State of the art on field data collection about air traffic control normal operations

Perspective on Normal Operations Safety Survey (NOSS)

direction générale
de l'Aviation civile

direction des affaires
stratégiques et techniques

sous-direction
de la sécurité et de
l'espace aérien

bureau des aéronefs
et de l'exploitation

06.02.07

DGAC/DAST

NOSS

STATE OF THE ART ON FIELD DATA COLLECTION ABOUT AIR TRAFFIC CONTROL NORMAL OPERATIONS

CONTRACT N°C1870

http://www.sofreavia.fr

TABLE OF CONTENTS

GLOSSARY

EWA	Ergonomic Work Analysis
ATC	Air Traffic Control
ATM	Air Traffic Management
ASR	Air Safety Report
CENA	Centre d'Etudes de la Navigation Aérienne [Air Navigation Study Centre] (currently SDER)
CRM	Crew Resource Management
HF	Human Factors
IATA	International Air Transport Association
LOSA	Line Operations Safety Audit
LOSANGE	Line Oriented Safety Analysis using Naturalistically Gathered Expertise
NOM	Normal Operations Monitoring
NOSS	Normal Operation Safety Survey
NOSSSG	NOSS Steering Group
NOTECHS	Non Technical Skills assessment
ICAO	International Civil Aviation Organisation
REX	Voluntary feedback of experience
SDER	Sous Direction Etudes et Recherche (formerly CENA)
STAFH	Suivi sur le terrain des acquis Facteur Humain: Field Survey of Human Factors Acquisitions
TEM	Threat and Error Management
TRM	Team Resource Management
UT	University of Texas
SMS	Safety Management System

1. INTRODUCTION

1.1 Context

NOSS (Normal Operation Safety Survey) is an approach associated to an observation based technique, to capture how the ATM system functions in operational conditions, barring incidents, in order to detect the possible sources of risk as soon as possible.
The NOSS approach consists in carrying out structured observations (with a "magnifying glass" on the threats and errors management) by controllers trained in the observation technique, in air traffic control settings, during "normal" working sessions, outside incidents. The need for this type of undertaking was identified in 2001, drawing a parallel with LOSA (Line Oriented Safety Audit) for the airline companies. NOSS was created in 2003 and a study group (NOSSSG) was created by ICAO in 2004 in collaboration by Eurocontrol, LVNL, DFS and the University of Texas. This group worked rapidly as the first tests were conducted in 2005 in Australia and New Zealand.
The NOSS concept is supported by the ICAO as an integral part of the SMS for obtaining data on threats, errors and undesired states that does not rely on the individuals involved.

NOSS appears also as a means to collect data on controller activity from a threats and errors management point of view, with the chosen means being limited to the structured observation carried by field activity experts.
In order to better apprehend this method and to contrast it with the other methods of analysis of observation of the controllers initiated in France, it seemed necessary provide a report on the analysis of the activity in ergonomics of French language (or EWA for Ergonomic Work Analysis) and more specifically on the methods of collection of data such as field observation and interviews. This summary enables a better description of the various observation methods of controllers' activity in terms of input and limitations and to position NOSS amongst these methodologies. An investigation into experience feedback (REX) methods is also offered to supplement this state of the art on field data collection.

1.2 Why compare NOSS to EWA and REX?

At first glance, these three approaches have different aims (though the NOSS and the REX both take part in the same process):

- NOSS aims at collecting information on controllers' practices whose work generate or aims at managing threats and contextual elements of external threats. The collected items must allow a diagnosis about hazards being confronted and allowing development of countermeasures.
- EWA aims at collecting operator's activity data for developing an understanding of work practices. The identification of the operators' actual practices, the operating modes, the management strategies of the controlled processes are the elements used for designing workstations and conceiving operating modes and procedures.
- The REX aims at collecting incident narrations (or near incident) written by the operators themselves and which describe the actions taken in a specific context, thus aiming at setting up defences at controller and organisational level.

Nevertheless all 3 approaches share an interest in the operator's activity. The means used are often quite close (observation). The form of data and their treatment respectively differs depending on the collection mode specific characteristics (NOSS and EWA versus REX), and of their goals. Therefore methodology transfer from one approach to the next might be possible to try and optimise data quality and validity.

1.3 Aims of the report

- To remind of the specificities of the French ergonomics,
- To characterise Ergonomic Work/activity Analysis (EWA) and its means to collect data such as observation and interview,
- To present controllers' activity analytical methods using observation and interview,
- To position NOSS compared to these controllers' EWA methods.

- To link NOSS to the existing REX procedures.

1.4 Structure of the report

Chapter 2 of this report is dedicated to a brief summary of "Activity Analysis" in French ergonomics. This approach, typical of ergonomic intervention, represents an unavoidable reference when trying to comprehend the reality of a job setting to understand and transform it.
Chapter 3 presents applied examples of this approach in the Air Traffic Control and a synthesis of the controller's duties identified by numerous field studies.
Chapter 4 is dealing solely with data collection via voluntary experience feedback. The analysis of the operators' narrations represents an essential source of information for the understanding of controllers' activity.
The last chapter contrasts NOSS to the French ergonomics methodological basis.

2. ACTIVITY ANALYSIS IN FRENCH ERGONOMICS: SUMMARY ON OBSERVATION AND INTERVIEW

2.1 French Ergonomics

2.1.1 Ergonomics and Ergonomics in French

Since 2000, an international consensus exists as to the definition of ergonomics, and this thanks not only to the valorisation of the various missions, works and field studies worldwide, and to the acknowledgement of the consultant in ergonomics, but also thanks to the various research on the ergonomics method of intervention.

Definition of ergonomics by the International Ergonomics Association (IEA)

> *Ergonomics (or the study of human factors) is a scientific discipline aiming at the fundamental understanding of the interactions between human beings and the other components of a system, and the implementation in concept of theories, principles, methods and relevant data in order to improve the human well being and the overall efficiency of the systems.*
>
> *The ergonomists take parts in the conceptualisation and the evaluation of the tasks, the work, the products, the environment and the systems in order to make them compatible with people's needs, abilities and limitations.*
>
> *Its name coming from the Greek argon (work) and norms (laws) to define it as the science of work, ergonomics is a discipline using a systematic approach in the study of all aspects of human activity. The practicing ergonomists must have a wide understanding of the discipline extent, because ergonomics advocate a holistic approach which takes into account physical, cognitive, social, organisational, and environmental and other factors.*

Previously, when referring to ergonomics, it was necessary to distinguish between two trends:

- The Anglo-Saxon trend where research were initially essentially done in laboratories to improve knowledge on mankind. However, these researches were sometimes lacking realism compared to the real world of work. Thus, the Anglo-Saxons came looking for the French methods of ergonomics.
- In this second trend, called French ergonomics, as well as Ergonomics Analysis of French Tradition (AETF) or Activity Ergonomics, scientists such as Faverges or Jacques Leplat insisted, during the sixties, on the importance of analysing the worker's activity in real situations.

The two trends are obviously complementary to each other. The knowledge of workers' behaviour must be increased by laboratory and field research (which is why full scale simulator are more and more often used as they enable to carry out intermediary research between, on the one hand, the world of work where control of the variable is quasi impossible and, on the other hand, the world of laboratory).
This distinction can be found when trying to lift the ambiguity between the terms Ergonomics and Human Factors. For Bugs (2001) and the ACE (Association of Canadian Ergonomists), the lack of distinction between these two terms reduces ergonomics. The current problem of the *Human Factors* make it assume that to take into consideration some human characteristics in the conceptualisation is enough to practice ergonomics whereas ergonomics through work analysis provides its own knowledge on the person in activity (development of activity models as well as intervention models).
It is to be noted that for ten years or so, the Anglo-Saxons have integrated the value of the French ergonomics into their works such as Rasmussen (1997) or Hollnagel (1993), yet a part of French Ergonomics have not reciprocated.

Summary table of the differences between the French ergonomics and the Human Factors trends:

Human factors	*French ergonomics*
- is concerned with the equipment - rather normative - concept of standard - application of scientific knowledge - production of databases	- is concerned with the work - rather adapted to the user - concept of dynamic situation - rely on reality and the variety of situations

2.1.2 Specificity of French Ergonomics

Definition of French Ergonomics:

> *"Ergonomics is a scientific discipline which studies the functioning of humans within the framework of professional activities: it is a technology which gathers and organise knowledge so as to make it usable for the conceptualisation of the work means; It is an art when it comes to applying this knowledge to transform an existing reality or for conceptualising a future reality. Its application criteria belong to the realm of protection of the physical, cognitive, psychological and social health of the workers, the realm of the development of their professional abilities during their working lives, within a framework of production goals. "* (Antoine LAVILLE)

French ergonomics specifications:
As described in the previous chapter, specific traits define French ergonomics.
This specificity is characterised by the fact that French ergonomics is focussed on ergonomic analysis of activity in context and considers **workers as active subjects** in this analysis.
Hence, French ergonomics does not seek to deal with the (psychological, physiological ...) functions of humans but with the actions involving these functions.
Furthermore:

- It constitutes a questioning of the links between knowledge and action, which becomes a focus of study.
- It is opened to the needs born out of the evolution of the working population and of work and it initiates dialogues with other disciplines concerned with work.
- It succeeded in gaining recognition not only in the world of research and teaching but also in the industrial world.

2.2 Ergonomic Work Analysis (EWA)

2.2.1 Definition of EWA

A main trait of EWA is the analysis of activity in real work conditions. The activity analysis can be considered as follow:

> "*A look which, in a work situation, detects elements compatible with human functioning modes, and which, because of this, are sources of errors, incidents, additional stresses, unjustified tiredness or health problems.* (Vilatte, Gadbois, Bourne and Visier, 1993)

In order to comprehend the work, it is necessary to go beyond the partial representations held by the operators. It is therefore necessary to collect data during the effective implementation of this activity, that is to say being present during the undertaking of the work.
The activity analysis rests on a work done at a given moment (specific conditions) whereas the other approaches rest generally on work representations, its determinants or consequences but outside of the real undertaking of the work (for instance with the help of interviews and analysis of documents). This is this

recognition which highlights the fundamental difference between the methods relating to activity analysis and the other work approach methods.
EWA tries to read the operators' conduct from their standpoint, in order to circle the coherence they give to their actions. We are referring here to a *problem setting* approach compared to a *problem solving* logic with the use of norms (Lamonde and al. 2000).

> *"The work analysis results must render obvious the elements which in human work, or of a given population, are particularly difficult or not adapted, so as to correct this work situation for a better adaptation of people during their activity which include minding not only the health, the reduction of workloads, the improvement of work conditions, but also reaching economic targets."* (François DANIELLOU)

2.2.2 EWA's objectives:

- to observe and analyse human work,
- to identify the relevant and determining elements of the man-machine system,
- to note its functioning modes and the resources (psychological and socio-organisational) invested,
- to liaise between the expected objectives and the knowledge of human functioning.

2.2.3 EWA condition of application:

- EWA is a method to observe and understand the complexity of the activity,
- it is applied in real situations (analysis of the action in progress),
- it does not try to test a model chosen before hand,
- it is a bottom up approach as opposed to laboratory approaches,
- its implementation originates in a request,
- it proposes various causes and various solutions,
- it relies on the users' representations and experience,
- it is based on a quantitative and qualitative study (fine observation of behaviours and objectification of the facts),
- its interpretation stems from the facts, and always with the consciousness of its limitations.

2.3 Observation in activity analysis

2.3.1 Observation inputs

Observation is a data collection tool. This data is used to describe what the operators are doing and how they are doing it.
Observation is thus indispensable for collecting data on real activity.
Observation highlights the factors which influence or determine operators' activity in a given situation. Resorting to observation enable to bypass unavoidable conflicts coming from the diverging point of views of the various concerned actors.
To observe is to note variations of a category of behavioural markers (movements, data collection ...) compared to an element of the situation (type of task, timings,).
Observation is only possible for what is observable. It is thus impossible to directly observe an operator's intents or objectives, his/her reasoning, his/her data and knowledge treatment modes that he/she is implementing.
To observe, data must be collected on:

- one or many operators,

- operators interacting with tools,
- the environment.

2.3.2 Behavioural Markers:

Everything cannot be observed. Observation requires the compilation of a catalogue of variable behaviour markers (movements, data collection, verbal exchanges, ...).
What is notable is what a third party can observe in a situation: facts, behaviours, actions, expressions. It derives its meaning from its context.
Example of category of behavioural markers:

- gestures, positions, movements,
- expressions, emotional markers (paleness, agitation, sweating, shakes, ...),
- some data collection (direction of glance),
- communications, exchanges,
- the collective dimension,
- the activity results.

All these factual categories must be taken into consideration during observation, but their interest is of unequal importance depending on the nature of the work and the study objectives and what is being sought after. All depends on the variable taken into consideration during the observation.
A list of behavioural markers is proposed in appendix IV, coming from the HERA study carried on behalf of Eurocontrol in 2000, and which goal was to identify errors through observation amongst air traffic controllers.

2.3.3 Cautions associated to observation

1. TO MINIMIZE THE INFLUENCE ON THE SITUATION.

An observer is fundamentally by definition an intruder and his/her presence modifies somewhat or a lot the observed situation. To obtain reliable data, the observer must trivialise his/her presence on the field, which requires some time. Trivialisation does not only mean "to be part of the furniture or of the landscape", it is also to be accepted in a specific function that the concerned actors have perfectly identified.

2. TO UNDERSTAND THE OBSERVED SITUATION.

The efficient use of the "observation" tool relies on the prior knowledge of the specificities of the observed situation. This prior knowledge will be based, amongst other, on interviews with the operators. This knowledge is based on:

- the task (objectives, means in terms of men and machines).
- the task requirements (temporal demands or resources, ...),
- the task organisational context (hierarchy, operators' status)
- the known dysfunctions or incidents

3. DISSOCIATING OBSERVATION FROM INTERPRETATION

"To observe the work" of an operator must not be misconstrued with "to take his/her place", that is to say to imagine the reasons for the actions of this operator. Observation, not interpretation must be done; Interpretation comes later. For instance: *"S/He stretches his/her arm towards ..." must not be translated as "S/he wants to take ..." " ; "S/he is motionless ..." must not be translated into "S/he waits..." or "S/he has nothing to do ...".*
It is thus necessary to keep the observation and interpretation stages clearly separated.

4. DEVELOPING ADEQUATE TOOLS TO PERFORM A RELIABLE DESCRIPTION OF THE OBSERVED SITUATION.

The development of observation worksheet aims to circumvent these flaws. Yet, the worksheet development phase must enable the observer to identify a maximum of potentially relevant variables, that is to say that the observer has a range of various situations and the widest possible identification sheet.

5. *ORGANISING AND STRUCTURING OBSERVATION THROUGH AN OBSERVATION PROTOCOL*

The observer creates observation "protocols" in order to check that s/he obverses what had been selected for observation.
Creating observation protocols rely on:

- the stages and the chain of work processes: a same task can be done in various stages by various people,
- the possible variations of the conditions of the task completion: depending on the time of the day there could be different temporal constraints,
- the representation the operator has of his/her task: depending on his/her years of service, experience, the operator uses different stereotypes and tends to use only some data;
- the known dysfunctions.

The observer performs work **situations sampling** taking into consideration:

- the observation timing (continuous or at intervals),
- its duration and frequency,
- the places where the observation will take place,
- the workstations.

6. INTRODUCING YOURSELF AND EXPLAINING

Operators' cooperation is critical and is only possible if the observer presence does not lead to risks or complications for them: The observer must explain what is observed and why. Thus, before any observation, it is necessary to grant the concerned people with:

- a definition of the observation conditions (the stakes, destination of the results, ...),
- a guarantee as to the anonymity of the people, the secrecy of the data source,
- a rendering of the results when the analysis will be done,
- a justification of the type of data sought after,
- a definition of the observation "geographic" field,
- a precision as to the means used (video recording ...).

At that moment, the observer must not hesitate in presenting again the origin of the request, his/her approach and his/her perspectives. This explanation must not only be directed to the people in charge concerned by the study, but also to all those who at one time or another will be in contact with the observer. This information is critical to clarify local stakes linked to the study, reduce gossip and rejection risks.

2.3.4 Observation limitations

It is possible to distinguish two main types of limitation to the activity of observation:

1. PRACTICAL LIMITATIONS ASSOCIATED WITH THE IMPLEMENTATION TECHNIQUES:

To overcome these, it is necessary to create new tools.
The activity can only be observed through its visible manifestations by an observer or a recording device. Hence, even if observation appears to be the undeniable means to gain knowledge of the real activity, it is often insufficient to understand the motives for the activity, the underlying reasoning and knowledge.
It is nonetheless critical to trigger explicit clarifications from the operators because it is from those real cases that in depth exchanges on observed events and actions witnessed by the observer and experienced by the operators can be produced.

2. Limitations linked to the fact of observing:

To overcome these limitations, it is necessary to implement complementary methods.
Activity analysis based on observation can only bear on limited, and therefore specific, time slots. It is thus important during the analysis to take into account the details of the activity.
It is important to ensure knowledge of its specific conditions. To be able to identify them, it will therefore be necessary to rely on the operator(s) experience to ascertain it: This complement is critical and is to be linked to the observation.
The operators' characteristics are also defining elements of the concerned activity and the observation will have difficulties rendering this diversity. Knowledge of the population and its diversity composed a second complement to the observation.
During observation, it is not possible to observe everything, and in fact, prior to the observation and depending on what is needed (nature of exchanges, communications, movements, ...) some activities must be selected.
Observation is a selection and facts classification tool. It enables the development of a model of the work situation model amongst many other possible. Its use has only meaning if it is included in a structured study approach.
Observations do not give directly access to the operator's representations.

2.4 Interview in French activity analysis

2.4.1 What interview brings in

Interview is an exchange relationship during which various logics can exist. There are different forms of interview (free interview, semi-directed, closed, ...)
Verbal exchanges are critical. Nonetheless, data collected in this manner are only interesting if the methodological conditions are fulfilled and if nothing more than intended are extracted from the interviews.
The interviews can be individual or collective. The results obtained are various. Individual interviews are generally focussed on the execution of the task, whereas collective interviews concentrate more on the organisation of the work.
Interviews used during a study about an existing situation or during the identification of the users' needs aim at various objectives. They enable:

- the presentation of the methods used to the concerned actors of the study;
- the users to voice their needs, their demands and their expectations;
- the access to the representation held by the operators of their work, to the knowledge required for its performance, to the work relationships within the organisation, to the difficulties encountered and the means to solve them;
- the validation of the observations, the interpretations of the observed behaviours. This validation allows the opening of new explanatory tracks through the collection of users' comments.

2.4.2 Cautions associated to interviews

Interviews concentrate on the work done by the actor, on the work organisation, and on work relationships. The technical setups, equipment and software, work variations, conditions of completion, and work difficulties are generally collected without much probing. The interviewer reformulates without interpretation the elements seemingly the more conductive as to the actor's representation of his/her task. Reformulation is also a means to ensure the interviewer perfectly understood what was said.
The interview's aim is not to pass judgement or an opinion, but to understand the interviewee's logic, to help him/her formulate and express his/her needs and difficulties.
An interview guide introducing the main themes to be dealt with during the interview can be sent to the interviewee before hand so that he/she can prepare - for instance- documents that would be useful.
The format: The interview situation implies an exchange and equality relationship. The interviewer introduces himself or herself, explains his/her mission, the aims of the interviews and the rules of the "game" (source confidentiality, output ...). S/he must remind that s/he remains available to the interviewee after the interview for potential complement of information or corrections. S/he specifies that the collected data shall only be used with the agreement of whoever provides it.

2.4.3 Limitations associated to interviews

The interviews only give access to the representations of the tasks and means to execute them held by the operators.

Some expertise cannot be expressed. The know-how and know-how to say are not exactly matching.

Verbal exchanges can only give access to the subjects' representations and not to reality. These must be validated, confronted to data obtained by other means (observations and measurements). It is only when put in relationship with those that verbal exchanges are of interest. The differences between discourse and data collected by other means might stem for various reasons:

The cognitive process is not entirely conscious: the acquired experience is erased from the conscious mind as it does not generate problems anymore and is seldom spontaneously mentioned.

The speaker omits more or less unconsciously some facts. S/he describes what s/he supposed to do, not what s/he is really doing. S/he keeps quiet practices that s/he knows to be unorthodox, difficulties s/he attributes to his/her shortcomings even if they are shared by all. S/he "uses" the listener to "pass on messages" distorting more or less reality to do so.

Some themes are not mentioned such as the fear no to do the job, the feeling to be incompetent, the fear of being judged. Some taboos exist concerning work relationships, hierarchy and submission to authority. They hide important difficulties which can be reduced by technical-organisational solutions.

3 EWA's applications in air traffic control

3.1 Generalities

This chapter aims at presenting some studies or projects carried in air traffic control which requested the use of French ergonomics methods. The applications described here below only represent a small sample of the existing work in this field. They were selected because of their lateness, their link to the NOSS or because they constitute a known reference in this field. Older works, considered to be references in this field, are listed in the appendix.
Each study presented here applied the activity analysis principles of the French ergonomics with various purposes. These purposes can be the conception of a non-technical competency acquisition method for air traffic controllers or the conception of technical devices for the controller (definition of a specific system or tool).

3.2 Illustrations by recent studies

3.2.1 Study HERA-Observe (Human Error in ATC) conducted by Eurocontrol in 2000/2001

Year: 2001
Project manager: Eurocontrol
Target: Investigators and the people responsible for the safety of the European air traffic control centres
Objectives:
The general objective of the HERA project is to better characterise the role of human error in the ATM safety and the management components, that is to say detection and recovery. This aims at improving ATM safety management for which taking into account of human error is unavoidable as in all high-risk areas.
Phase 1 of the HERA project enables the development of a detailed methodology as well as specific techniques for analysing and learning from errors committed during ATM incidents and accidents (post analysis of incidents).
Phase 2 aim is to explore more profoundly the operational applications of this technical analysis of the error linked to the following safety fields:

- HERA-Observe: to develop an approach using the HERA technique to observe in real time the way in which human error is detected and managed in real time simulation conditions or operational conditions.
- HERA-Predict: to develop the potential HERA classification as an ATM prediction tool (prediction of error occurrence) within the framework of environment changes.
- HERA-SMART: to develop a methodology and an exploitation tool of the various safety events for ATM safety managers.
- HERA-Train: to develop training for the application of HERA error analysis techniques in the investigation files on incidents and accidents for investigators and safety managers of the member states.

Object of HERA-Observe study:
The principal means of validation of the HERA method is the observation of human errors in real time simulation and the analysis of these errors with the help of the techniques described by HERA. Another objective of the study is to gain an idea of scale of the level of errors committed by the controllers. The results of this study were presented in two parts:

- Firstly, by giving the definition of an observation methodology based on the HERA technique (classification), in order to catch controllers' errors (and generally speaking their performance) in a simulated environment at the Eurocontrol experimental centre;
- Secondly, by developing a stronger methodology for error collection and analysis (Tool Kit), based on results obtained.

The various phases of the method (Tool Kit):
The Tool Kit describes the methodology to collect the data pertaining to human (the controller's) errors and the analysis method of those errors.

There are 3 main stages. For each stage, various support materials are available to assist in their completion. This includes a description of the documents and explanations of their usage. They also contain advice for the implementation of the data collection method itself.

- Stage 1: Observation of controllers
  - Presentation of the observation objectives to the observed controllers
  - Indicative list of operational behavioural markers in ATC (see appendix V)
  - Supports to observation check-list
  - Series of instructions for observers
  - Observation log (worksheet) including a diagram of the radar screen
- Stage 2: Observer debriefing
  - A log for the preparation to interview with the controller
  - The principles for questioning in preparation for the interview
- Stage 3: The interview with the observed controller(s)
  - An introduction text of this stage for the controller(s)
  - A notebook
  - Controller self-evaluation cards (situation control, risk evaluation)

Results

Three problems were identified during the observations of real time simulation exercises. Firstly, error and violation definitions must be shared between all observers. Secondly, the method requires not only an ATC expertise, but also a psychological expertise to understand the cognitive elements of the controller’s work (not directly observable). Thirdly, the observation method must be mastered to be able to distinguish between observable facts during the observation session and the controller's cognitive work. Hence, the method must manage the sensitivity differences of each professional (point of reference specific to each observer).

The main observation results during the simulations illustrate the diversity of the errors committed and indicate that their majority is linked to the planning and decision-making process. This is coherent with the work done during Phase 1 of the HERA study project where the incidents and accidents reports were analysed. Observation and consecutive interviews explored the reasons behind the controllers' decisions. Thus, it was revealed that some elements remained invisible to the observers, whereas they were critical to the controller’s decision-making process. Actually, many controllers’ actions could be qualified as performance adjustment (proceeding one from the other) rather than errors strictly speaking.

Therefore the observation method was efficient in collecting data. A sufficient amount of data was thus collected and the HERA analysis method could be used. The results were nevertheless more geared towards uncovering the mechanisms of situation control (by adjustments) and safety margins management rather than uncovering errors. These mechanisms seem actually to be at the heart of the controllers' activity.

3.2.2 ODS Phi base study conducted by the SDER in 2002

Year: 2001-2002

Project manager: SDER (DGAC)

Target: Air traffic controller for sectors Under Way

Objectives: To proceed to a feedback of experience collection after a 6 months use of a new technical control environment (ODS) leading to an evolution in work methods.

Framework of the method: This study is part of the search for indicators for how well adapted this new environment is, focussing particularly on the appearance of new risks deriving from these new tools and the way in which controllers manage (or not) these risks.

The various stages of the method:

- the observation of the controllers in their activities by two expert observers, one a HF expert, the other a controller,

- the preparation of debriefings by the two observers (comparison of the collected data by each expert and preparation of the question for the interview with the observee),
- interview with the observee following the strict rules of the explicit clarifications (Vermerch).

Results: an executive summary presenting controllers' practices in managing risks with their new tool functionalities and controllers' difficulties encountered during the implementation of these practices (situation control management)
Interests: the application of EWA principles in this audit enabled the understanding of the controllers' appropriation of their new technical system and of the risk associated to the transition phase.
Limits: This approach being heavy did only allow for a qualitative analysis based on a small sample of 10 controllers selected randomly.

3.2.3 STAFH (Field Survey of Human Factors Acquisitions) conducted by the SDER in 2004

Year: 2004-2005
Project manager: SDER (DGAC)
Target: the air traffic controllers
Objectives:
The awareness, acquisition and/or maintenance of professional practices with HF components (non technical competencies and their impact on safety), approached theoretically in the TRM (Team Resource Management) stage. This awareness is done through the implementation of observations and debriefings by controllers (with the help of the STAFH method) during simulations.
Method's framework:
Instructors having a good knowledge of HF concepts mobilised in the Air Traffic Control activity (notably thanks to the TRM) are trained to the STAFH approach (minimum 2x3 training days). They are able to offer on a voluntary basis STAFH sessions to the controllers (during initial or continuous training). These sessions are divided in various stages. They occur either as simulation work or real working conditions.
The various stages of the STAFH sessions:

- Observation: The STAFH observer notes up to 5 behavioural markers (the observed controller's behaviour, facts, ...) involving a set of non technical competencies and their context of appearance.
- Debriefing preparation: The observer alone will formulate a hypothesis for each behavioural marker and develop questions aiming at checking the validity of the hypothesis. The formulation of these questions follows a certain number of rules and is backed up by techniques assimilated during the training to the STAFH method.
- Debriefing: The Observer and observee meet. Each behavioural marker will be debriefed following the questions formulated during the previous stage as a guide. For the observer, the interest of this stage does not lay in checking the validity of the hypothesis formulated, but the setting up of an open think-tank for the observee to reflect on the behavioural markers (implementation situation, stakes and risks) insofar as acquired or interesting to master non technical competencies are concerned. This stage ends with the formulation of a conclusion and, if deemed necessary, of improvement targets for the observee.

Expected results:

- The awareness of the real connections between the TRM (setting up of an open think-tank on its own practices by the controller) and real work.
- An improvement of the management of non-technical competencies as well as the implementation of professional practices more adapted to the activity.
- An optimization of controllers' behaviour when confronted to situation with the final aim being the improvement of the safety.

Interests:

- The linkage of the concepts developed in the TRM (Team Resource Management) for the controllers (Approach and En Route) with their daily practices.

- The follow up and improvements of the knowledge of and acquisition in Human Factors concepts for the controllers due to an awareness or a better identification of the non-technical competencies involved in their activity.
- The setting up of a structured debriefing relying on proven interview techniques (facilitation, re-formulation, explicit clarifications, behaviour management, communication agreement) enabling to minimize a great number of biases.

Limits:
In the current development stage of the method, there is no recording means for the collected data during STAFH sessions. Organisational learning process is therefore not possible as there is currently no database like tool to compile results anonymously.
The STAFH approach is a French adaptation of the BOOM (Behavioural Oriented Observation Method) approach developed by Eurocontrol, as an integral part of the TRM process. The French version particularly developed the interview techniques used during debriefing as well as the references to the content of the French TRM.

3.3 The identification of the HF specificities of the controller's work thank to the studies of French ergonomics.

The studies conducted for almost 30 years in air traffic control by research centres and Human Factor consultants enable the definition of the air traffic controller's work specificities. These specificities make this work difficult to comprehend solely from its observation, and indicate the hidden complexity of the processes involved in the air traffic controller's activity.

3.3.1 A few specifics of the air controller's work

1. WORK ESSENTIALLY COGNITIVE

The controller's work is dominated by a cognitive know-how about building up control strategies. The behavioural markers are thus very few. The use of interviews is compulsory if the objective is to understand and transform the activity.

2. GREAT VARIABILITY OF THE ROUTINE

The air traffic controller must face both routine and "never exactly identical" situations. There is a general way of working (processes, practices, automatisms) but a tiny environmental modification can force a total modification. Very little is needed from a normal situation to develop into a difficult one to manage: the weather, a pilot acting differently from expectations. The controller thus constructs an action plan for the situation as it unfolds itself at a moment *t*, and s/he must accept that everything, all parameters, cannot be taken into account (the situation is too complex). However this action plan must be extremely flexible to be able to adapt to changes. Furthermore, the situation must be closely monitored, as it is extremely dynamic and can suddenly change. In the following paragraph, we shall try to clarify the constraints associated to the HF.

3. "COUPLING/INTERDEPENDENCY" OF A SECTOR WITH THE ADJACENT SECTORS

The controller must at the same time fulfil his/her duties within *his/her* sector while inheriting the situation from the previous sector. This "legacy" depends tremendously on the colleague's way of working (choice in the problem solving process, and more generally speaking in the risk management strategies). In some instances, the colleague is seating just near by and both controllers belong to the same team. In other instances, the colleague is physically separated (thus not forcefully known) and the use of telephone is required for communication purposes.
The controller inherits a situation, that later will need to be handed out to someone else, and the strategies used to deal with this situation can be influenced by the next or adjacent sector. For instance, the next sector there may require workload regulation. For the adjacent sector, cooperation is almost compulsory. Therefore, there are *compulsory* cooperation (in the sense that some strategies are not compatible) and some *desirable* cooperation for the sake of safety.
Here, the importance of communication is highlighted for this job which can rely on extremely implicit forms.

4. A STRONG TEMPORAL CONSTRAINT

A third specificity of this work concerns the strong temporal constraint. This constraint is obviously linked to the operational specificities in an approach area or in an airport: The planes are closed to each others, and have little manoeuvrability during take off and landing stages.
In a dynamic situation, it is intuitively understood that there are temporal constraints: Such or such action must be done before such or such moment. And, of course, there are temporal limits beyond which a planned action is not valid anymore (it is too late, at least from the safety criteria defined by the controller, another solution has to be found, etc.). The solutions are right for a given moment, which can be extremely short. Therefore there is a moment, a time window opportunity *right* for action[1]. Moreover, the controller must manage various temporal constraints associated to various planes or conflicts between planes.
Nonetheless, mirroring this need for the management of his/her actions within temporal constraints, the controller's art consist in letting the "things come to" him/her, or even, according to controller's jargon, to let the situation "mature". Indeed, some essential elements can be missing to the diagnostics or the decision, and only the natural evolution of the situation will enable the clarification and specify if and how to act on the planes. If the work under temporal constraints (to act before) is a stress factor, the need for postponing the action or refraining from acting in some instances (wait before acting) implies a certain amount of cold blood and hence represents a very specific, very characteristic, form of stress of the controller's work.

5. CLEAR OBJECTIVES BUT A CERTAIN AMOUNT OF VARIABILITY IN MEANS

Work methods are different from a control centre to the next depending on the organisation culture (age of the controllers, history, levels and types of air traffic, specificities of the sectors to be managed, ...). Hence, there is no real reference or norm to cope with given situations, the tasks being weakly defined from an organisational point of view. The definition is often limited to a list of objectives.

3.3.2 Cognitive aspects of the controller's work

Passing from the real world to an evolving cognitive representation is done via a set of psychological filters. These filters are of various nature.
They enable to work efficiently in most situations while saving cognitive resources. It must be noted that generally, an operational loop occurs between the filtering means and the cognitive representation itself (mutual influence).
These filters are managed by a set of cognitive functions, tools or mechanisms with the best known being:

- The default reasoning: the lack of availability of some data (for instance, the descent top or the real profiles of climbs and descents, or the real pilot intentions) requires from the controller decision-making mechanisms based on partial ignorance. These mechanisms are base on a default reasoning process associated to the monitoring of the planes real behaviour on the radar image. The controller anticipates on the planes *routine behaviour* basis or "normal" basis that we shall refer to as the "default world". The default reasoning can by its nature be revised. The mechanisms associated to the revisable reasoning enable the operator to compensate for micro errors or diagnostic errors and are an essential safety factor.
- Script: an action plan which enables to activate and follow sequences of actions adapted to a given context. It can be activated by recognising patterns (specificities of a situation) and can be implemented as the action develops.
- Work sphere: this concept connects to what the controller decides to take into account during his/her activity management (Collective work). Is s/he going to consider only his/her own position and own aims? Is s/he going to integrate the adjacent sectors goals and constraints and up to what point? The response will condition the information intake and the nature of the cognitive representation.
- Risk management: This notion is composed of a set of elements which will condition the shift to a more or less precise cognitive representation:
  - Trust: in oneself, in the others, in the system. This concept is very important because depending on the level of trust at any given moment, Situation Awareness will require more or less details.

[1] The CETCOPRA researchers demonstrated that one important aspect of the controllers' competencies was the choice of the favourable moment for action. **A. Gras, S. Poirot Delpech : Facing the automation: the pilot, the controller.**

    - Metaknowledge: this name is given to knowledge that we have of our own knowledge (I know what I can do, I know my level, I know this situation well, etc.). Metaknowledge will intervene in our way to manage risk, our aim being to keep the situation under control.

- Frame of mind on the day: Risk management is also influenced by our own psychological and physiological states. (Stress, tiredness, etc.)

These filters act in such a way as to respect the limits of our cognitive functioning:

- Principle of cognitive economy: To cope with our limited cognitive resources, we choose first and foremost solutions or strategies which are cognitively the least demanding. This principle influences all the other filters. Hence, the concept of resource management is central to the controller's activity, and influences real time control strategies (the experienced workload impacts on a search for efficiency rather than stylishness)
- Attention - focus: our cognitive resource limitation makes it difficult to have a divided attention (extremely demanding in resources), but at stake here is the updating of the cognitive representation.

4 NOSS and EWA

The criticisms formulated on the NOSS methodology are the same as those formulated against the LOSA in the framework of the LOSANGE project (DGAC/DAST/SEA 2005). During this study, it was demonstrated that the methodology proposed by the University of Texas was only partially respecting the EWA principles, while having a certain disregard as to the limits of their approach (not taking into account biases and limitations in data collection during interpretation of the results).

Furthermore, NOSS is not a method for specifically collecting data adapted to the specificities of the air traffic controller's work, but rather a "cut and paste" of the method developed for commercial airline pilots. This lack of adaptation weakens even further this approach.

For a more precise description of the NOSS approach, refer to the appendices of this document.

4.1 Observation with NOSS versus observation with EWA

Insofar as we know, the training offered by the University of Texas to the NOSS observers does not show the rules, limitations and biases of such a process. It is requested of the observers to note only the facts and nothing else but the facts. However, this filtering can only be done when the consequences are known and understood. Even in this instance, such a filtering remains difficult as it requires to permanently differentiating between fact and the interpretation of fact.

In the EWA, this observation bias is taken into account and treated at the time of result analysis.

Furthermore, many items present in the NOSS form contain judgements and not facts ("Late response to alarms", "Late issuance of speed restriction", "Incorrect speed instruction", " Actively monitor and cross-check others controllers", "Operational tasks are prioritized and properly managed", "Existing plans are reviewed when necessary")

4.2 NOSS and access to controller's representations

How can you levy the ambiguity on the observed elements or get a realistic picture of the internal context of the operator (level of tiredness, awareness of the situation) without an interview with the observed controller?

The NOSS designers chose to consider the controller as a « black box », stimulated by threats and able in feedback to create visible reactions more or less adapted. This simplistic vision of the situation management processes involved and of the expertise required to perform the control task might not bring in any spectacular data on the controllers' risk management practices.

An interview adequately presented (taking all necessary precautions) so as not make the controller ill at ease and not give the feeling of an evaluation (or of a justification of actions performed during a shift) would enrich the data collected by the observer and would complete the understanding of the stakes for the controller. The interview would enable to compensate for some biases which could have appeared through the observation.

4.3 NOSS and accounting for the specificities of the controller's work

In chapter 3.3, a summary of many years of field studies highlight the specificities of the air traffic controller's work.

These specificities are as many clues to take into account when the controller's activity is to be studied, especially the way risk is managed (threats, errors, ...).

As stated in the first specifics of the role (see paragraph 3.3), the controller's work is essentially cognitive. Very few actions are visible. Hence the limitations to observation and the need for a complement to be found (interview, questionnaire, and feedback of experience) are easy to understand.

According the second specificity of the controller's work (see Paragraph 3.3.), the controller's work is a permanent adjustment in a familiar framework. Action is always implemented depending on the current context. Without consideration for this context (and of its understanding by the controller), his/her actions can easily appear to the observer as errors, even for experts in the task (even if this risk is far less important in this instance). In all instances, the post-observation interview is a means to validate hypothesis formulated during observation (error, choice, ...).

In the third specificities, the controller's work is both individual (alone confronted to his/her traffic) and collective as s/he depends on the adjacent sectors. His/her action can therefore find justification in constraints coming from the collective work. The consideration of this collective work during the observation is therefore advised. Yet, nothing in the NOSS approach shows such a consideration.

5 A complement to real work observation: feedback of experience

Data collection on controllers' real work cannot be reduced to a single approach. As the airlines did, the French air traffic control centres developed various types of tools to look for the precursors to the dreaded events within the framework of the controllers' normal activity.
The feedback of experience is one of the means to reach this objective. The setting up of a NOSS type approach could therefore find or be part of a complement of information in the feedback of experience.

5.1 The principle of the feedback of experience (REX)

The necessity to learn lessons from more or less serious events (catastrophes, accidents, incidents) having involved or susceptible to involve large systems safety is more and more acknowledged. Thus the practice of "experience feedback" tends to become more generalised throughout large public and private organisations.
On the one hand, this concept is often understood in its general meaning: it is always good to investigate systems dysfunctions in order to improve the overall quality. But, on the other hand and in so far as safety is concerned, the "established" high risk business (aeronautics, nuclear) have for a long time formalised experience feedback of procedures (referred to as REX) with the obvious goal to progressively reduce accidents and (or) their seriousness.
All high-risk activity sectors use experience feedback not only from a technical perspective but also in management (Road transport, SNCF, RATP). Experience feedback tends to get integrated into some companies' safety culture.
The example of Air France is a demonstration of the efficiency of the implementation of a coherent system of experience feedback channels.
The generic REX process consists of various stages:

- The identification of an abnormality or difficult experience during a flight by the flight crew or a system.
- The use by the flight crew of a REX form, ensuring anonymity and including various fields: the operational conditions and/or the weather, the description of the event, the experience of the flight crew, the role played by company procedures in the problem management, the role of personal experience in the problem management, suggestions to limit the reproduction of this type of problem.
- Analysis by the flight safety service (or the flight safety officer)
- Publication of the REX to the attention of the pilots in the company periodicals and/or the use of this event in the (theoretical or practical) trainings

5.2 Application of this principle in French air traffic control: the QS subdivisions

5.2.1 The QS missions

The mission of the entity of Quality of Service and Safety is to:

- To detect all shortcomings, dysfunctions and/or drifts, having an impact on safety and the quality of the given service.
- To propose to the head of department all measure aiming at avoiding the occurrence and/or the reproduction of undesirable events.
- To organise experience feedback at local level.

To do so, the QS subdivisions have two distinct approaches:

- A reactive approach consisting in cataloguing all out of norm situations (triggering of alarm system STCA type), the airlines' complaints (Airprox) or claims. The QS thus lead each event to be investigated to a depth deemed necessary (that could lead up to simulation replay). The depth of the investigation is also depending on the potential impact of each event on safety.
- A proactive approach consisting, without waiting for the event to happen that explicitly puts safety in question, to identify the **precursors** so as to feed an analysis on the necessary safeguards to be set up. This approach finds one of its main sources of information in the controllers' voluntary report of events. This feedback of experience inspires itself of the

principle set up by Air France (described in Report 3 of the LOSANGE-DGAC project). On average, 25 cases are dealt with yearly. The supporting documents are specific to this approach (notice form, databases).

5.2.2 The organisation of experience feedback

The dissemination of information is an essential aspect in the follow up of an analysed event.
The QS subdivisions have various possibilities, depending on the control centres, to organise the experience feedback and dissemination of information:

- Wide dissemination at national and local level of the safety report;
- Awareness briefings to the controllers on themes or areas identified as factors contributing to incidental situations;
- Assignation of QS focal point in each team of controllers;
- Cooperation with the training subdivision to direct actions;
- Information to the controllers via periodical safety posters or bulletin;
- Organisations of meeting with airline companies;
- Development of training to Human Factors (TRM) in order to allow for a richer experience feedback (use of HF specific vocabulary or concepts to analyse events).

5.2.3 Handling of events

5.2.3.1 Handling at local level

Pre-analysis

The event is the object of a pre-analysis on the basis of the available elements following its notification (depending on the circumstances: ATC feedback, pilot feedback, automatic analysis of the result, preliminary data collection and preliminary analysis). This pre-analysis can, depending on the event, require the event traces to be visualised again and the involved controllers to be interviewed.

Process for the local analysis

If the pre-analysis shows that the event deserves a deeper study, the organisation creates an analysis file and collect complementary elements to identify the causes of the event to proposed lessons to be learned and measures to prevent the event to happen again.
The local analysis phase must enable, through a methodical search resting on the collection of the technical elements and the testimonies (see documents type 2, 3 and 8), the description of the context in which the event occurred.
Generally speaking, the organisation in charge of the analysis must systematically seek the cooperation of all (civilian and military) air traffic organisations, airlines, etc, during the compilation of a file, and this in order to collect the highest number possible of relevant data on the circumstances surrounding the event.
A systematic approach must be adopted for the identification of the circumstances surrounding the event.
The collected elements during this phase can lead to giving up the local analysis of the event if they reveal that the event does not correspond any more to the selection criteria taken into account.
It is down to the local organisation to study the setting up of the immediate corrective measures, without waiting for the local committee's examination.

Local analysis results

The analysis results are written in the local analysis file. This file is composed of the following components:

- closing of enquiry:
  - established facts (explanatory chronology);
  - contributory causes and factors;
  - risk and dysfunction;
  - proposed lessons and measures;

Local Quality of service/Safety committee

Seizing of the local committee

Any event can be presented for closing to the local Quality of service/Safety committee upon proposal by the QS entity, which selects it based upon its gravity and/or its interest from a learning or feedback of experience point of view.
Upon this proposal, the local safety committee president shall summon a gathering of the committee for the purpose of closing the local analysis.

Committee gathering

The committee must gather so as to deal with the event within a time frame of three months from the date of the awareness of the event.
The local safety committee examine the submitted files. They validate them and if necessary complete them. They can also have to propose other corrective actions.
Following the meeting of the local committee, a summary reflecting the content of the discussions is signed by the President and addressed to the SCTA.

Close of the local analysis

When the local analysis is finished (with or without presentation to the local committee), the organisation is in charge of:

- inputting the results into the INCA database;
- answering to the FNE writer or to the pilot-feedback form (except Airprox and files to be closed by national committee);
- transmitting to the SCTA the analysis files to be submitted to the national committee;
- insuring the feedback of experience and diffusing information on closed events;
- transmitting actions proposals to the head of the organisation.

5.2.3.2 Treatment at national level

The SCTA exploits events notified or analysed by the organisations from the national database of events, local committee summaries and received file analysis: Statistical analysis, identification of recurring causes through the various types of events and proposal of action to remedy them, feedback of experience at national level.
It validates events files aimed at being presented to the Nation Committee so as to pass them on as quickly as possible or to request complement of analysis to the organisation.

Contents of the REX

The designation by name of the organisation's air traffic agents or any other person concerned with the event must not appear in the analysis file.
The committee summary is signed by its President.
The person in charge of the referring organisation, in an accompanying letter, can formulate an opinion on the event.

The elements composing the file, hereafter listed, are to be adapted to the type of event to be analysed. The entity or subdivision of the Quality of service/Safety shall only complete the categories necessary at the analysis of the event and shall only provide appendices useful to its understanding. In case of doubt or if circumstances require it, the inquiring organisation will seek agreement to the SCTA for a reduced content.

Basic information

- Synopsis
- Established facts
- Classification of the incident
- Causes of the incident
- Lessons learned from the incident analysis

Appendixes

- Appendix 1: Detailed summary of the local committee
- Appendix 2: Work stations - work load
- Appendix 3: Weather conditions
- Appendix 4: Radio communications transcriptions
- Appendix 5: Aircraft paths reconstruction
- Appendix 6: Controllers' declaration
- Appendix 7: Pilot(s) account
- Appendix 8: Miscellaneous

Generally speaking, the organisation in charge of the enquiry must systematically seek the cooperation of all (civilian and military) air traffic organisations, carrier companies, flying clubs, etc., for the constitution of the file so as to collect the largest number of information relating to the circumstances surrounding the incident. If needs be, it could ask for help to the SCTA to get access to necessary elements hold by other organisations.

The list of actions to take and elements to provide within the file is neither exhaustive nor limited. This list is only provided as a guideline and can be adapted according to the circumstances by the organisations in charge of compiling the file and who shall try to provide all the necessary and sufficient elements and pieces of information which would enable the local committee and eventually the national committee to analyse the event in depth.

6 Conclusion

The comparison of the NOSS, EWA and REX approaches let us foresee the possibility to optimise the data collection process for each while respecting their specific objectives. For instance, we could imagine:

- The addition of an interview with the operator for the NOSS
- The reconstruction of a complete story with a pair of complementary observers (an ergonomist and an operator trained as an observer)
- The addition of a clarification interview of the narration with the writer of a REX

It is also important to note that the NOSS approach, inspired from the LOSA approach for pilots, does not take into consideration the specificities of the controller's work as presented in paragraph 3.3. Indeed, behavioural markers in the controllers' activity are far fewer than in the pilots' activities, and the logic (or strategies) of process management (plane, traffic) are only reliably accessible via interviews with the controller.

The improvement of the NOSS approach will end up by implementing a methodology very closed to that of the EWA, concentrating on the data collection of the threat management strategies, or in other words on situation control.

APPENDIX I: BIBLIOGRAPHICAL REFERENCES

Ergonomics general references:

Faverge J.M. (**1972**) Work analysis In Reuchlin M., « Traité de psychologie appliquée » (Treatis of applied psychology), Paris, PUF.

Amalberti R., de Montmollin M. & Theureau J. (eds.) (**1991**) Work analysis models. Liège: Mardaga.

Hollnagel, E. (**1993**) Human Reliability Analysis, Context and Control. Academic Press, London.

Villatte R., Gadbois C., Bourne J.-P. & Visier L. (**1993**) Pratique de l'ergonomie à l'hôpital: faire siens les outils du changement. InterEditions, Paris.

Montmollin M. (**1995**) Vocabulaire d'ergonomie. Editions Octarès,Toulouse.

Amalberti R. (**1996**) La conduite des systèmes à risques. Coll. Le travail Humain, Paris, Presses Universitaires de France.

Daniellou F. (**1996**) L'ergonomie en quête de ses principes. Editions Octarès, Toulouse.

Guérin F., Laville A., Daniellou F., Duraffourg J. & Kerguelen A. (**1997**) Comprendre le travail pour le transformer - La pratique de l'ergonomie. Editions ANACT, Collection outils et méthodes, 2e édition.

Leplat J. (**1997**) Regards sur l'activité en situation de travail. Contribution à la psychologie ergonomique. PUF, Paris.

Rasmussen J. (**1997**) Risk management in a dynamic society: a modelling problem In Safety Science, Vol. 27, N°2/3,

Amalberti R. and all . (**2000**). La maîtrise des systèmes à risques. Psychologie Française.

Lamonde F., Beaudoin M. & Beaufort P. **(2000)** Besoin d'un ergonome : quand et lequel ? In "Actes du 22e congrès de l'Association québécoise pour l'hygiène, la santé et la sécurité au travail (AQHSST)", Québec.

Buck L. (**2001**) Point de vue sur l'évolution de l'ergonomie au Canada. Dans "Comptes rendus du 36e congrès SELF-ACE, "Les transformations du travail, enjeux pour l'ergonomie", Montréal.

Laville A. (**2001**) Repères pour une histoire de l'ergonomie francophone. In the "Comptes rendus du 36e congrès de la SELF-ACE 2001 – Les transformations du travail, enjeux pour l'ergonomie", Montréal.

Leplat J. (**2002**) De l'étude de cas à l'analyse de l'activité. In the review PISTES, Vol. 4, N°2.

Reference projects quoted/detailed for this report (sources SOF/DDL/SDER):

STAFH: *Synthesis of the tests of application of STAFH (April 2005),*

ODS PhiBase:

Moulin L. & Noizet A. & (**2002**) ODS-Phibase: Retour d'expérience. Dédale pour la SDER.

ERATO:

Leroux M. (**1999**) ERATO – Dossier pour la revue Control. February 1999. SDER. On the website: http://www.tls.cena.fr/divisions/CEP/ERATO/Dossier_CONTRoL_a_lire.html

Abdesslem E., Boudes N., Bressolle M.C., Capsie C., Corredor A.F., Leroux M., Mesguen L., Paris R., Torrent Güell M.& Tremblay E. (**1998**) Rapport d'évaluation ERATO. SDER – NR98-842.

HERA:

Noizet A. & Moulin L. (**2001**) HERA - The Investigation of Human error in ATC simulation. Dédale pour EUROCONTROL.

Noizet A. & Moulin L. (**2001**) HERA - The Investigation of Human error in ATC simulation – Tool Kit. Dédale pour EUROCONTROL.

Documents for Quality Systems:

SCTA (**2000**) Nouvelle Procédure de report et de traitement des évènements à composante Navigation aérienne – Rapport du GT SCTA.

Fleury L. (**2002**) EPOQUES : Evolution des postes de travail des entités Qualité de Service Sécurité. SDER - NT01-865.

Abdesslem S., Moulin L. & Joseph S. (2003) PRATIQS – Storyline du CD de formation pour les QS. Sofréavia for SDER.

References projects for the SDER (CENA) & EUROCONTROL:

Chabrol C., Garron J., Vigier J.C., Pavet D. & Martin J.L. (**1999**) CENA PD3 – Final report. February 1999. SDER – R99-502.

Chabrol C (**2000**) Evaluation de l'IHM GEISHA Radar – protocole expérimental. October 2000. SDER - NT00-041.

Menuet L. (**2000**) Evaluation de l'outil ADAGIO BASE : Protocole expérimental. November 2001. SDER – NT00-186.

Chabrol C (**2001**) GEISHA Radar: Résultats des expérimentations – Environnement CDG. January 2001. SDER - NT01-001.

Chabrol C (**2001**) GEISHA Radar – Environnement Province: Résultats des expérimentations CENA d'octobre – novembre 2000. May 2001. SDER - NT01-093.

Chabrol C (**2001**) GEISHA Radar – Environnement CDG: Résultats des expérimentations CENA d'octobre – novembre 2000. May 2001. SDER - NT01-095.

Chabrol C. (**2001**) Meuble IFR – écrans plats : protocole d'expérimentation. October 2001. SDER - NT01-198.

Chabrol C. (**2001**) Expérimentations meuble IFR – écrans plats au STNA en novembre/décembre 2001. November 2001. SDER – NT01-200.

Garron J. (**2001**) SALADIN : Protocole d'expérimentations. July 2001. SDER – NT01-120.

Garron J. & Chabrol C. (**2001**) Pré-expérimentations meuble Approche: Réflexion sur la conception d'un guide de débriefing. October 2001. SDER – NT01-199.

Menuet L. (**2001**) Evaluation de l'outil ADAGIO BASE : Résultats. February 2001. SDER - NT01–016.

Chabrol C. (**2002**) Résultats expérimentations meuble Approche au STNA. SDER – NT02-033.

Garron J. (**2002**) SALADIN : Résultats des expérimentations 2001. March 2002. SDER – R02-003.

Rousselle M.P. (**2002**) Protocole de validation VERTIDIGI. March 2002. SDER – NT02-576.

Espagne O. & Chabrol C. (**2003**) Validation Master Plan for A-SMGCS Implementation Level I. September 2003. SDER – NT03-162.

Espagne O. & Chabrol C. (**2003**) Validation Master Plan for A-SMGCS Implementation Level II. September 2003. SDER – NT03-163.

Garron J. (**2003**) Mini-expérimentations VIGIESTRIPS. July 2003. SDER – NT03-095.

Garron J. (**2003**) VIGIESTRIPS : Résultats des mini-expérimentations manipulations. October 2003. SDER – NT03-179.

Menuet L. (**2003**) Etude de risques ADAGIO BASE – Aspects Facteurs Humains. January 2003. SDER - NT03-027.

Menuet L. (**2003**) Description des principaux rôles, procédures, outils et méthodes de travail associés aux positions de contrôle arrivée de la salle IFR à Roissy – CDG. July 2003. SDER – NT03 – 137.

Parise R. (**2003**) Guide d'entretien et d'observation pour un état des lieux dans le cadre d'EBENE (Phase I). November 2003. SDER – NT03 – 1013.

Rousselle M.P. (**2003**) Bilan des expérimentations ASTER – Interface VERTIDIGI. June 2003. SDER – NT03-756.

Chabrol C (**2004**) TAMATA Approche étape 2 : Protocole expérimental. September 2004. SDER - NT04-185.

Chabrol C & Joseph S. (**2004**) TAMATA Approche étape 2 : Résultats des expérimentations. December 2004. SDER - NT04-271.

Delain O., Chabrol C. Joseph S., Chauvin E. & Henry-Ducos P. (**2004**) A-SMGCS simulations level I & II Validation Report (2003/B79). December 2004. SDER – NE04-004.

Garron J. (**2004**) VIGIESTRIPS : Résultats des mini-expérimentations centrées sur l'écriture. April 2004. SDER – NT03-082.

Menuet L. (**2004**) Protocole expérimental des expérimentations ADAGIO 2004. January 2004. SDER – NT04-009.

Rousselle M.P. & **Benhacene R.** (**2004**) Synthèse des expérimentations ASTER. Evaluation de l'interface VERTIDIGI. June 2004. SDER – NT03-536.

Ameri Z. (**2005**) GATE-TO-GATE: Protocole experimental G2G RTS1. January 2005. SDER – NT05-012.

Garron J. (**2005**) SALADIN Etape 2 : Protocole d'expérimentations. April 2005. SDER – NT05-106.

Garron J. (**2005**) SALADIN Etape 2 : Résultats des expérimentations. November 2005. SDER – NT05-340.

Martin J.L. (**2005**) GATE-TO-GATE: RTS-1A Experimental plan (consortium version en). April 2005. SDER – NT05-098.

Martin J.L. (**2005**) GATE-TO-GATE: Organisation validation analyse RTS-1A. June 2005. SDER – NT05-165.

Menuet L. (**2005**) Résultats ADAGIO – expérimentations 2004. June 2005. SDER – NT05-171.

Menuet L. (**2005**) ADAGIO : Communication des principaux résultats des évaluations 2004/2005. October 2005. SDER – NT05-281

Hebraud C. (**2006**) GATE-TO-GATE: Protocole experimental G2G RTS-2. January 2006. SDER – NT06-006.

To be published:

Chabrol C., Claquin L., Favennec B. & Joseph - Sudret S. (**2005**) Validation of operational concept for A-SMGCS level I & II through operational trials at Paris-CDG (D3). Sofréavia pour EUROCONTROL, December 2005. TRSC19-04

Chabrol C., Joseph - Sudret S., Améri Z., Hébraud C., Menuet L. & De Beler N. (**2006**) GATE-TO-GATE: Analysis Report of DSNA Real Time Simulation RTS1 (RTS - 1A & RTS-1B). SDER.

Hébraud C., Joseph - Sudret S., Joblet L., De Beler N. & Menuet L. (**2006**) GATE-TO-GATE: Analysis Report of DSNA Real Time Simulation RTS2. SDER.

LOSANGE reference reports:

Moulin L., Joseph S. & Claquin L. (2004) LOSANGE – Etat de l'art LOSA. Sofréavia pour la DGAC/DAST.

Moulin L., Joseph S. & Claquin L. (**2005**) LOSANGE – Les modalités alternatives à LOSA. Sofréavia pour la DGAC/DAST.

Moulin L., Joseph S. & Claquin L. (**2005**) LOSANGE – La récolte de données de terrain dans les compagnies partenaires et LOSA. Sofréavia pour la DGAC/DAST.

Klinect J. R., Wilhelm J. A. Helmreich R.L. (The University of Texas) (**1999**). Threat and Error Management: Data from Line Operations Safety Audits. In Proceedings of the "Tenth International Symposium on Aviation Psychology" (pp 683-688). Colombus, OH: the Ohio State University. (UTHFRP Pub241).

Human Factors Research Project (University of Texas). (**2001**). Human Factors Checklist (Version 7.0)

Tesmer B. (Capt, Continental Airlines)**, Sumwalt R.** (Capt, ALPA Safety)**, Anderson J.** (Capt, Delta Airlines)**, Gunther D.** (Capt, Continental Airlines)**, Helmreich R.** (Dr, University of Texas)**,** Human Factors Issues – Line Operation Safety Audit. In Proceedings of the "ATA Operations And Safety Forum 2000". On the website:
www.air-transport.org/public/committees/p_oc/pda.asp?nid=4440

Klampfer, B., Flin, R., Helmreich, R.L., Hausler, R., Sexton, B., Fletcher, G., Field, P., Staender, St., Lauche, K., Dieckmann, P., & Amacher, A. (**2001**). Enhancing Performance in High Risk Environments: Recommendations For the Use of Behavioural Markers. Document presented at the "Behavioural Markers Workshop" sponsored by the Daimler-Benz Stiftung **GIHRE**-Kolleg, Swissair Training Center, Zurich, 05 & 06/07/ 07 (UTHFRP Pub2001).

Bove T. (RisØ National Laboratory). (**2002**). Development and Validation of a Human Error Management Taxonomy in Air Traffic Control. Report of the RisØ National Laboratory - (RisØ-R-1378(EN)).

Klinect J. R., Murray P., Merritt A. & Helmreich R. (University of Texas) (**2003**). Line Operations Safety Audits (LOSA): Definition and Operating Characteristics. In Proceedings of the "12th International Symposium on Aviation Psychology" (pp. 663-668). Dayton, OH: The Ohio State University.

Maurino D. (ICAO) (**2003**) Monitoring Normal Operations and the Line Operations Safety Audit (LOSA) – The Perspective of ICAO. Presentation at the "Royal aeronautical Society Conference on Mitigating Human Error", London, 15/11/2003.

ICAO (**2006**). Safety Management Manual (SMM) - Doc 9859 AN/4 - First Edition 2006.

APPENDIX II: MINUTE OF INTERVIEW WITH I. LAPORTE WULLENS (HEAD OF FEEDBACK OF EXPERIENCE OF THE DTI-SDER PROGRAMME)

Reserved

APPENDIX III: MINUTE OF S.FIGAROL ((WORKSHOP NOSS ICAO/EUROCONTROL)

Reserved

APPENDIX IV: MINUTE OF L.MOULIN ((WORKSHOP NOSS ICAO/EUROCONTROL)

Reserved

APPENDIX V: EXAMPLES OF BEHAVIOURAL MARKERS: THE HERA PROJECT

The observed position is that of the radar operator.

Receipt of the information on the flight plan:

- Lack of reaction on flight specifics (level, plane performance).
- Unsatisfactory/incorrect note taking regarding the flight plan specifics
- Lack of reaction of the OC to an anomaly in note taking
- Incoherence in strip positioning

Acquisition of the plane:

- Absence of immediate answer to the pilot
- Exchanges/communication with the pilot:
    - Lack of reaction to an error committed by the pilot (call + match)
    - Communication of an incorrect information
- Absence of note taking on the strip
- Incorrect note taking on the strip

Intervention on the sector:

- Intervention initiated by the pilot (specific requests)
    - Absence of immediate answer to the pilot
    - Adaptation/relevance of the answer given

- Intervention initiated by the controller
    - HCI: Lack of/incorrect note taking
    - Exchanges/communication with the pilot:
        - ➢ Lack of reaction to an error committed by the pilot (call + match)
        - ➢ Communication of an incorrect information
    - Instructions:
        - ➢ Instruction not adapted to the environment (traffic, structure, air space, unbundling strategies of the control room)
        - ➢ Lack of required action (from the observer's point of view)
    - Controls/checks: Lack of reaction to an instruction not followed by the pilot
    - Coordination RC/OC: OC’s action not relevant (problem of understanding)

Treatment of conflicts:

- Absence of note taking on the strip
- Provisional note taking (OC or RC)

- Negative reaction towards the OC
- STCA

Transfer to the next sector:

- Exchanges/communication with the pilot:
  - Lack of reaction to an error committed by the pilot (call + match)
  - Communication of an incorrect information
- Incorrect classification of the strip
- Conformity of the outbound configuration (level, vector)
- Conformity of the outbound sector (visible on the strip)
- Transfers too early/too late (extremely subjective behavioural marker)
- Refusal of the conterminous sector during coordination
- Lack of coordination with the conterminous sector

Control strategy, global vision:

- Incorrect point of measurement of the relative distance
- Obvious change in strategy
- Omission to feedback to a flight path
- Lack of de-grouping (from the observer's point of view)

Behavioural markers:

- Verbal or non-verbal expression (for ex. a facial expression) of incertitude
- Thoughtful attitude
- Any behavioural marker: interjection, excitation, etc.
- Pointing at the radar screen or towards a strip

Elements to be systematically collected

- Plane code
- Time code
- PSF

APPENDIX VI: ABOUT THE AUTHORS AND THE REPORT

The authors of this report at Sofréavia are named here after:

The project manager, **M. Ludovic MOULIN** is an expert in Human Factors (Ergonomics psychologist with a Masters in ergonomics) with 10 years experience in fields such as aeronautics and nuclear, and in activities as varied as air traffic control, piloting, cabin safety, nuclear maintenance, nuclear centrals management. The carried out interventions consisted with the production of reports of studies, programmes and supports of formation (CRM, TRM, and other formations on the topic of the HF and safety) and the development of methodologies of observation of non-technical competences. The techniques used for these works, other than the classical approaches such as work analysis and individual interviews, the trials, did often consist in animating interdisciplinary workgroups.

M. Laurent CLAQUIN is a specialist in Human Factors (Ergonomics psychologist with a Masters in ergonomics) with 6 years experience in various fields such as the industry, the services, the aeronautics and the nuclear, with each time the objective to improve safety and/or health. Thanks to his various advice and study missions, he developed competencies in the conceptualisation of methodologies, in Human Factors evaluation tools, and in training. His participation in cockpit simulations and projects associated to NOTAMs enabled him to acquire experience in onboard activities.

The profile of the proofreaders having approved this document at F-DGAC/DAST (Direction Générale de l'Aviation Civile Française / Direction des Affaires Stratégiques et Techniques) is presented here below:

M. Stéphane DEHARVENGT is Chief Scientific and Technical Advisor Human Factors for DAST at DGAC-F. He is an aeronautical engineer with a Masters in Ergonomics. He is currently working on an Ergonomics PhD. From an international point of view, he represents DGAC-F within JAA-HFStG in his functions as president, and to the ICAO Flight safety and Human Factors study group. He is responsible on behalf of the EASA of the regulatory proposal EASA CS-25 on the Human Factors cockpit certification following the harmonisation group JAA-EASA/FAA. He was also an evaluator and a technical adviser to the EU-DG TREN for the civil aviation research study. In addition, he has competences in Design and Certification of cockpit (he is the Human Factors specialist in the A380 Certification), in CRM, Experience Feedback – Flight Data Analysis, and in Cabin Safety. Furthermore, he teaches aeronautical engineers and ergonomist's on regulations related to the Human Factors in aeronautics, experience feedback and Cabin Safety. He has a private pilot licence for the last 11 years.

*** End of the document ***

direction générale
de l'Aviation civile

direction des affaires
stratégiques et techniques

sous-direction
de la sécurité et de
l'espace aérien

**bureau des aéronefs et
de l'exploitation**

50, rue Henry Farman
75720 Paris cedex 15

téléphone : 01 58 09 46 87
télécopie : 01 58 09 45 13
mél : stephane.deharvengt
@aviation-civile.gouv.fr