Aérea
ANS	Air Navigation Services
APP	Approach Control Office
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer/Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
ATSA	Air Traffic Services Authority
CAA	Civil Aviation Administration/Authority
CEU	Central Executive Unit
CENA	Centre d'études de la Navigation aérienne (F)
CFIT	Controlled Flight Into Terrain
CFMU	Central Flow Management Unit
CNS	Communications, Navigation and Surveillance
CRM	Cockpit/Crew Resource Management
CRNA	Centre régional de la navigation aérienne
CSCW	Computer-Supported Computer Work
DAC	Direction Aviation Civile
DED	Directorate EATCHIP Development

DEI	Directorate EATCHIP Implementation
DEL	Deliverable
DFS	Deutsche Flugsicherung
DLR	Deutsche Forschungsanstalt für Luft- und Raumfahrt
EATCHIP	European Air Traffic Control Harmonisation and Integration Programme
EATMS	European Air Traffic Management System
ECAC	European Civil Aviation Conference
EEC	EUROCONTROL Experimental Centre
ENAV	Ente Nazionale di Assistenza al Volo
ET	Executive Task
EU	European Union
EWP	EATCHIP Work Programme
FAA	Federal Aviation Administration
FANS	Future Air Navigation Systems
FL	Flight Level
HCI	Human Computer Interaction
HFs	Human Factors
HMI	Human-Machine Interaction
HRI	Human Resources International (Ltd.)
HR(T)	Human Resources (Team)
HUM	Human Resources Domain
IANS	Institute of Air Navigation Services
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IFATCA	International Federation of Air Traffic Controllers' Associations

JAA	Joint Aviation Authorities
JAR-OPS	Joint Airworthiness Requirements Operations
LOFT	Line-Orientated Flight Training
NASA	National Aeronautics and Space Administration (USA)
NATS	National Air Traffic Services (UK)
NTSB	National Transportation Safety Board (USA)
OJT	On-the-Job Training
OPR	Operator
OPSroom	Operations room
PTRMC	Prototype Team Resource Management Courseware
REP	Report
R&D	Research & Development
R/T	Radio/Telephony
SOPs	Standard Operational Procedures
ST	Specialist Task
TRM	Team Resource Management
TWR	(Aerodrome Control) Tower
WG	Working Group

Intentionally left blank