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CAATS

Cooperative Approach to Air Traffic Services

**Deliverable D1.4
Safety Report**

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CAATS Safety R&D Workshop Report

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Executive Summary

This report summarises the results of a stakeholder workshop held in October 2005 in EUROCONTROL on the subject of European ATM safety Research & Development (R&D). The aim of the workshop was to bring together for the first time a representative set of people from the full spectrum of organisations involved in ATM Safety R&D, to consider the priorities in ATM Safety R&D. This was achieved with more than 58 people attending from a total of 28 organisations and companies from 13 countries in Europe, as well as invited attendance from the US and the European Commission (EC). The workshop was funded by the EC CAATS (Collaborative Approach to Air traffic Services) project which aims to develop and disseminate best practices in Safety, Human Factors and Validation processes in ATM.

Workshop organisation

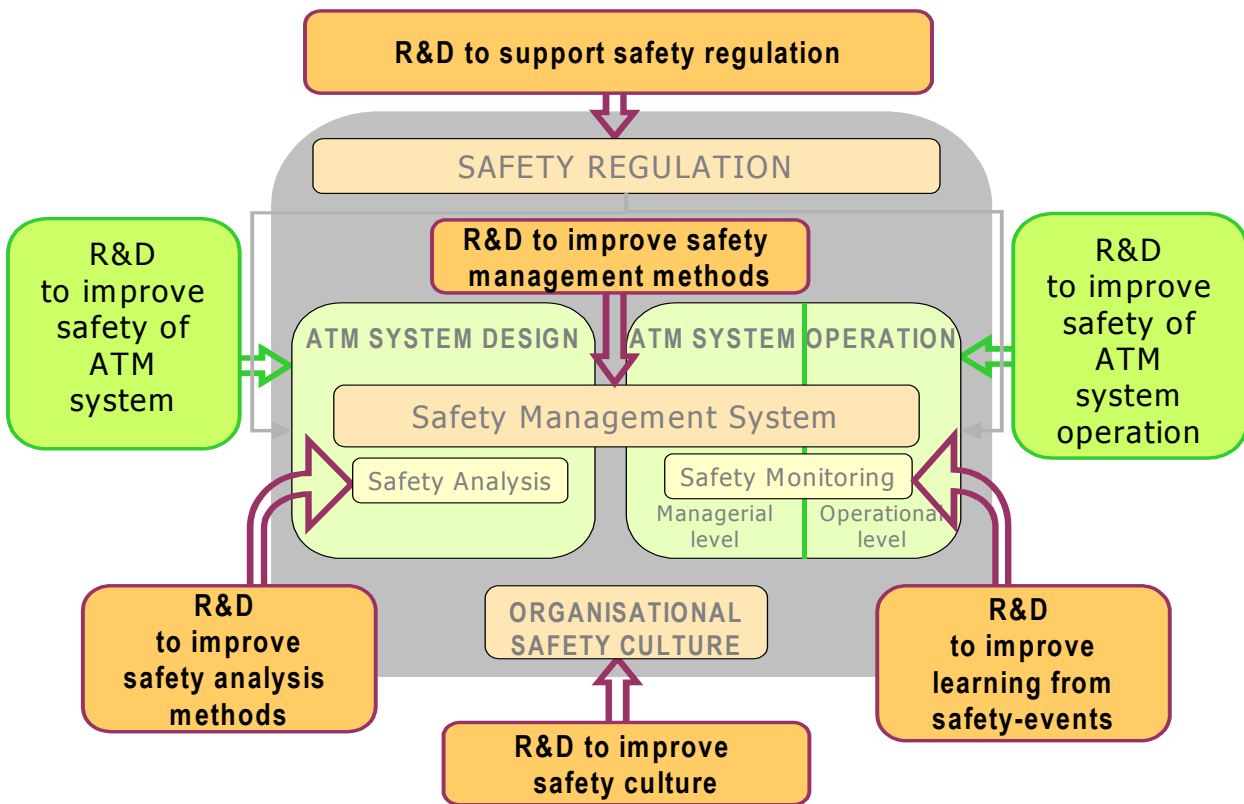
The workshop was divided into three sections.

- The first comprised a number of plenary sessions with speakers from various industrial and research sectors giving their perspective on safety R&D needs. Included in this first part of the workshop was an extensive presentation of the linked survey of sixteen countries' R&D agendas.*
- The workshop's second section ran parallel seminars on six areas of developing best practices in safety and Human Factors assessment and assurance.*
- The third section of the workshop considered the best way forward for Safety R&D in European ATM. Three individual work-groups formed, followed by final plenary discussions.*

Workgroup outputs

The first group concerned the reasons for change in this area. It was agreed that the ATM Safety R&D community is fragmented in Europe, and needs to be brought together to work on more strategic issues, rather than focusing only on tactical and 'unconnected' R&D. Additionally, it was noted that much current Safety R&D in fact is safety assessment of operational improvements, rather than true R&D on ATM safety itself. Safety R&D resources are being used to answer the question of whether a proposed concept or improvement will be safe, rather than being used to determine the best way to deliver the increases in safety demanded by such programmes as SESAR for the mid-term and ACARE for the longer term. Safety R&D therefore was felt not to have a strong enough 'voice', and so was put into a reactive fashion, working in a piecemeal mode, rather than more strategically informing the future safety of ATM. Underlining this observation was the fact that much of Safety R&D has a short-term focus, with less R&D aimed at the longer term issues (outside the universities), even though it is known that development of successful safety concepts (as with any concepts in ATM) can require significant timescales.

The second group proposed a set of detailed ideas for safety, showing considerable overlap with those identified by the former-mentioned Safety R&D Survey. There does not appear to be any shortage of good ideas, though it was agreed that a framework was needed to structure these ideas into a more coherent and productive work programme. The framework produced by the CAATS Safety team after the workshop is shown in the figure below, with seven main and related axes of research.



Safety R&D Framework

The high level priorities for these axes appeared from both the workshop and the survey to be the following:

- **Improving the safety levels of the ATM system and its operation (in green)**
 - R&D to improve the safety of the ATM system
 - * Improved design of old & new safety barriers (e.g. enhancing existing safety nets; developing new ones that increase the resilience of the ATM system)
 - * Understanding the impact of large-scale changes such as functional airspace blocks, new information sharing systems, etc. on ATM safety, human performance and resilience.
 - R&D to improve the safety of ATM system operation
 - * Improved Training for the entire ATM crew (including technical support, maintenance, etc.)
 - * Human error reduction techniques, including development of Human Factors Assurance methods that result in practical Human Factors Safety Requirements and manageable cognitive workload and situation awareness in mid and longer term concept realisations



- * *Approaches to optimise safety early in design conceptualisation, to determine where and how to invest in safety in future concepts*
- * *More utilisation of controller and pilots in safety optimisation R&D to ensure practicability and to capture their ideas/concerns*
- **Enhancing the regulation and safety practice means to verify the ATM system satisfactory operational safety status and its certification (in orange)**
 - *R&D to support safety regulation in the following areas*
 - * *Harmonisation of international, European and national regulation*
 - * *Analysis of the relative benefits of certification and risk assessment approaches, to inform the optimum approach for EASA's regulatory role with respect to ATM*
 - * *TLS derivation and apportionment methods*
 - * *Regulation formulation (e.g. for ATM-related software)*
 - * *Separation Minima*
 - *R&D to improve organisational safety culture*
 - * *Promotion at managerial and operational level – developing the concept of 'safety intelligence'*
 - * *Safety culture metrics for assuring effective safety management and true commitment to safety throughout organisations, bridging the divide between management and controller workforce*
 - * *Development of guidance on safety culture 'enablers/disablers' to facilitate healthy organisational safety cultures*
 - *R&D to improve safety management methods*
 - * *Processes to identify, prioritise, and resolve key risk areas that arise in operational ATM.*
 - * *Comprehensive integration of Human Factors into Safety management*
 - * *Development of decision support tools for managers, to understand their safety and risk priorities, and inform decision-making at corporate levels*
 - * *Development of both lagging and leading safety Key Performance Indicators for management*
 - * *R&D on future safety paradigms for 2025*

- *R&D to improve safety analysis methods*
 - * *Development of Human Reliability Assessment techniques*
 - * *Development/Evolution of Safety and Risk Assessment Methodologies particularly in the areas of common cause analysis, dynamic risk assessment, error of commission analysis, and both fast and cognitive simulation capabilities*
 - * *Development of a reliability database for the industry*
 - * *Sharing of safety case information using a common database so that safety cases can learn from each other*
 - * *Common Safety and human error Data available as R&D input*
- *R&D to improve learning from safety-related events*
 - * *Availability of incident and accident information for common analysis purposes*
 - * *Development of a European-wide ‘early warning’ system based on rapid analysis of emerging incident trends and an effective dissemination system*

The third group considered ways forward for helping the Safety R&D community to become more effective and strategic in both its mandate and its operation. This was seen as necessary since the safety challenges facing ATM are significant and strong collaboration and coordination in Safety R&D will be needed to identify and deliver the required safety developments, yet the community remains fragmented and under-resourced.

Conclusions

The ways forward identified were

- *First, to generate a Safety R&D database that would contain information on the work that was ongoing and who was carrying out the R&D (ARDEP does not cover all the ongoing work).*
- *Second, one organisation should try to co-ordinate more strategic R&D in Europe.*
- *Third, the European Commission was seen as the most logical potential funder for the type of research areas listed above. Such a research framework and agenda, could inform the forthcoming European Framework 7 programme, leading to a single large co-ordinated programme of work in this area.*

A programme answering to the above ‘ways forward’ would ideally have a layered structure covering short, medium and longer term R&D, and the partners should include a good level of representation from universities working in this area, as well as the R&D centres, ANSPs, and other industrial partners. The governance of such a programme of work should include a strong input from industrial stakeholders, to ensure the relevance, and also the take-up of R&D results as they are produced.



Such a programme of work would energise the Safety R&D community and allow it to reach its true potential, and therefore enable ATM to continue to expand while remaining safe in the near, medium and longer terms.



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1. INTRODUCTION

1.1. Background

In the Sixth Framework Programme, the European Commission is proposing a paradigm shift in the way air traffic services are provided. This shift will be achieved through research to achieve effective collaboration in a complete air and airport environment, including innovative research to increase the efficiency of air transport service provision. The overall objective is to achieve the Single European Sky and EUROCONTROL's ATM2000+ Strategy.

The research proposed by the EC combines Human Factors, Safety and airport efficiency with co-ordinated validation methodologies, supported by business cases and safety assessments. More specifically, the Commission is proposing a cluster of seven research areas, ranging from airport efficiency to co-operative air traffic management. The projects that will implement these research areas in FP6 will be based on previous knowledge and, in turn produce new knowledge.

The objective of the CAATS (Co-operative Approach to Air Traffic Services) project is the co-ordination of processes and methodologies across EC's, FP6 ATM projects in relation to Safety, Human Factors and Validation domains. Best practice from these areas can be identified and brought into a selection of *target projects* within this FP6 ATM projects domain. The aim is to provide a co-ordinated approach by all FP6 projects to achieve the EC's paradigm shift.

The most significant expected output of CAATS is the achievement of a co-ordinated, co-operative European approach to ATM research and technical support in the domains of Safety, Human Factors and Validation. Emerging good practice manuals will be produced for use not only by EC projects but other interested stakeholders.

1.2. Objectives

The CAATS Safety R&D Workshop is part of the Cooperative Approach to Air Traffic Services (CAATS) EC FP6 Project supporting the Safety domain, and in particular the safety key element (SKE) III: 'Safety Research and Development' (Safety R&D).

The main objectives of this Safety R&D Workshop were:

- to disseminate and promulgate the identified up to date CAATS best practices on Safety R&D.
- for stakeholders, ANSP and R&D Organisations and Universities to present current, mid and long term planned activities in the areas of safety R&D, safety practices and culture together with their identified safety needs and priorities.
- to discuss and identify safety research needs and priorities in order to facilitate better co-ordination and collaboration on key European ATM Safety R&D issues.

Beyond EUROCONTROL ARDEP (ATM R&D Activities in Europe) information, it is difficult to identify on-going and planned safety R&D activities in Europe, the rationale behind them, and the organisations involved in them. There is a complete lack of a safety R&D 'landscape' and in many areas of ATM, there appears to be little safety R&D. The Safety R&D survey focused a



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significant effort first on 'painting' a picture or landscape of European safety R&D. EUROCONTROL, NLR, BR&TE and ISDEFE interviewed 43 people from 32 organisations in 16 Member States on ongoing Safety R&D activities, results obtained and views on required future activities in the short, mid and long term. For the first time ever, many of these people met and discussed these issues in the Safety R&D Workshop that took place in October 2005 at EUROCONTROL HQ, with the objective to build the foundations of a European safety R&D community or network, to carry out better and more targeted safety R&D in unison or in collaborative projects.

In order to promote CAATS objectives awareness and to disseminate available best practice identified to-date, two selected CAATS target projects (OPTIMAL, SAFEE) presentations were scheduled so that their representatives could present their research activities and describe their needs and issues in terms of safety management, assessment methodologies, safety R&D and regulatory support and how safety R&D initiatives could contribute to their project goals. In addition, a series of 'clinic' sessions was organised for active demonstration of what is considered best safety practice currently applied today in safety R&D projects.

1.3. Participation

Representatives (listed in Annex B) from the following organisations attended the CAATS Safety R&D Workshop:

- Governmental, Agencies & International Organisations:
 - **EC** (European Commission) & **JRC** (EU Joint Research Centre)
 - **EUROCONTROL**
 - **CANSO** (Civil Air Navigation Services Organisation)
 - **IFATCA** (International Federation of Air Traffic Controllers' Associations)
 - **FAA** (Federal Aviation Administration, USA)
 - **JSSI/FAST** (Joint Aviation Authorities Safety Strategy Initiative, Future Aviation Safety Team)
 - **DGTL** (Directorate General of Civil Aviation and Freight Transport, The Netherlands)
 - **CEATS** (Central European Air Traffic Services Programme Directorate, Czech Republic)
- Air Navigation Service Providers:
 - **ENAV** (Società Nazionale per l'Assistenza al Volo, Italy)
 - **LFV** (Luffartsverket, Sweden)
 - **NATS** (National Air Traffic Services UK)



- **DTI/SDER**, former CENA (Direction de la Technique et de l' Innovation, Sous Direction des Etudes et de la Recherche Appliquée, France)
- **DGAC** (Direction Générale de l'Aviation Civile, France)
- **AUSTROCONTROL** (Austria)
- **SKYGUIDE** (Switzerland)
- Industry:
 - **THALES** (France)
- R&D Centres and Aviation/ATM Consultants:
 - **NLR** (National Aerospace Laboratory NLR, The Netherlands)
 - **BR&TE** (Boeing Research and Technology Europe, Spain)
 - **NASA** (National Aeronautics and Space Administration, USA)
 - **CRDS** (EUROCONTROL CEATS Research, Development and Simulation, Hungary)
 - **INECO** (Ingeniería y Economía del Transporte, S.A, Spain)
 - **ISDEFE** (Ingeniería de Sistemas para la Defensa de España, Spain)
 - **Deep Blue** (Italy)
 - **Slot Consulting** (Hungary)
 - **APAC GesmbH** (Austrian Product Assurance Company, Austria)
 - **Helios Technology** (UK)
- Universities:
 - **Cranfield University** (UK)
 - **TU-Dresden** (Technische Universität Dresden, Germany)
 - **Delft University of Technology** (The Netherlands)
 - **RC-AUEB** (Research Centre, Athens University Of Economics And Business, Greece)

1.4. Opening and Workshop Aims

Mr. Morten Jensen, Scientific Officer from EC DG-TREN, formally opened the CAATS Safety R&D Workshop describing the CAATS (Co-Operative Approach to Air Traffic Services) Coordinated Action aim to manage and disseminate knowledge and best practice amongst EC and national states projects. The CAATS project is trying to harmonise the R&D community results in ATM Safety, Human Factors and Validation, by identifying available best practices in order to avoid duplication of work, and by detecting gap areas into which more R&D effort is needed.

The EC expectations on the Workshop consisted of collection, interchange and dissemination of expert knowledge, leading to the identification of best practice and gaps, of specific areas in which research activities are going on, and of areas in which the number of activities is insufficient, thus contributing to meeting the CAATS objectives. Furthermore, an objective for the audience was to identify where are the safety R&D future needs and a way forward to continue to develop research in the safety area avoiding effort duplication.



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Information was also provided about future planned work, such as a new CAATS project extending the scope to cost-benefit analysis and that DG-RES had published a task calling for the formation of a Network of Excellence in the area of safety (not only ATM but aviation in general).

Dr. Barry Kirwan, Safety Research and Development Coordinator from EUROCONTROL Experimental Centre and Chair of the workshop, developed further the aims of the CAATS Safety R&D Workshop. Currently, the main safety R&D motivation for EUROCONTROL and European ANSPs is to undertake a major drive towards ways of improving safety following the recent ATM-related accidents (i.e. Überlingen and Linate). Although the need for ATM Safety R&D is universally recognised as a fundamental contribution towards this aim, there is a perception of fragmentation in the different ways the safety R&D “community” is undertaking these R&D activities. In order to achieve tangible results in safety improvement, it is considered that the need exists for a comprehensive safety programme to react to the community fragmentation.

A recent ARDEP review on behalf the SRU showed that there was limited “true” safety R&D amongst the several hundred projects in the database, as safety activities described were mainly assessments of operational improvements. Following the CAATS Safety R&D survey (interviewing representatives from more than 30 organisations in 16 countries) assessment of ongoing safety R&D and its needs, the CAATS Safety R&D Workshop aimed at promoting a better co-ordination and collaboration on Key European ATM Safety R&D issues and at contributing to a common Safety R&D Agenda.

To promote the necessary debate, a selection of representatives from the international Safety R&D community was invited to act as speakers in the workshop. The brief they were given was to provide an overview of on-going Safety R&D activities in their organisations, together with special emphasis placed on what, in their view, should be the priorities and the needs for co-ordination in Safety R&D in the short, mid and long terms in Europe. The interrelationship between the workshop aims and the planned sessions are shown in the following table:

Objective	Workshop Events
Promote better co-ordination and collaboration on Key European ATM Safety R&D Issues	All
Identify Safety Research Needs and Priorities	Survey and speaker presentations by survey team, CAATS target projects, ANSPs, ATM Organisations, R&D Centres and Universities
Disseminate and promulgate best practices	Clinics on TLS, Human Factors in Safety, FAST process, Human Factors Case, TOPAZ, and PSSA methods
Determine a Common Safety R&D Agenda	Workshops to focus on clarification of safety needs, priorities and best ways forward, and Closing session

Table 1 Interrelationship between workshop aims and planned sessions



1.5. Safety Survey Summary

Ms Mariken Everdij, from the National Aerospace Laboratory in The Netherlands, described the objectives and outcome of the CAATS Safety R&D survey conducted earlier in 2005. In the field of European ATM safety R&D, initial exploration of the area suggested that whilst safety R&D was occurring, it was indeed fragmented. A necessary step towards defining best practice was to establish the safety R&D 'landscape' in Europe – namely who was carrying out what research, for what reasons, and with what resources. The survey amongst the European ATM Safety R&D 'community' involved 36 interviews over sixteen countries, in which 43 persons from 32 ATM-related European organisations participated.

The survey utilised a set of categories, a 'taxonomy' of research areas, to classify different types of R&D (e.g. Safety assessment; safety regulation; safety nets and warning devices; etc.). Interviewees were asked what types of R&D they were doing, why they were doing it, and what types of results they were gaining. They were then asked what they believed were the priorities for European ATM Safety R&D, and lastly they were asked for ideas on how to improve the organisation of such R&D in Europe, since many interviewees agreed the situation was fragmented and hence not strategic or coherent.

The outcome of the safety R&D landscape revealed by the survey in terms of safety focus i.e. what parts of ATM, ATM accidents / incidents are being targeted by safety R&D and in what time horizon are shown in Figure 1.

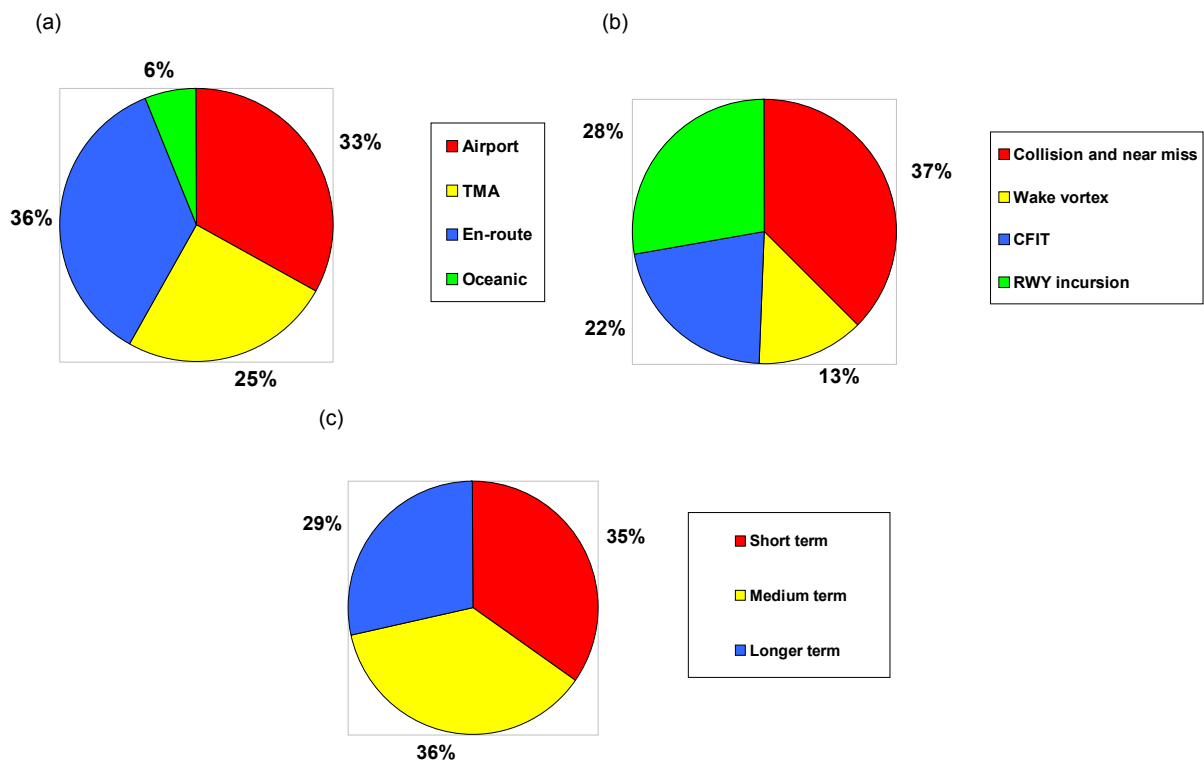


Figure 1 Safety R&D Survey focus on: a) ATM flight phase; b) ATM related risk and c) horizon



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With regards to the survey results on safety areas currently being researched across Europe, Ms Everdij described a classification scheme versus priority given by the interviewees in tabular form, indicating the degree of balance in ongoing and planned R&D for each type of organisation surveyed (ANSP, regulator, R&D Institute and University). The presented diagrams for each safety research area surveyed can be utilised as a measurement to indicate what safety areas are being over-researched and in what ones an increased R&D effort would be needed to match the priority with achieved results.

A full account of the CAATS safety R&D survey can be found in Ms Everdij presentation and the CAATS Deliverable D1.4 Safety Report - Volume III: Safety Research and Development, CAATS-SKE III Safety R&D-WP1.1-NLR-V0.7-D-PU-004, both available in the CAATS website¹. The survey main conclusions and recommendations are reproduced below:

Top priority issues for European ATM Safety R&D:

- Coherent Safety R&D policy and strategy across Europe.
- Harmonisation of safety metrics and safety assessment approaches; Quantitative safety evaluation must become less expensive.
- Sharing of safety cases and incident data, e.g. by means a common database in a common language and a common format.
- Better participation of experienced pilots and controllers in safety cases, and inclusion of the User in the process of what to model and what not to model in a safety assessment.
- Certification and harmonisation of the different European ATM systems.
- Integration of safety issues in all phases of the system lifecycle, and strengthening of the feedback process after system changes.
- Understanding the human factor and introducing the human element into safety cases.
- How to deal with rare events for which there are no incident data.
- Safety Culture for all actors of the ATM system, and Safety Management Culture.
- Standardisation of controller training.
- Safety regulatory issues, harmonised quantitative target levels of safety, and the ESARRs.
- Single sky and re-organisation of airspace.
- Re-organisation of air traffic control.
- Establishment of an SMS in ATM and a roadmap to safety management maturity.

¹ <http://www.caats.isdefe.es/home.html?dissemination>, Dissemination/Events tab, then CAATS Safety R&D Workshop link



Best way forward for co-ordination and/or collaboration in European ATM Safety R&D:

- Collaborative projects with different countries across Europe and also different stakeholders (e.g. ANSPs, R&D institutions, SMEs). Activities should link to the requirements of ANSPs and other users.
- Make the EU formal selection procedure to grant research projects more clear, less political and less bureaucratic, and improve vision in funding awarding.
- Real motivation and shared objectives in large projects. Projects driven by interesting ideas, not by 'what can I finish within the timeframe'. Safety as priority.
- Centralise Safety R&D by nominating a single focal point that: Develops clear guidelines and objectives and that holds the R&D together; Develops a European Strategic Research Agenda (running through multiple years); Determines what Safety R&D should be done, direct it, co-ordinate it, support it, and make sure it is done; *And* it should get a significant budget. This focal point should not have self-interest.
- Listen to each other in discussion groups, task forces, workshops, working groups, user groups, brainstorming forums, or other means (e.g. by making use of internet technology).
- Maintain a database in a common language and a common format, accessible to all, for: Who does what on Safety R&D in Europe; Ongoing work and safety studies; Incident data.

Following the presentation, an interesting debate ensued about the survey and its outcome. Mr Brüggem (CANSO) enquired about the top one R&D priority to which Ms Everdij replied that not really one specific issue stood out but there were many issues across the board. Mr Paries (DEDALE), pointed out that the survey revealed a great deal of organizational issues but asked about "what makes ATM safe?". Ms Everdij answered that the survey showed that not one single answer fits all ANSPs.

Mr Jensen (EC) emphasised that the survey conclusions highlight the relevance of the workshop, as it appears the community are not aware of activities going all around Europe and that they need to be communicated better. Mr Deharvengt (DGAC) enquired about what would be the funding source for R&D co-ordination and who were the decision makers who would facilitate co-ordination to take place. Ms Everdij noted that candidate identification of these were one of the workshop objectives and Mr Jensen (EC) pointed out that funding should originate from the European community and that it was paramount to make the case for the importance of the subject to present a plan to decision makers at European and national levels. There is an agenda at European level in terms of research, the priorities are set but there needs to be a clearer communication mechanism.

Mr Brüggem hypothesised about the safety "problem" ownership, e.g. ANSPs/Regulator and how could it be proved that safety R&D was delivering results and getting recognition. Mr Kirwan replied that without R&D the ATM system could suffer as a result, though he recognised that safety is difficult to justify as it is difficult to make safety results visible and to prove that safety R&D is making ATM safer. Mr Smith (FAA) noted that there was an implicit safety improvement in technological innovation and Ms Everdij confirmed that such a fact was highlighted in the survey.



2. PLENARY SESSIONS

2.1. Eurocontrol Safety R&D Perspectives

Barry Kirwan, Safety Research and Development Coordinator at EUROCONTROL Experimental Centre (EEC) presented an overview of the Safety R&D activities at the EEC, and the strategic plan on Safety R&D for the future.

The first slides showed the origins of the Strategic Safety Action Plan (SSAP). The SSAP was the result of a High Level European group (AGAS), whose objective was to propose enhancements in ATM safety within the 41 States of the European Civil Aviation Conference (ECAC). The SSAP covered 8 main “threads”:

- Safety related human resources in ATM;
- Incident reporting and data sharing;
- Airborne Collision Avoidance Systems (ACAS);
- Ground-based safety nets;
- Runway safety;
- Enforcement of ESARRs and monitoring of their implementation;
- Awareness of safety matters;
- Safety and human factors research & development (R&D).

Later in the presentation the participants were introduced to the 7 principles which the EEC has identified should guide Safety R&D to continue with the 8 Activity Areas of the SSAP:

- Safety Learning – the future learning from the past.
- Safety in Design – getting design right early.
- Safety Assessment – safety methods and applications.
- Key Risk Areas Improvement – new approaches:
 - *Level busts.*
 - *Safety net interactions.*
 - *Low vigilance.*
 - *Complexity.*
- Safety Roadmap – where will needed safety come from?
- Safety Culture – safety competence & commitment.
- Safety R&D Co-ordination – joining forces & resources.

The chart below is a maturity model of the EEC’s Safety Research & Development activities. The chart shows the seven key activity areas that the EEC has identified, against a yearly framework and the phase they consider each activity area has reached.

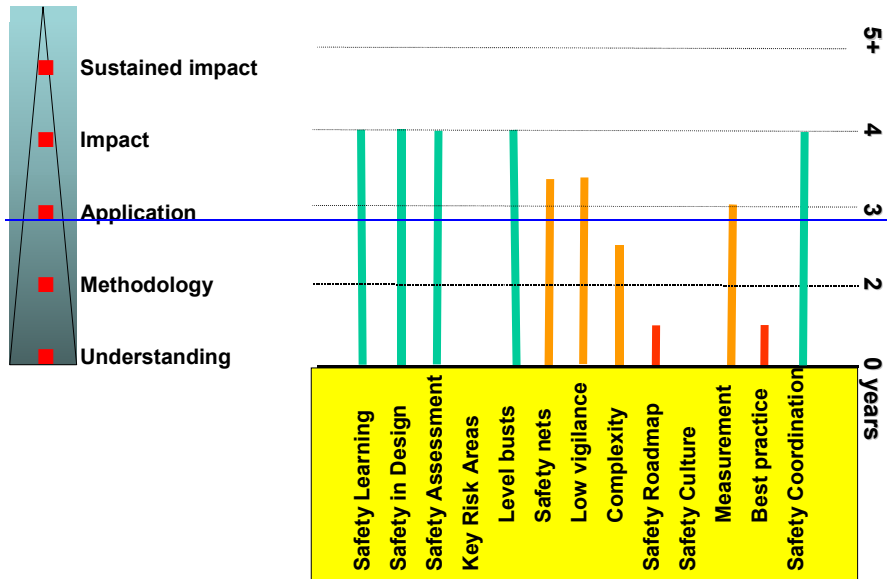


Figure 2 A Maturity Model of Research and Development

From the EEC's point of view, there is an added value in the Safety R&D compiled in the present presentation as follows:

- Safety Assurance methods and application for future ATM Concept (2012-2017).
- New approaches & insights for Key Risk Areas.
- Developing ways of managing safety culture.
- Trying to develop a European community of Safety R&D.

To finalize the presentation Mr. Kirwan introduced the proposed new Safety Plan which will be developed from 2006 onwards.

As final conclusions from EEC session, they could be summarised as:

- *A measurable roadmap towards mid-term (2012-2017).*
- *An industry learning and rapid reaction capability.*
- *A strong European ANSP safety culture supporting SMS.*
- *Resilient safety nets with minimal dependencies.*
- *A 'teaming' concept for European Safety R&D.*

2.2. Stakeholder Views

2.2.1. CANSO-Mr. Job Brügger

CANSO is the Civil Air Navigation Services Organization. It was founded in 1998 and it represents the interests of the ANSP's worldwide. The Mission of CANSO is to provide a global platform for customer and stakeholder driven civil Air Navigation Services (ANS), with paramount emphasis on the provision of safe, efficient and cost effective service.



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There is a CANSO Safety Standing Committee. This committee has been in operation for two years and its components are all Safety Directors of ANSP's. The CANSO Safety Standing Committee meets on a yearly board to discuss among others: best practices in safety management systems, safety management organization, target level of Safety and the Safety Information Exchange Programme.

CANSO considers that the main problems in Safety are not coming from the technological domain, safety technology is very advanced; the main problem (in their opinion) in Safety R&D derives from the organization and management areas.

CANSO has recognized that the current Safety R&D needs are for every day issues like the identification of risks or the target level of safety.

To the question from Tim Porter (JSSI/FAST) about whether there are no people working in these identified areas yet, the answer from the CANSO's representative was that as far as they know there are some initiatives to cover these areas but not at a European level.

Other questions were raised about who should be a Central Safety R&D Directorate. To this, Job Brüggén responded that he considers EEC would be a suitable candidate or in the eventuality that this is not possible, another option could be a Consortium with the involvement of the European Commission.

Professor Fricke from Dresden University mentioned during the discussion time after the presentation that he considers, in general, that the dialogue with the ANSP's is difficult. Besides he questions whether the ANSP's are ready to evaluate the safety of specific ATM system elements or the regulators should take a more important role on that. The CANSO representative considers ANSP's as governmental organizations having constraints in their innovation due to regulation, he considers this is part of the reason for them not being more innovative.

2.2.2. LfV- Mr. Billy Josefsson

Mr. Billy Josefsson from LfV Group (the Swedish Air Navigation Service Provider) presented the LfV view and experiences in Safety R&D. Mr Josefsson presented the LfV motivation to do Safety R&D as Safety being what they sell as an ANSP. From this thought they do research in Safety to develop and improve in order to stay in business.

He introduced Safety Management System development as LfV understands it, starting by a PFHA (Preliminary Functional Hazard Analysis) to continue with FHA (Functional Hazard Analysis) in order to prepare PSSA (Preliminary System Safety Analysis) and finalised with SSA (System Safety Analysis). The reasons addressed to develop SMS following these phases were to allow hazards to be identified locally before implementing local changes to operational ATM systems. In order to be able to do this, some guidance material should become available and operational management should receive some training. Some results obtained from this approach to SMS development were presented.



This was followed by an overview of proactive analysis of incidents carried out in LFV and the LFV position regarding Safety current status. As main points of weakness in Safety R&D, LFV considers:

- the lack of safety experts,
- communication and dissemination of results,
- the link with other actors in Air Transport.

The presentation was finalised with the introduction of a joint project between LFV and Lund University. The project studies Human Factors in Future ATM and aims to study Safety Culture and related organizational issues in order to monitor these during the change process with the background of the project being new air traffic control systems and the new team-based organization.

Some aspects of this project were discussed, like the study locations, the research design or the methods used.

After the presentation there was a brief discussion with the audience, the first question came from Mr. Michel Masson (BR&TE) regarding the lack of safety experts LFV identified in its presentation. Michel Masson disagreed with that appreciation based on that he reckoned all ATCO's should be considered Safety Experts. Also, concerning the project to study Safety Culture, Michel Masson questioned how Safety Culture could be measured. Billy Josefsson explained they did it using questionnaires and interviews and that it has been successful. The discussion about the lack of safety experts continued further after a question to Mr Josefsson about the reasons he considered were behind this lack of experts. In Billy Josefsson's opinion the reason was that most of the experts in safety are from the nuclear and energy field and it is difficult to get them interested in Safety due to lack of funding. Furthermore Mr. Josefsson considers that this lack of experts is very much slowing down the business of the ANSP in Sweden.

2.2.3. NATS-Mr. Martyn Richards

Mr. Martyn Richards from NATS presented NATS Safety Destinations. They have identified two main safety 'destinations' to be implemented by 2007:

- eliminate all the events which breach the safety barrier and
- improve safety to such an extent that there are no NATS-attributable risk-bearing approxes.

In order to achieve these destinations they have identified a Safety R&D line to follow, based in understanding the Safety Performance.

It was explained that the analysis NATS has been undertaking focuses on understanding current performance through operational research, identifying key events through incident analysis and causal factors, measuring risk & estimating risk reduction for mitigation and maintaining a register of safety issues (SIR) and a database to track safety actions.

In order to understand Safety Performance, NATS has established workstream topics that derived from R&D topics. Some of these topics were listed during Martyn Richards presentation.



Level Bust, identified as one of the key areas of operational risk for NATS was among the workstream topics, and it was used to show an example of the analysis methodology associated to each of the workstreams. It was shown that from statistical studies of level bust incidents, the main causes of these operational risks were identified and as a consequence, the key actions to follow were addressed.

Regarding the top causes of the level bust Mr. Nigel Makins was surprised not to see the ATCO performance included in them, as they were based on the pilot performance. The response from Mr. Martyn Richards was to emphasise that some of the identified actions to mitigate the level bust risk include more emphasis on safety culture during the ATCO training.

To the question from Dr. Henk Blom (NLR) about the Safety innovation in NATS, the answer was that NATS consider they do more operational research than conventional R&D, but emphasising that they include safety even in the new analysis techniques and tools.

As a final question to the presentation from Martyn Richards, it was raised a query about how NATS knew the initiative they were embarking on was going to be translated into the safety directions to which they were aiming. The answer was that NATS does not consider what was presented an initiative any more, they consider it part of the everyday work in which management at all levels was involved.

2.2.4. JSSI/FAST- Mr. Rudi den Hertog

Mr Rudi den Hertog represented the Future Aviation Safety Team (Joint Safety Strategy Initiative) at the Workshop. Mr den Hertog exhibited the Joint Safety Strategy Initiative (JSSI) context thorough a series of slides in which he explained JSSI terms of reference, the areas in which JSSI focuses, he described the model that JSSI uses to manage risk and the procedure it is following to approach problems. Finally he presented the spectrum and magnitude of the areas of change affecting the Future Aviation System.

Mr den Hertog also outlined the Future Aviation Safety Team (FAST), (including a list of its members and core team) by explaining the objectives of the team that basically were described as:

- identifying Areas of Change (AoC's).
- identifying Hazards inherent to AoC's and those resulting from interaction with other AoC's.
- developing recommendations to eliminate hazards or to mitigate their effects (information to influence entities shaping the future, tools to analyze and mitigate the hazards).

Mr den Hertog included in his presentation some characteristics that to his understanding, reveal FAST as an extraordinary group. Among the cited features there were:

- offering a Future Hazard Analysis method that can be used universally by any organization or
- having an up-to-date repository of AoC's.

There was an overview of the FAST work process. The work has been organized in phases. Three of them have already been finalized Phases I (Oct/99-Sept/00) to Phase III (Oct/01-Jan/04). The fourth phase started in January 2004 and it is planned to be completed by July 2006. Also included in the presentation from Mr den Hertog were some of the results obtained.

The Top 4 AoC (Areas of Change) identified, prioritized and categorized were revealed:

- increasing Crew reliance on flight deck automation (Aircraft),
- emergence of new concepts for airspace management (Air Navigation System),
- introduction of new technologies with unforeseen HF aspects (Crew),
- proliferation of heterogeneous aircraft with widely-varying equipment and capabilities (Aircraft).

Examples of prioritizations of AoC, Hazards and Recommendations were also presented. Finally, this was followed by some slides including useful definitions to understand the FAST Method. This is summarized in the slide hereafter (Figure 3). The JSSI/FAST presentation was developed in more depth during the clinic session.

FAST METHOD

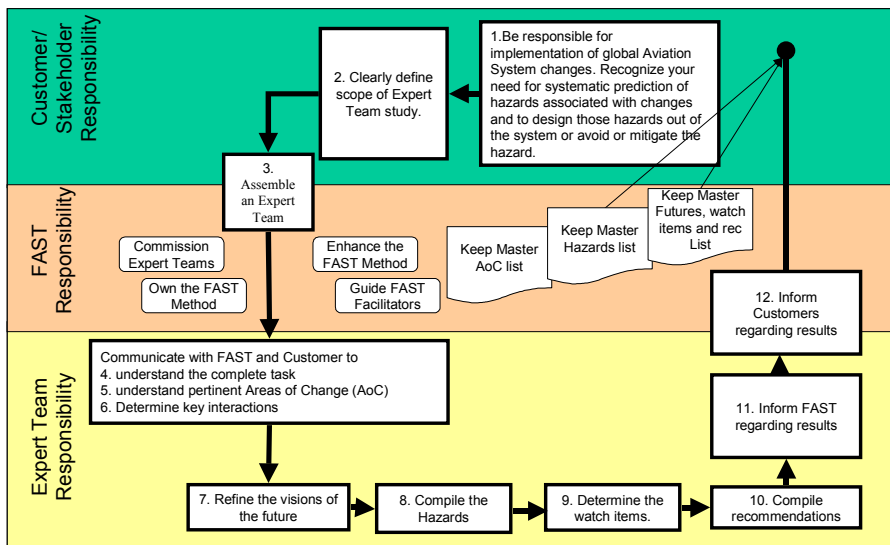


Figure 3 The FAST Method

2.2.5. IFATCA- Mr. Anthony Smoker

Mr. Anthony Smoker from the International Federation of Air Traffic Controllers Associations gave a presentation to confer IFATCA's point of view in R&D and Safety.

IFATCA considers that regardless of the progress made in Safety R&D in the past twenty years, there is quite a different level of implementation across Europe. Anthony Smoker mentioned in his presentation the main challenges in Safety R&D that IFATCA envisions for today and for the future.



He explained the vision of IFATCA on safety as a result of the changing nature of the present ATM system. These changes involve many factors; ranging from the status of the ATS providers to the reduction of separation standards. IFATCA considers there must be one constant in the process and that is Safety. Mr. Smoker insisted on the essentialness of directing sufficient resources towards establishing robust and independent safety regulation at global, regional, and national levels to encompass ATM equipment, procedures and personnel. The presentation continued with an explanation of Safety as it is understood by ATCO's.

IFATCA considers that those events which threaten Safety are confronted on an everyday basis. It also considers that human intervention is at the same time the main strength and weakness of the system in a rich learning environment.

IFATCA considers that Safety learning is more than the implementation state of a system, with lessons to be learnt in every point of the ATM system to help human actors. Anthony Smoker questioned in his presentation whether models used for safety analysis be based in Normal Operations, taking into account that he considers ATCO's and pilots do not behave as models are described sometimes. He further questioned the reality that these models represent. Previous to the final conclusions of his presentation Anthony Smoker analysed the current use of the gathered data to understand and prevent Safety threats. He considers that there are some powerful instruments in place to collect safety related data, but at the same time he thinks these data are not effectively communicated to the field, and therefore he questions whether these data reach and/or are positively used by ATCO's detached from the R&D groups.

At the end of Anthony Smoker's presentation, Rudi den Hertog insisted that changes and the wisdom of extrapolating the future from the past might be wrong. As an answer Anthony Smoker agreed with him and added he predicted a high risk of failure if ATM stakeholders intend to do that.

2.3. CAATS Target Projects

2.3.1. OPTIMAL – Mr Eric Perrin

Mr Eric Perrin presented the safety best practices and R&D needs identified in one of the CAATS target projects: OPTIMAL.

OPTIMAL is an air-ground cooperative project aimed at defining and assessing new operational procedures for approach and landing using advanced navigation functions and enhanced ATM.

The safety activities in OPTIMAL were presented. The safety analysis of the approach and landing procedures-based operations includes airborne and ground elements and encompass both technical and operational aspects. Along the safety assessment process carried out in OPTIMAL several issues are worth being considered among the safety best practices or are identified as safety R&D needs:

TLS setting

Many gaps and inconsistencies are detected in the current sets of TLS when considering the accident categories and flight phases relevant to ATM projects. Among the roots of complexity to select suitable TLSs it is remarkable that there is an extreme difficulty of finding an unambiguous definition of the boundaries of ATM.



OPTIMAL has adopted a method for developing TLSs in a systematic way by projecting the baseline risk obtained through historical risk analysis towards the horizon year considering ATM contribution. This approach benefits from current research, noteworthy the Integrated Risk Picture *IRP 2012* based on a system wide risk model that represents how ATM causal factors combine to result in aviation accidents as well as their consequences.

Human Reliability Analysis

Human error is a dominant risk factor in safety oriented industries such as ATM. The techniques followed for human error identification in OPTIMAL along the system lifecycle were shown and compared. It was presented how an hybrid approach with HAZOP, in the conceptual and pre-design stages, complemented by a detailed TRACER analysis, in later design stages, is the most suitable method to support safe design.

OPTIMAL has used TRACER-lite, an abbreviated version of TRACER (*Technique for the Retrospective and Predictive Analysis of Cognitive Errors*). This method is a highly comprehensive tool for human error prediction in which the analyst, supported by operational experts, conducts a task analysis applying human error taxonomy.

As a second step of human error modelling, the techniques used in OPTIMAL to quantify the identified human errors were presented and the need to improve prediction and quantification of human error was emphasized.

Common Cause Analysis

How to tackle Common Cause Analysis in a total aviation system approach has been identified by OPTIMAL as one of the needed research lines, as CCAs are important sources of safety critical situations and their identification may eventually lead to a more resilient ATM system.

CCA in ATM reveals to be significantly complex due to the high degree of interaction between elements in the ATM operation, despite the various methods available in the literature that seem not to be sufficiently structured as to address the particular features of the ATM field.

2.3.2. SAFEE – Ms Monica G Medina

The SAFEE presentation dealt with the vision on the safety R&D needs and initiatives that could be beneficial for a future SAFEE system implementation.

After a short introduction to the project and the systems developed there that are subjects of safety analysis, the safety activities carried out and planned were outlined. SAFEE safety activities are structured along three lines:

- A certification study intended to derive safety constraints from regulations in order for the system to be a certifiable product. At the same time, conflicts with current regulations are addressed.
- A safety assessment consisting of a FHA and a PSSA, based on ARP 4761 methodology intended to show compliance with CS 25.1309.



- A combined approach to identify safety constraints coming from the end users (analytical human factors study and brainstorming sessions).

The innovative philosophy of SAFEE, that involves high levels of automation and ultimately the withdrawal of human control over the aircraft due to security considerations, enters in conflict with current regulations and safety practices which pose a challenge in the accomplishment of its final goals.

From the project participants, it is clear that safety objectives for a system of these characteristics operating in normal situations have to be as stringent as for any other system element. This fact is not as clear as that when the situation analysed is a 'malevolent scenario'.

In these cases it is necessary to come up with a revised system safety assessment methodology and appropriate safety targets. It is at least necessary to wonder whether neglecting the interaction between security threats and safety hazards may affect the analysis. Another question to solve is whether current severity classification schemes are still applicable, that is, whether the focus to determine the severity of an event have to remain in crew, aircraft and occupants or should be moved to third parties i.e. other aircraft and people on ground, to cite some examples.

Related to the need for a coherent approach to the safety and security interaction that includes methodological and regulatory aspects described above, the most important safety R&D lines identified by the SAFEE team were presented. These lines are derived from the experience gained from the safety activities developed so far but are not intended to be exploited by the project itself at this stage. However they are essential safety R&D targets for the successful safe implementation of the system.

Among these lines, it is notable the need to study the safety issues associated to the introduction of special airspace users in the ATM system. This study should be, from SAFEE viewpoint, accomplished using the total aviation system approach with special emphasis in the operational part.

It is recognised that most of these lines cannot be undertaken in isolation. In this sense, it is worth to mention the current collaboration that exists between SAFEE and the Eurocontrol / NATO programme ERRIDS (*European Regional Renegade Information Dissemination System*).

2.4. US FAA Vision on Safety R&D Priorities

Mr. Dino Piccione presented the safety R&D activities in the FAA.

Human Factors Safety and in particular, operational error reduction dominates FAA R&D. Other fields of research include CD&R modelling, wake turbulence and weather. The two major focuses of the ATM safety research in the FAA are loss of separation and RWY incursions.

On the human factors safety domain the following initiatives were presented:

- **JANUS project**, initiated as part of Action Plan 12 as an international effort, identifies operational error causal factors with the goal of finding out appropriate mitigation strategies. JANUS research programme is transitioning into operational domain. The data collection



system is functional and is completed by ATCOs on a voluntary basis. There are plans for national deployment. In parallel, the technique originally looking at ATCo associated factors, is nowadays being adapted to cover pilots and ground operators.

- **ATCO time vulnerability study** developed strategies to reduce the human factors causes of operational errors that occur during the early periods of the day and on position, which have revealed to be by far the ones with more prevalence of these errors.
- **NATPRO** (National Air Traffic Professionalism) is a voluntary tool for ATCOs off-duty to avoid time vulnerability as described above. After a positive user acceptance, the next step will be to relate the NATPRO use to the job performance.
- **Operational Error literature review** completed in August 2005 where gaps in research have been identified and recommendations developed.
- **NOSS** (ATM Normal Operations Safety Survey), based on concepts of Threat and Error Management (TEM), and Line Operations Safety Audits (LOSA).
- **RISC** (RWY Incursion Severity Categorisation Model) developed to ensure appropriate severity assignment in runway incursions, based on objective parameters.
- **Sector characteristics and Operational errors** study aimed at an airspace design that reduces operational errors since it is found that a correlation between them and sector complexity exists.
- **Supervisory best practices**, collected in field site with the objective to develop 'Best Practices' packages for categories of ATC facilities.
- **Hear-Back / Read-Back** study intended to come up with a phraseology that increases the probability of read back errors detection by ATCOs.
- **Safety culture transformation**, towards a more robust safety culture by developing, applying and evaluating interventions based on the adjustments needed to the current state of safety culture.
- **Human error safety risk analysis techniques** applied to ATC system maintenance in the manner of a system FMEA, intended to focus the Human Factor programme in the areas that involve more risk.

The FAA wake turbulence programme was presented with a detailed description of its short term goals. The safety challenge associated to the wake turbulence research is the integration of wake turbulence information into a decision support tool to manage risk at the same time that limitations in airport and terminal area operations are overcome. Additionally the objectives, accomplishments and future plans regarding convective and oceanic weather as well as ATCo weather displays were presented. R&D in this area is motivated by losses in injuries, fatalities and aircraft damage.

Finally future safety R&D activities were presented. Emphasis will continue in operational errors and runway incursions. It is also worth to mention among the FAA future safety R&D lines the



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definition of responsibilities and roles of human and automation for the new ATM environment as well as the required transformation of safety culture to support them.

2.5. Aviation Safety R&D Organisations Views

2.5.1. NLR – Mr Michel Piers

Michel Piers appreciated the work done by the CAATS team in the synthesis of the main lines of thinking in the R&D community and the stakeholders regarding the most important areas for future safety R&D. Nevertheless, some observations and remarks for the consideration of the audience about the main CAATS findings were presented and are summarised below. These observations refer to safety target identification and prioritisation and key points in the implementation of a coordinated Safety R&D agenda.

Safety R&D is constrained by the real world in the same manner as other disciplines are. A right balance has to be pursued between striving for interesting ideas and realistically meeting the constraints from the real world. The capability of conducting safety R&D within limited time and budget is essential.

Safety R&D is not the only means to resolve all safety constraints. To identify and set the priority of a safety R&D target it is necessary to define the objectives very explicitly and to analyse in depth the results that can be expected from an R&D conducted in this specific area. Some guidelines were presented to get effectiveness when setting R&D target priorities.

Focus on rare events should be avoided as it is considered that normal operations hold sufficient potential for safety improvement thanks to safety R&D and more benefits can be achieved in this way.

Human Factors Safety R&D is deemed as an important focus. However the need for sound models based on validation is stressed in detriment of the generation of new models.

Regarding Safety R&D funding, any request should be supported by a determination of real R&D needs to achieve the predefined design goals, an estimation of their costs and a longer term action plan.

As far as new concepts and new technology are concerned, it is necessary to highlight that in most cases their introduction is driven by efficiency and not by safety considerations. Their implementation cannot be made at the expense of safety margins but on the contrary, the safety gains that these concepts may undoubtedly entail should be a major driver.

Safety R&D has to be set up by Air transport System partners together in an integrated and European-wide coordinated way. The role of researcher's education was emphasised to improve research in a longer term perspective.

The Network of Excellence EXANET focused on the latter topics, research and education, was presented as a means to realise the intended common European research programme and bring together the fragmented safety R&D European landscape.

2.5.2. DTI/SDER – Ms Sylvie Figarol

Safety research at the DTI/SDER has been from its beginnings centred around the understanding of the human role in safe normal operations and the conciliation of the risk perception by different actors specifically through the feedback process. These studies led to the recommendation of a *human-centred SMS implementation*.

Before defining the key points for this implementation, the presentation showed how risk management decisions are strongly influenced by risk perception and how this perception varies enormously depending on the type of actor, that is manager or operational controller.

Safety insurance for managers relies on the four pillars: procedures and rules; technical proficiency; tools and safety nets and the working organisation. SMSs are a powerful tool to manage them and guarantee that safety is not impaired. However, safety is perceived by operational controllers quite differently as they are confronted daily to the challenge of finding the appropriate trade off between safety margins and efficiency.

The feedback process of the SMS shows even more the gap between the two different safety perceptions described above. From both managerial and operational sides, the SMS is seen as a key to manage risk, but the understanding and expectations differ from one to another.

From the managerial point of view, the feedback process is aimed at learning from the operational errors through the detection of significant events, investigation of their causes, classification according to their risk, filling a safety database and giving feedback to the operational side. However, from the operational side, the feedback process is often perceived as a rule reminder by managers and presents practical concerns such as whether an event is significant as to be reported or not. Instead, sharing of successful overcome of events is seen as a useful improvement process, currently underexploited.

In this context, human factors understood as the assessment of key human aspects in performance and safety, are seen a means to fill the gap between both perceptions. (*HF Efficiency Thoroughness Trade-Off (ETTO) concept, Hollnagel*).

The four main attention points in the successful implementation of a human-centred SMS derived from the understanding of the problem summarised above were presented:

- Integration of technical and non technical skills in a continuous training environment.
- Enhancement of feedback process and safety culture.
- Improvement of pilots/controllers cooperation.
- Integration of human factors in safety cases (HF case).

To conclude, a number of lines or cooperative safety research were presented. The need to share sensitive data was noted as a limitation for this cooperative approach. Four of the proposed general R&D streams are cited below:

- Normal operation observation methods.
- Methods to integrate human factors and safety into the design process.
- Company culture and safety issues: observation of the SMS effect.
- Methods to conciliate provided and perceived safety.



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2.6. University Aviation Safety Departments Views

2.6.1. Dresden University – Prof. Hartmut Fricke

Professor Hartmut Fricke from the Institute of Aviation (IFL) at the Technical University of Dresden gave the first presentation during the Universities Safety Department view session.

First of all Professor Fricke explained the motivation of Dresden University to do research in Safety. This motivation is based on target figures published by aviation international organizations such as the International Civil Aviation Organization, EUROCONTROL and the European Commission, but also by National Regulations.

Some of the on-going R&D activities at the IFL focused on Safety, Security and Human Factors were presented structured in three main workstreams:

- Air Transport Infrastructure Planning,
- Logistics in Air Transport,
- Air Transport Systems Technologies.

Included in these three main workstreams there are:

- Optimizing passenger flow including abnormal situations.
- SAM-Demand, Capacity, Punctuality for the Frankfurt Main Airport with correlation to Safety or Safety Management System for Airports.

Two key results of the on-going R&D at IFL in Dresden University were also presented.

The first key result is the “External Risk Model” that studied both individual and group risks.

Individual risk was described as being the result of three components: the accident ratio, the accident location and the accident consequences. Further than this, Professor Fricke exhibited the definition and the formula to calculate the probability of occurrence of each individual and group risk.

In the case of the individual risk, the crash probability was presented as being calculated for each framework through surface integration, whereas to calculate the group risk the individual framework cells within the area under consideration are examined sequentially and a pair of values is created consisting of individual risk and the number of persons affected.

The second key result presented by Professor Fricke was the “Level of Safety Model”. Regarding this model, level of safety was defined as it is understood by ICAO, followed by an introduction of a hybrid approach to identified level of safety based in risk analysis, methods of empirical crash/incident probabilities and human factors.

The level of safety model being developed by Technical University of Dresden, also explained, defines a safety zone, based in probability of conflicts. They consider that a conflict is given, if the safety zones of two or more aircraft touch each other and/or penetrate. The final slides on the level of safety model developed by Dresden University explained Human Factors within the model and a Software Tool used as a Safety Correlator.



To conclude his presentation Professor Fricke explained that he considers the Interdisciplinary Safety Research as one of the success factors in Safety R&D.

2.6.2. Cranfield University – Prof. Peter Brooker

The next speaker was Professor Peter Brooker from Cranfield University. Professor Brooker started his presentation emphasising the percentage of aviation fatalities that are ATM related (showing some data taken from the Aviation Safety Network website) and the evolution of the absolute number of fatalities that he forecasts as it is supposed the number of accidents is related to traffic increase.

Professor Brooker continued sketching the ATM Safety Components dividing the scheme between guardians and providers to later define the legal responsibilities of each of them (guardians and providers) insisting that all ATM Safety Systems have a duty of care when it comes to assure Safety.

The ATM Safety System in layers was described from Air protection to Safe Route Design. In order to later explain mid air collision causes that he defined as Failure of Position Integrity or Failure of Reasonable Intent, Professor Brooker showed a scheme to represent controller workload (Figure 4).

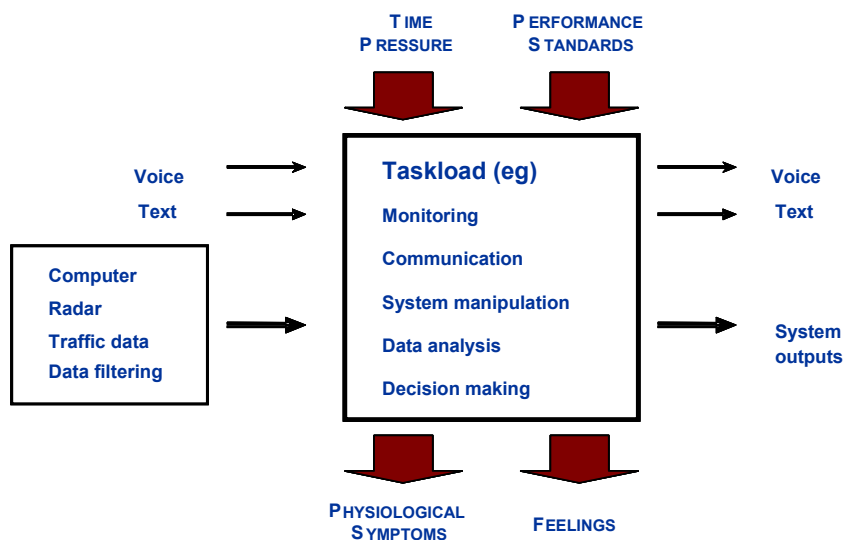


Figure 4 Controller Workload

He clarified that the scheme represented workload as a multi-dimensional concept that encompasses task difficulty and the effort – physical and mental – needed, including also a personal dimension. Some examples of Reasonable Intent Failures extracted from UK Airprox reports were also cited.

The presentation from Mr. Brooker continued with an analysis of characteristics of the incidents that give most guidance about potential accidents with a mention to some relevant (in Peter Brooker's view) conclusions extracted from a USA ATM paper.



Furthermore, Peter Brooker introduced a Risk Assessment Method “Ideal Checklist” that he has developed.

Near to the end he expressed that to his understanding, realistic risk assessments should incorporate STCA (short Term Conflict Alert) and ACAS (Airborne Collision Avoidance System) based on that he considers hazard analysis calculations incorporating STCA and ACAS provide measures of true risk potential.

Peter Brooker finalized his presentation including some practical recommendations to Safety Regulation Methods and summarizing the messages he wanted to transmit with his presentation:

- Legal pressures regarding causes/responsibilities.
- Total ATM Safety System approach.
- ‘What if’ analysis of incidents:
 - Reasonable Intent Failures - situation awareness, prospective memory’.
- ‘Best practice’ Risk Assessment::
 - rational, evidence-based and realistic modelling.
 - measure of the true risk potential in the real world.
 - focusing on practical safety assessment based on methods with demonstrated merits regarding ‘ideal checklist’.
 - Openness to peer review.

The only question raised after Peter Booker’s presentation was about the reaction to his analysis of the ESARR4 in the SRC, with the clarification that there had been no reaction what so ever.

2.6.3. Delft University – Prof. Andrew Hale

Last speaker from the University session was Professor Andrew Hale from Delft University of Technology in the Netherlands. Professor Hale presented Safety research at the University.

He started by giving an overview of the levels of cooperation between Faculties, within the University, at National level and also internationally through some European projects and networks that he mentioned.

Professor Hale presented some of the work carried on at Delft University. Some of the work done is the result of linking emerging themes across application areas (risk modelling, risk & design, risk management, risk regulations and learning from incidents, accidents and operational experience).

Four workstreams were presented:

- Risk modelling for design and management, described as looking for answers to:
 - how to visualise the link between technical, procedural & organisational risk factors in order to plan prevention, choose priorities and controls and evaluate their effects, using the Accident deviation model, and the Bow-tie model (both models included in the presentation).
 - how to make risk models dynamic keeping within a safe envelope for system operation (Rasmussen: drift to danger model).
 - how to make risk management systems transparent for managers and assessors.
 - how to quantify all influences to prioritise intervention.
- Risk management to:
 - integrate risk management across levels in the organisation and system.
 - answer how to assess and improve risk management systems: modelling and auditing structures and processes.
 - answering how to adapt risk management to different cultures, technologies & types of organisation: Linking culture to management structure & process. High reliability organisations and the meaning of resilience.
- Learning, carried on in the projects ADVISES and HILAS.
- Risk Regulation.
- Risk & Design.



3. CLINICS SESSIONS

3.1. PSSA GBAS – Mr. Eric Perrin (EUROCONTROL)

The PSSA clinic aimed at illustrating the process of development of a Preliminary System Safety Assessment (PSSA) through the application of a case study: the implementation of approach procedures based on GBAS CAT-I.

The background and objectives of a generic PSSA were stated as well as a brief introduction of the GBAS CAT-I operations to centre the clinic. Later, the approach and overall PSSA process followed for the GBAS case were outlined.

Development of Fault Trees and Event Trees

The Bow-Tie modelling technique was presented as an appropriate means to identify risks. Its advantages were analysed and its use explained with the application to a real occurrence.

The Bow-Tie modelling facilitates a correct assessment of the severity of hazard effects accounting for the whole range of possible consequences. Additionally this technique supports the appropriate setting of safety objectives eluding simple approaches that apportion the safety targets equally among hazards independently from their involved risk, which can lead to misallocation of safety efforts. The event tree part of the bow tie modelling enables quantification of SC1 events and handling of events whatever their severity class is.

Regarding the inclusion of safety nets in the analysis, the approach followed by GBAS was in line with SRC and the ICAO ATM concept panel, that is, the risk reduction originated by them is not taken into account. To ensure comprehensiveness of the safety assessment, their qualitative effects are considered along the event tree structure.

One of the key tools of this part of the PSSA process is the elaboration of a functional-logical model to represent hazards and how these interrelate.

Identification of Dependencies

Dependencies may exist within fault trees and event trees, between them and across hazards. The types of dependencies were analysed and the methods to address them outlined. The presentation includes detailed information about the THERP modelling.

On the other hand, the nature of dependence was examined, a set of examples were given to illustrate this concept and its importance. Finally the factors contributing to human dependence either personnel, task, scenario or equipment related were pinpointed.

Quantitative analysis

The quantification process is one of the most complex ones along the PSSA process. The quantifications techniques and data were presented to the clinic participants, with special emphasis on the human reliability analysis.

APJ (Absolute Probability Judgement) and PC (Paired comparison) were presented as the expert judgement methods used in GBAS project for Human Error Probability estimation. In addition to that, HEART (Human Error Assessment & Reduction Technique) was presented as one of the most accepted analytical tools for human error quantification techniques.

Results

Finally, as an illustration to the outcomes of a PSSA process, the results for the GBAS CAT-I case were presented outstanding the relative approach with regards to the ILS current operation.

A few examples of safety requirements were presented to highlight the impact of safety process in design, implementation and operations. The importance of producing meaningful safety integrity requirements was stressed, being especially key in the case of human factors and procedural issues due to quantification difficulties associated to these system elements.

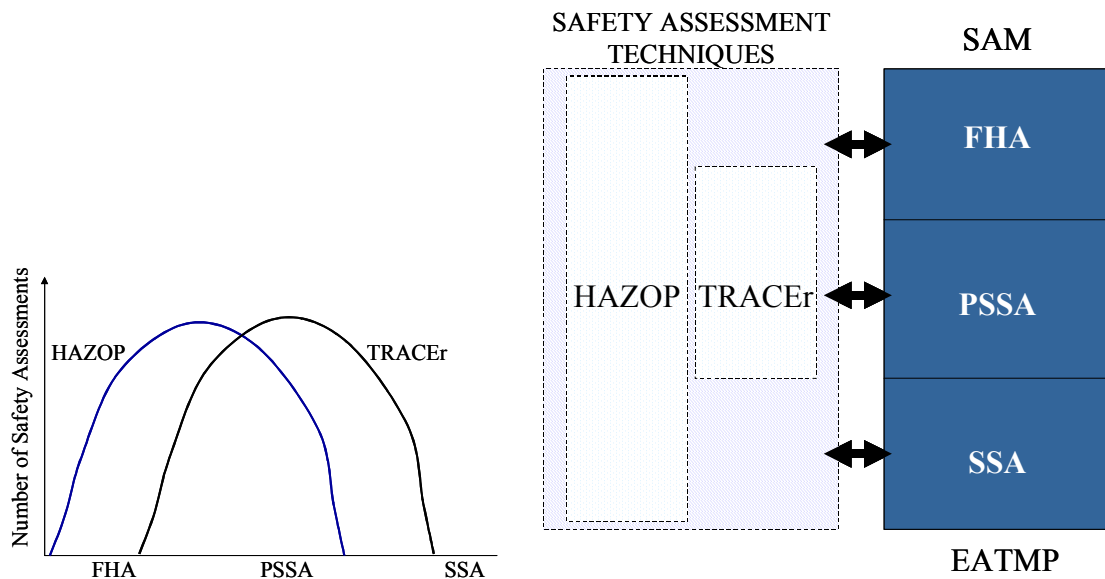
3.2. Human Error Identification – Ms Rachel Gordon (EUROCONTROL)

The main purpose of this clinic was to present Hierarchical Task Analysis (HTA) and Human Error Analysis. It was explained what HTA was, and the reasons to use it. Also it was discussed when task analysis was beneficial and what to use HTA for. After showing some examples of Task Analysis diagrams, detailing his parts and the specific definition of each of the parts; the presentation focused on what does HTA entail. As a summary, it was mentioned that: *HTA provides an effective means of stating how work should be organised in order to meet a system's goals*. The basic process to conduct HTA was examined step by step in detail, some examples were discussed to clarify and fix the ideas introduced. First example, included in the presentation on the Annexes to this document, was a simple example of an every day life situation. In the second example, the methodology was applied to a Future ATM concept: Mediterranean Free Flight ASAS Separation. Finally advantages and disadvantages of the HTA methodology were summarized and discussed.

The clinic continued with the presentation and analysis of two Human Error Analysis Methods: Hazard & Operability Study and TRACER-lite. Each method was analysed individually and then some comparison was carried out. First of all, HAZOP method was mentioned to be a method developed in the chemical industry during the 70's and now extrapolated to many other industries, ATM included. Some of HAZOP characteristics were listed, followed by descriptions of members of a team that is carrying out HAZOP analysis should compile. HAZOP analysis is normally performed using a table that should be filled by the team undertaking the analysis, with the help of some guidewords. This table was presented and the severity & frequency column was described in more detail. The HAZOP process was illustrated using the same of two examples the HTA had been illustrated for. These examples were aimed to get the audience familiarized the audience with the studied methodology.

Next, TRACER-lite analysis was explained. This is a methodology designed by NATS for ATC. TRACER-lite was presented as a tool more suited for projects later in the concept and procedure development. It was mentioned that the methodology is normally led by an individual analyst and that requires quite a lot of dedication to review of documentation and procedures. A project team has to validate the results. TRACER-lite uses HTA and HE taxonomy and provides a highly comprehensive register of error.

Towards the end of the clinic, there was a comparison between TRACER-lite and HAZOP methods, their life-cycle applicability and how do they fit with SAM. This was shown in the figures below.



Other methods were also mentioned for Task Analysis and Human Error Identification.

Some of the conclusions that could be extracted from the reported clinic session are listed hereafter:

- Human Factors / Human Error are thought to play a large role in the cause of accidents in ATM.
- Human Error should be taken into account during the design process.
- Changes in ATM systems mean ATCO jobs will alter.
- HTA and Human Error Analysis can be used throughout the design lifecycle to help designers articulate how tasks should be carried out.
- System Designers should work together with human factors experts during the design process.

3.3. FAST Hazard Identification – Mr Brian Smith and Mr Tim Porter (JSSI/FAST)

The purpose of the FAST clinic was to demonstrate with a hands-on exercise the FAST Expert Team Process. In particular, the exercise carried out during the clinic focused on hazard identification based on the Concept of Areas of Change and interactions. A hazard was defined as a “*situation that increases the possibility of an accident*”.

The novel concept used in the example was based on a “future” Fully Automatic Cargo-carrying airplane (it was noted that the use of such airplane in the illustrative demonstration was in no way connected with plans or advocacy by FAST or any of its member organizations). The characteristics of the Fully Automatic Cargo-carrying airplane were presented as follows:

- In the future, cargo-carrying airplanes, having no pilots on board, are introduced.

- Most pilot functions have been replaced with autonomy.
- Automated systems coordinate and execute all navigation, systems management, communication and flying functions.
- The autonomy is supplemented with ground control intervention when necessary for continued flight and landing.

Following ad-hoc hazard identifications by the clinic audience, the FAST team presented the following relevant areas of change applicable to the given example in order to facilitate the identification process:

1. Introduction of new technologies with unforeseen human factors aspects.
2. Introduction of artificial intelligence.
3. Emergence of new concepts for airspace management.
4. Variation of sophistication of hardware and software within an individual aircraft type.
5. Shift in responsibility for collision avoidance from ATC to pilots.
6. Complex interactions among highly automated ground-based and onboard systems.
7. Widening gap between skills, abilities and attitudes of aerospace Industry people (Includes government people).
8. Changing means of flight deck warning and alerting.
9. Increasing amount of information available to the flight crew.

Several additional hazards were identified following the FAST methodology and the audience agreed that the FAST methodology could focus the hazard identification change in a systematic manner.

FAST advocates for its process being implemented through expert teams employing the FAST methodology, such a team may include Air Traffic Controllers, an Air Traffic Controllers' Union Representative, an Airline Passenger Association leader, Air Navigation Service Provider representatives, an Airline Association Representative, Safety Regulators, Airline Pilots, a Journalist/Media Person, a Pilot Union Representative, an Airframe Manufacturer, an Avionics Manufacturer, a University Professor, an Airport Manager, an Aviation Underwriter, an Aviation Mechanic and a Flight Attendant Union Representative. Additionally, the FAST team noted as a key benefit that the FAST process of information collection could become a knowledge repository and a centre of excellence regarding aviation future contributing to a safer future global aviation.



3.4. TLS Application to Safety Cases – Mr Mario Lenitz (AUSTROCONTROL)

The purpose of the TLS clinic was to present a method developed and used by Austrocontrol for derivation of quantitative safety objectives starting from Target Levels of Safety set by regulators.

Standard approaches used in risk assessment in ATM set safety objectives to define the acceptable probability of the occurrence of a hazard. However most of them are done in qualitative terms using probability classes such as *remote, improbable frequent...* One of the novelties of the model is that translates the qualitative probability classes into values validated by the experience that can be used for calculations.

The method is a structured approach that provides full traceability about how each quantitative safety objective is derived from the TLS. It allows to integrate safety effectively into the system with the appropriate focus in the key risk areas. It is of application in a proactive system analysis environment that includes all the elements of the system, although it is currently in place for the procedure and equipment elements of the ATM system only. The human element is not introduced yet in the model as regards to the hazards associated to humans, but only in the mitigation factors part.

The TLS values currently used as inputs for the method are the safety minima enforced by ESARR 4 for the Severity Class 1 events and safety minima for the rest of categories SC2 to SC5 promulgated by the Austrian National Aviation Authorities.

Through the application of the method, acceptable probability levels for a specific failure are determined in quantitative terms enunciated in the following form:

“The probability for the failure mode total loss of the function X shall not be higher than y per hour. This equals to an MTBF higher than z hours”.

To reach this result the following steps are done:

- 1) Target levels of safety for each SC set by regulators are apportioned into the different events considered within this SC. This apportionment is decided at a managerial level based on the consequences on the organisation among other factors. e.g. TLS for Accidents (SC1 events) set by ESARR 4 is apportioned into mid air collisions, CFITs, accidents on ground with fatalities, accidents on ground without fatalities and losses of control due to MET.
- 2) Safety targets per function in each specific service (TWR, APP, MET, etc) are apportioned from the results of the previous step through the use of the involvement factor that reflects the relevance of the function for the specific service, and the average number of movements supported by the function in the service.

To consider the **Mitigation** means, due to the complexity and high effort associated to the development of event trees, these are substituted by use of the “Swiss Cheese Model” by J. Reason. This model predicts and set values for the permeability of the different barriers in place for the mitigation of a specific hazard. i.e. organisational, procedural and human defences and safety nets as last barrier.

Three types of existing mitigation means are considered to modify the safety objectives depending on their strength. These are infrastructure barriers, procedural barriers and human barriers.

- The mitigation factor associated to an infrastructure barrier is a value from 1 to 1000 that represents the degree of independence with regards to the function that intends to protect.
- The mitigation factor associated to a procedure is directly linked to its PAL (Procedure Assurance Level) as defined by Eurocontrol SAM.
- The mitigation factor associated to a human barrier is obtained from a matrix workload & awareness / experience based on a British defence model for human performance.

The method has been successfully applied for four years by Austrocontrol and for one year in CEATS. It raised the interest of the audience. More details on the method are available from the facilitator.

The discussions brought about by the clinic revealed that the objections to the method derive from the different notions of the system under study: its boundaries and components and the fact that there is no a common view of what is under investigation.

3.5. TOPAZ – Dr Henk Blom

TOPAZ (Traffic Organization and Perturbation AnalyZer) is an accident risk assessment methodology that can be used to assess advanced air traffic operations. The development of the TOPAZ methodology (illustrated in Figure 25) started more than 10 years ago and was initiated due to the significance of safety assessment as one of the primary filters in ATM concept design. The output of TOPAZ modelling and simulations provide early feedback to ATM designers on the safety of the design at the required capacity level, while also identifying safety & capacity bottlenecks at an early stage of concept development, thus constituting a valuable decision-support management tool. With respect to advanced procedures in air traffic, TOPAZ is a most advanced safety/capacity assessment methodology currently available, going beyond established approaches by incorporating the following features:

- a modular representation, for effective communication with designers;
- context-related human reliability models at cognitive level, enabling the impact on safety/capacity of new technological advances, including resulting changes in operator workload, to be assessed;
- a sound combination with aircraft collision risk models;
- posterior traceability of safety-critical elements in the design.



Designing ATM inherently safe with TOPAZ

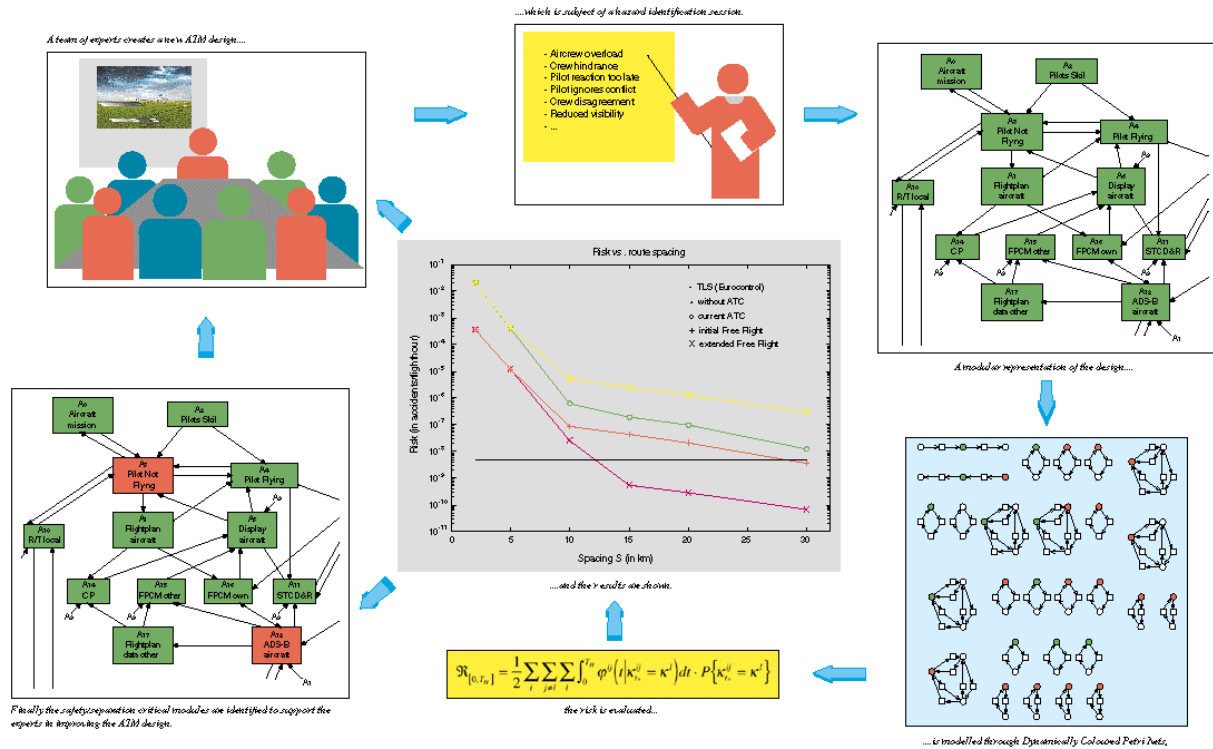


Figure 5 TOPAZ Risk Assessment Cycle

TOPAZ has been successfully applied for risk evaluation in opposite en-route lanes, free flight equipped aircraft, wake vortex induced risk, converging runways, active runway crossings, runway occupancy time, noise abatement approach and Galileo.

The opposite en-route lanes collision risk assessment was illustrated during the clinic. The model-based accident risk results are presented in Figure 36, with on the horizontal axis the nominal distance (Spacing) between the centre lines of two opposite-direction routes at the same flight level. The light-blue bar indicates the 95% credibility range due to uncertainty in the parameter values for one particular spacing. The circle on that bar indicates expected accident risk, which is the result of compensation for bias due to all assumptions adopted during the risk assessment. The interval is from a factor 4.5 higher to a factor 12.2 lower than the expected risk. The collision risk assessment shows a conservative spacing of 10 NM meeting the selected TLS.

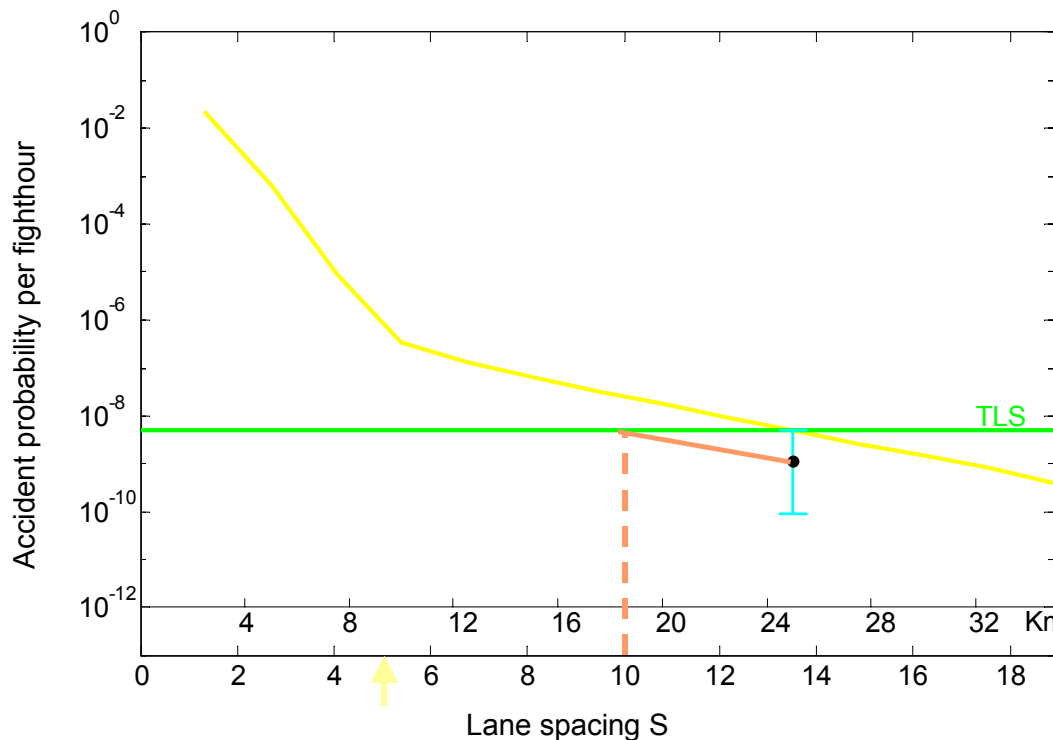


Figure 6 Accident Probability as a Function of opposite en-Route Lanes Spacing

3.6. Human Factors Case – Mr Michael Woldring (EUROCONTROL)

Previous to the discussion on Human Factors Case, Michael Woldring, the facilitator gave a brief presentation about Human Factors Case developed in EUROCONTROL as part of the HIFA (Human Factors Integration in future ATM system). The Human Factors Case is an easy approach that can be used by project leaders to ensure HF integrated in their projects, performed in Four Phases. The presentation (included in the Annexes to this report describes the Four Phases of the Approach).



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Figure 7 EUROCONTROL HIFA website

The discussion started with some questions about which projects have used this methodology. It was answered that it has been used in at least 10 projects, e.g. ASMGCS – used it as part of the study into head-down time. It was mentioned that there is a need to introduce Human Factors on the basis that Human Factors studies help the system to be fit for the purpose it has. It may also be important to present Human Factors and Safety Factors as integrated activities because this could be considered as a more efficient use of resources and could help to get Human Factors introduced from the start of projects.

As it was discussed Human Factors Case has not yet been developed to stage to provide assurance and the study of Human Factors is still seen more as an impediment than as a benefit for the project. It was also mentioned that this view (of little appreciation) will probably continue until Human Factors has to be included as part of the certification of ATM systems, because although there have been some improvements there is still not enough realization among the designing/engineering community of the importance of the inclusion of HF in the designing of the systems. It would be different, and this also was discussed during the clinic, if there was a human factors manager included in the project that had to certify the system in human factors, this might be the solution to have a more relevant presence of Human Factors in projects. In consonance with the rest of the discussion, it was mentioned that human factors experts are more requested to get involved in projects unfortunately because of previous failures in systems the project team wants to avoid, but the important thing that should be highlighted is human factors people start to get more involvement in projects.



4. WORKSHOP SESSIONS

On the final day, three workshops were held aiming at establishing a common Safety R&D Agenda, focusing on participants from “all corners in the aviation sector” to clarify safety needs, priorities and to identify best ways forward.

4.1. Strategic Safety R&D Plan

Facilitator: Nigel Makins (EEC)
Rapporteur: Mónica G. Medina & Natalia Suarez (ISDEFE)

Objectives:

- Identify strategic lines to lead on the Safety R&D development process

The purpose of this workshop was to identify the characteristics of the future safety R&D paradigm. In particular the workshop looked for the changes that current approaches have to undergo to face the challenges of the future and overcome the problems of the present.

To come up with the required changes, firstly the workshop participants explored the deficiencies and weaknesses of the current approach and pinpointed the rationale for these deficiencies. Secondly, on the basis of these findings, several proposals at strategic level were done to drive the safety paradigm shift, sustained in some cases for a number of more specific measures.

The workshop participants gave answers to the questions below. The following paragraphs summarise their conclusions in these four areas:

- Why are changes to the current approach needed? *Reasons for change.*
- What should be the required changes? *Strategic lines of the development process.*
- How can these changes be achieved? *Specific measures to support the strategic plan.*
- What should be the foundations of the future safety R&D approach? *New safety paradigms.*

Reasons for change

Historically, safety R&D has been based on lessons learnt from accidents. This vision is widened to the inclusion of incident as accident precursors, particularly important as the number of accident decreases. However, reactive approaches may not be sufficient to cope with the objective of ensuring the safety of the system due to several reasons. On the one hand ATM is a system in continuous change, where things rarely happen twice in the same manner. On the other hand, the future environment with a high level of traffic, a mixture of traffic patterns and aircraft equipages, poses a great challenge on safety.

Implementation of new concepts with incorrect or insufficient safety focus may endanger the resilience of the system. A high percentage of system related accidents reside in causes not envisioned during design. Therefore it is necessary to put measures in place to provide the system with the capability of coping with unexpected situations.

Safety does not have the role it deserves in the system lifecycle both in the design and during the operation. With regards to the design phase, in most cases, safety is quite intensive prior to



industrialisation. This late inclusion of the safety issues into design prevents the safety case from driving the development from the very beginning.

There is a poor perception of safety activities by the designers. Safety is seen as a consumer instead of as an enabler for business. To a large extent, safety is perceived as a barrier; even more when safety reasons make the design process to go backwards. Safety added value is not appreciated as the high interrelations between integrity, reliability and safety make the designers to feel that design techniques are sufficient to tackle the safety issues. The lack of confidence in the safety practitioners and the deficient understanding of the safety R&D added value is also evidenced in the operations phase.

There is a gap between safety perceptions by managers and operational controllers and a need is detected to bring together perceived and provided safety.

There seems to be a lack of interest in the safety field at the educational level. The absence of safety issues in the majority of MBA programmes is symptomatic of the problem.

Safety is not all about failures. This erroneous belief is rooted in the lack of a systemic approach. The absence of equipment failure cannot be equated to the absence of hazard. Conversely, the deviations from nominal conditions are not inherently unsafe and the limits up to which safety is preserved can be a field of research.

Strategic lines of the development process

- To enlarge the safety lifecycle by embedding the safety practice along the whole system lifecycle. To follow a systematic safety approach that avoids discontinuous participation of safety experts and starts at the very early stages of the design.
- To improve the perception of the safety practitioner role by the designers. To propitiate understanding and appreciation of safety practice and safety R&D. To increase awareness of safety added value.
- To improve the safety awareness by managers preventing the overconfidence in the current safety of the system. To keep actors informed of safety implications.
- To bridge the gap between the different safety perceptions by managers and operational controllers through safety culture promotion and ultimately reconciling provided and perceived safety.
- To adopt safety approaches which preserve the resilience of the system.
- To improve the safety expertise starting at the educational level. To capture interest towards the safety domain by improving the perception of safety practitioners.
- To reinforce the systemic approach with strengthened focus on the human element.
- To move towards a **user centred safety**.



Specific measures to support the strategic plan

- Consider Areas of Change (JSSI/FAST) as best practice to plan the way forward.
- Use best practices from other domains to make the information to flow through stakeholders and ease the implementation of strategic lines (OCVM-alike document for the safety domain).
- Implement a safety technology watch in search of new theories.
- Study accident precursors, e.g. RWY incursions.
- Promote the system safety engineering as discipline to get the global safety picture.
- Apply benchmarking from other industries to improve safety methods and tools.
- Develop / use decision making supporting tools for managers to evaluate the risk associated to system changes at the conceptual level (e.g. TOPAZ).
- To continue initiatives to understand the human performance envelope.
- Apply maturity models for safety to find out the soundness of the design lifecycle and to which extent safety is included in it.
- To explore ways to better manage the risk associated to system variability.

New safety paradigm

Although having an inherent reactive component by nature, safety R&D has also to challenge into the future and become in charge of its own directions.

For the new paradigm it is proposed to find the right balance for safety R&D between a reactive and a proactive approach. Safety R&D has to look at the future and emerging concepts up to the point that new concepts might be even driven by safety issues.

The path towards the safety paradigm shift should be based in evolution rather than in revolution. To make it happen, an overall action plan is needed. A collaborative setup of R&D programmes ensuring they are sufficiently comprehensive to cover all the needs is an essential step of the development process.

4.2. Identification of Technical Areas for R&D Prioritisation

Facilitator: Richard Kennedy (Boeing R&TE)
Rapporteur: Mariken Everdij (NLR)

Objectives:

- Identification of key Safety R&D “threads”
- Identification of priorities in each thread
- Identification of actual added value / benefit for each priority issue



The approach taken in this workshop was to have a brainstorming session to identify potential Safety R&D issues or threads. The results are presented below.

Safety Perception:

- Different actors / organisations have different views on what constitutes safety.
- Not all actors share the same situational awareness, how can safety be customised?
- Views on what kind of safety is expected from different actors to deliver a set of rules for safety assurance.

Safety as a Living Practice:

- Management leadership and commitment to safety and SMS.
- Ownership of safety problem.
- Need to understand how to influence safety values.
- SMS, approach harmonisation for implementation.

Safety Regulation Confusion:

- Despite the perceived view that only regulations can prompt management into action, safety regulation appears to be somewhat confusing throughout Europe.
- Perception that regulations are not clearly formulated.
- Perception of clear differentiation between ATM safety regulation and reliability regulation as the latter is easily defined through metrics.
- Regulators are undertaking their own Safety R&D without a clear relationship between R&D carried out by ANSPs.
- Perception of a need for regulation harmonisation as currently several are imposed from different quarters, e.g. ICAO, ESARR, national level etc. This would facilitate across-border issues.

Safety Regulation Enforcement:

- Differences between safety regulation enforcement points of view (e.g. regulator vs ANSPs)
- How to certify evolving systems.
- Need for experts to interpret Safety regulation Rules.

Safety Regulation Design:

- Regulation of “virtual airlines”.
- Flexibility so that regulations can adapt to changing conditions.
- Regulation is a paper exercise, perception for regulations to be more challenging.



- Given the ever increasing reliance of ATM systems on software, what is the impact on software regulation.

Safety Assessment Methodologies Development:

- There is no appropriate regulatory framework / assessment approach for legacy and existing systems (such as systems that entered operational service prior to regulation enforcements, e.g. without a safety case).
- Need for harmonisation of different methodological assessments.
- Methodologies are not readily available to assess human reliability, human error and human / system resilience.
- Thinness of methods for future system developments.
- Pilot and ATCO do not get much “credit” in available methodologies (e.g. quantification of redundant and adaptive capabilities provided by human agents).
- Are available methods ready to take into account the changing environment?
- Lack of holistic assessment methodology encompassing and integrating all players.
- Importance of dynamic quasi real time safety assessments of weather disruption to ATM.

Safety Case Building and Follow Up:

- Disconnection between Safety case development and monitoring after introduction into operational service.
- Need for the development of a tool to monitor and evaluate assumptions made during safety case development.
- Perception that dynamic (ongoing) monitoring of operations ought to be incorporated into the Safety Case process.
- Formal verification of the system, no formal readiness testing for appropriateness.
- Are the assumptions that we use for ATM safety correct?

Applications for Safety Cases:

- Transferring separation responsibility to the flight deck, what is the ASAS influence / impact?
- Perception that more emphasis needs to be placed in Safety Cases on safety being ensured by multiple interacting elements.
- Resilience to maintain system throughputs.



Safety Levels:

- Existing assumption is that the current ATM system is safe, is this correct and why is it safe?
- Aircrafts are originators of TLS and they are moving away from it again.
- TLS is derived from actual accidents whose statistics include the impact of safety nets, so why not factor in the benefits of safety nets into safety cases?

Safety Contexts:

- Keep an eye on legal and liability framework that surrounds the aviation industry as these aspects could shape the way the future develops.

Mitigations:

- Whose responsibility is on funding mitigations concerning airports?
- How to deal with long lists of mitigations that are in an assessment output?

Safety Nets, Warning and Advisory Systems:

- Many current safety nets are a mixture between safety nets and advisory tools, a new take is needed on safety defences.
- Should safety nets be independent, standard tools?
- The effects of “technical” safety nets are not often taken into account in safety cases, but a second controller usually is. This appears to be confusing and contradictory.
- Achieving proper balance between prevention and mitigation.
- Relationship between capacity increase and safety nets, given that the current system is assumed safe.

Separation Minima:

- Reconsideration of separation minima is needed as TCAS and controller supported minima are not related.
- Wake vortex and separation minima.

Human Factors:

- Do situational awareness measurements measure what is needed?
- Workload has different dimensions, need to be more discriminating as to what its effects are and what is the impact of distributed decision making.
- Identification of human factors in the system.



- How to define intuitive displays (e.g. display information in an intuitive fashion from the user point of view).
- Human performance monitoring.
- Errors of omission vs commission.
- Selection and training, are the methods appropriate for future developments?
- Automation, how to make the work still interesting for humans as they need to be kept in the loop well motivated.
- Function allocation: task carried out by human or machine?
- Emergencies: what to do. Resilience.
- Procedures are not always followed, prescriptive procedures vs normal procedures.
- Normal operations, how to cope with future challenges.
- Sharing of procedures between human and machine.

The future:

- Vision of the future, currently each aircraft controlled. Do we need many controllers or can we do with less. Aircraft taking care of themselves. How will humans react to such scenario (since the techniques to do this are already there).
- How do you change AT, what are the next steps? Quick changes are hard to prove safe.
- What form will safety take in the future system.
- Are we doing the right things right now, if not then how can we do something about the future.
- Practical realities of future concepts.

Safety Metrics:

- What are the needed safety metrics?
- We need to find a new generation of safety metrics.

Miscellaneous:

- Monitoring and incident data, safety learning.
- Safety paradigms we have now do not really reflect the real world.



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- What does society expect from aviation, how much safety do they want and what they are willing to spend on it. Societal cost benefit.
- All unknown safety threads or that we do not have knowledge about yet.

Lack of time prevented the workshop group from identifying thread priorities and assignation of added value. A detailed account on areas for safety R&D proposals for prioritisation can be found in the conclusions of the Safety R&D Survey [1].

4.3. Safety R&D Plan Implementation (Funding, management arrangements, etc.)

Facilitator: Michel Masson (Boeing R&TE)
Rapporteur: Paul Humphreys (Eurocontrol Brétigny)

Objectives:

- To define the who the actors are in the safety R&D field and how to connect them
- To identify the decision makers and ways to involve them
- To identify funding sources and appropriate funding mechanisms

The funding sources and mechanisms identified during the workshop are listed below:

- Public investment:
 - National level:
 - * Government.
 - * Ministry of transport.
 - * Ministry of Research.
 - * CAAs.
 - International level:
 - * JAA Research committee (CAA coordination).
 - * EASA.
 - * Eurocontrol through TRSs.
 - * European Commission through the framework programmes (different instruments).
- Private investment:
 - Airports.
 - Airlines.
 - ANSPs.
 - Manufacturers.

R&D organisation in Europe is a complex, distributed, multi-actors system. The main actors are R&D organisations, industry, ANSPs, Airlines, manufacturers, government and regulators.



These actors are in some cases self organised in structures such as networks of excellence. In the view of the participants, the balance of the participations of these actors in the safety R&D domain should be improved.

Current competition based funding mechanisms involve advantages and drawbacks.

Although some rulers exist, such as EUROCONTROL, EC and National agencies, there is no centralised agency, in the fashion of the JPDO in the US.

The workshop participants pointed out the possibility of a more centralised management in the manner of the JPDO. However, they did not come to a firm conclusion that a body of these characteristics was the best way to improve the current European organisational framework.

With regards to the current rulers, a number of proposals for improvement were done, that might be transposed to the eventual centralised safety R&D management agency. These proposals are:

- Transparency in the funding processes.
- Better access to R&D activities and programmes by other actors.
- Improved feedback of the results.

As a conclusion from the diagnosis of the current organisational framework, it was detected that there is a need for improved **coordination, integration and harmonisation** of the programmes with reference to existing strategic agendas.



5. CONCLUSIONS

The outcome of both the CAATS Safety R&D Survey and Workshop confirmed the previously held view of a fragmented Safety R&D activity state of play across Europe. Taking into account the Safety R&D landscape provided by the Survey, the Workshop activities were aimed at justifying the need for a Safety R&D Strategic Plan, establishing their main action lines and high-level contents (key safety R&D threads) and putting forward some ideas for a potential framework to enable both its generation and implementation.

Safety already features prominently in current ATM R&D European action plans and agendas, such as EUROCONTROLS SSAP (Strategic Safety Action Plan) placing a high priority on Research & Development into Safety and Human Factors and ACARE SRA1 and SRA2 (Strategic Research Agenda), setting objectives for an 80% accident rate decrease and a reduction in human error and its consequences. European ATM is undergoing a period of profound transformation in pursuit of the SES (Single European Sky), a period that anticipates increased capacity brought about amongst other changes by increasing reliance on automation and substantial changes in pilots' and controllers' roles (e.g. transfer of separation responsibilities). The emerging view from the Safety R&D community is that the delivery in the future of a safe ATM system requires the implementation of a co-ordinated safety R&D strategic plan, harmonised with the rest of agendas in place. Main anticipated benefits of such a strategic plan for safety R&D are avoiding duplication and offering adequate visibility on the prioritisation of ANSP safety needs and opportunities for co-ordination to collaborating partners (e.g. R&D Centres and Universities).

5.1. Identification of R&D development processes

The "Identification of R&D processes" session articulated the needs that the Safety R&D plan is to address, starting from promoting safety awareness to ensure the presence of safety throughout the lifecycle of the ATM system, especially by injecting real safety from the very beginning at the conception and design stages. Another key plan identified consists of achieving the right balance between reactive and proactive R&D efforts, leading to a safety paradigm that takes into account future and emerging concepts. The summary of key issues identified during the session is shown in Figure 8.

- Safety plan
 - How can safety have a voice?
 - ◆ Inject real safety into the design
 - ✎ Safety embedded into design life cycle from the very beginning even at conceptual level
 - ◆ Promote safety awareness among operational people
 - ✎ At the top managerial level
 - ✎ Among operational people
 - Right balance between predictive and reactive
 - ◆ Accidents, incidents as accident precursors Remain being essential but...
 - ◆ Towards a safety paradigm shift that takes care of future and emerging concepts
 - ✎ Even leading to new concepts driven by safety issues

Figure 8 Outcome of Workshop R&D Identification Processes

5.2. Key Safety R&D threads

The “Key Safety R&D threads” session identified many issues in need of further analysis and resolution that in combination with those already identified in the Survey could be incorporated into the contents of a generalised safety R&D plan. The emerging view from the community was that the research & development effort needs to balance both actions into how to make the overall ATM system² and its operation safer on the one hand, and the rules and safety practice means to verify the ATM system satisfactory operational safety status and its certification on the other.

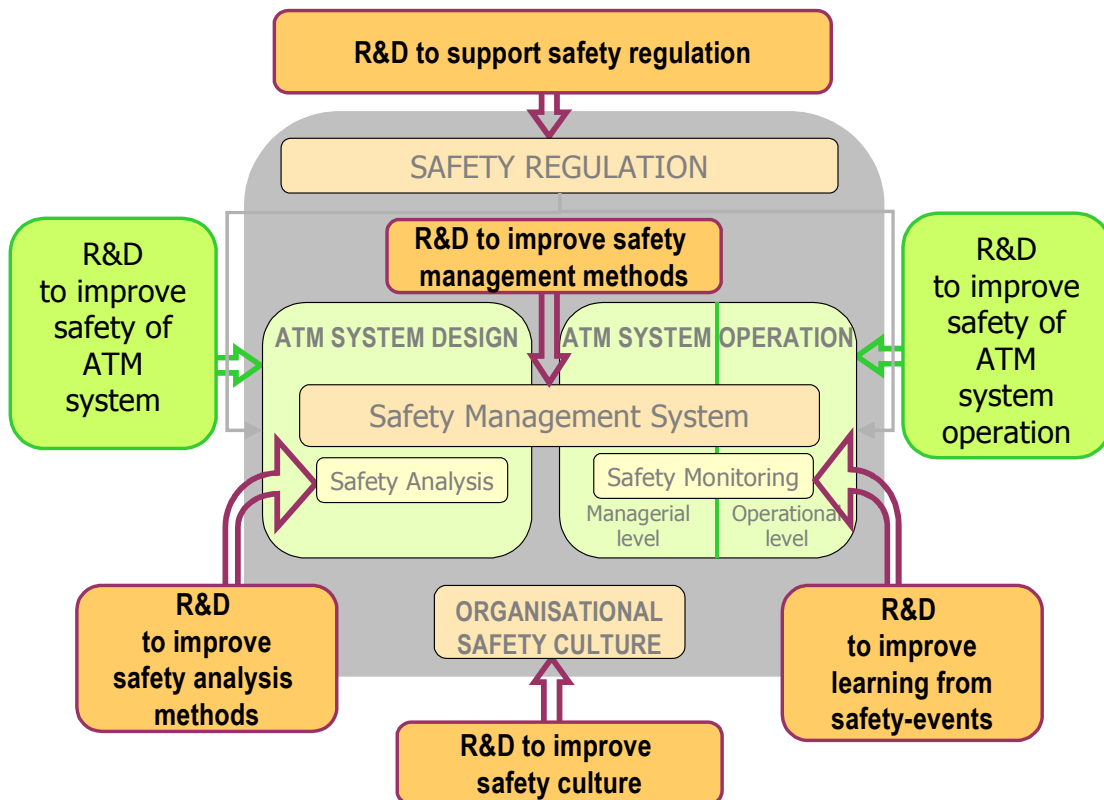


Figure 9 Proposed Safety R&D Strategic Plan constituting Action Lines

These R&D areas, illustrated in Figure 9, can be grouped into the following 5 action lines (issues given for each action are provided as examples identified for prioritisation and co-ordination and do not constitute a comprehensive list):

- **Improving the safety levels of the ATM system and its operation** (in green):
 - *R&D to improve the safety of the ATM system:*
 - * Improved design of old & new safety barriers (e.g. enhancing existing safety nets; developing new ones that increase the resilience of the ATM system).

² ATM system encompassing the human element, equipment and procedures



- * Understanding the impact of large-scale changes such as functional airspace blocks, new information sharing systems, etc. on ATM safety, human performance and resilience.
- *R&D to improve the safety of ATM system operation:*
 - * Improved Training for the entire ATM crew (including technical support, maintenance, etc.).
 - * Human error reduction techniques, including development of Human Factors Assurance methods that result in practical Human Factors Safety Requirements and manageable cognitive workload and situation awareness in mid and longer term concept realisations.
 - * Approaches to optimise safety early in design conceptualisation, to determine where and how to invest in safety in future concepts.
 - * More utilisation of controller and pilots in safety optimisation R&D to ensure practicability and to capture their ideas/concerns.
- ***Enhancing the regulation and safety practice means to verify the ATM system satisfactory operational safety status and its certification*** (in orange):
 - *R&D to support safety regulation in the following areas:*
 - * Harmonisation of international, European and national regulation.
 - * Analysis of the relative benefits of certification and risk assessment approaches, to inform the optimum approach for EASA's regulatory role with respect to ATM.
 - * TLS derivation and apportionment methods.
 - * Regulation formulation (e.g. for ATM-related software).
 - * Separation Minima.
 - *R&D to improve organisational safety culture:*
 - * Promotion at managerial and operational level – developing the concept of 'safety intelligence'.
 - * Safety culture metrics for assuring effective safety management and true commitment to safety throughout organisations, bridging the divide between management and controller workforce.
 - * Development of guidance on safety culture 'enablers/disablers' to facilitate healthy organisational safety cultures.

- *R&D to improve safety management methods:*
 - * Processes to identify, prioritise, and resolve key risk areas that arise in operational ATM.
 - * Comprehensive integration of Human Factors into Safety management.
 - * Development of decision support tools for managers, to understand their safety and risk priorities, and inform decision-making at corporate levels.
 - * Development of both lagging and leading safety Key Performance Indicators for management.
 - * R&D on future safety paradigms for 2025.

- *R&D to improve safety analysis methods:*
 - * Development of Human Reliability Assessment techniques.
 - * Development/Evolution of Safety and Risk Assessment Methodologies particularly in the areas of common cause analysis, dynamic risk assessment, error of commission analysis, and both fast and cognitive simulation capabilities.
 - * Development of a reliability database for the industry.
 - * Sharing of safety case information using a common database so that safety cases can learn from each other.
 - * Common Safety and human error data available as R&D input.

- *R&D to improve learning from safety-related events:*
 - * Availability of incident and accident information for common analysis purposes.
 - * Development of a European-wide ‘early warning’ system based on rapid analysis of emerging incident trends and an effective dissemination system.

5.3. Organisational Framework

Finally, the “Organisational Framework” session discussed a feasible structure for the implementation of the Safety R&D strategic plan to be undertaken amongst multidisciplinary players in the aviation sector, dealing with issues such as ownership and funding opportunities. For ANSP organisations at the front line of safety provision, usually limited by scarce overall R&D budgets and subject to a market under a clear liberalisation trend, it is very difficult to justify resource allocation to safety initiatives with beneficial outcomes often difficult to measure (as opposed to say, capacity). Additionally, the multiplicity of (often) conflicting agendas in Europe could not be more contrasting to the US JPDO (Joint Planning & Development Office) co-ordinating the transformation of the American air transportation system.



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It was identified that ideal ownership for the Safety R&D strategic plan was to fall on a consortium representing all stakeholders who were to directly benefit from ensuring ATM safety, ranging from the EC, EASA, national regulators & ANSPs and representatives from ATM (e.g. CANSO, IFATCA) and aviation organisations (e.g. airlines, manufacturers and industry). The creation of such a consortium undoubtedly constitutes a rather challenging task but an interim step towards this objective would be to delegate ownership and allocate responsibility for the safety plan initial generation to an already existing agency. A view expressed by some members of the Safety R&D community in the Workshop was that the EUROCONTROL Experimental Centre was one starting point for such endeavours. The safety plan ownership could be transferred at a later stage once initial steps had been taken, though facilitating in the meantime the co-ordination of the prioritised actions identified in the plan.

Notwithstanding securing funding for the Safety R&D strategic plan generation and implementation would require a significant justification exercise, it is considered that recent events (such as the Überlingen and Linate accidents) together with the safe SES requirement could provide a sufficiently strong argumentation line for its execution. Different sources for potential funding were proposed: national Governments and Civil Aviation Authorities, EC Framework Programme instruments (e.g. a Safety R&D Joint Undertaking, Networks of Excellence) and private investment (industry and manufacturers). These could be complemented through the internal effort from ANSP and national R&D organisations.

In the near term, it is hoped more generally that the workshop and its results have generated the beginnings of a consensus on the key ATM safety R&D issues, and shown the need and propensity for an ATM safety R&D community. It is also hoped that the safety R&D priorities developed may be considered as useful inputs to inform future R&D programmes, whether at national or European levels. Furthermore, Eurocontrol is considering sponsoring a second event in 2006 to follow up the CAATS workshop, to further support the development of this needed R&D community.



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6. REFERENCES

1. CAATS Deliverable D1.4 Safety Report Volume III: Safety Research and Development, CAATS-SKE III Safety RD-WP1.1-NLR-V0.7-D-PU-004, 10 Oct 2005.



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Deliverable D1.4

CAATS

Contract N° Aero1/2003/502791

Project

Coordinator: Isdefe

Partners:

Isdefe
Aena
EEC
Ineco
NERL
NLR
CDV
Deep Blue
Deimos
DFS
Nickleby HFE
RC AUEB
Slot Consulting
TUD

Date: 13.12.2005

**PROJECT FUNDED BY THE EUROPEAN
COMMISSION UNDER THE TRANSPORT
RTD PROGRAMME OF THE
6th FRAMEWORK PROGRAMME**



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Annex A. CAATS Safety R&D Workshop Programme



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Cooperative Approach to
Air Traffic Services

CAATS
SAFETY R&D WORKSHOP

18-20 October 2005

EUROCONTROL HQ
BRUSSELS



European Commission
Sixth Framework Programme

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SAFETY R&D WORKSHOP

Preliminary Detailed Programme

Day 1: Tuesday, 18 October 2005

(09:30 – 18:00)

- 09:30 - Registration
11:00 - Welcome & Opening
Morten Jensen (European Commission)
Barry Kirwan (Eurocontrol Experimental Centre)

Session 1

- 11:15 - Workshop Aims
Barry Kirwan (EEC)
11:45 - Safety Survey Findings & Current European Safety R&D Landscape
Mariken Everdij - Survey Team (NLR, BR&TE, EEC & ISDEFE)
13:30 - Lunch

Session 2

- 14:30 – Eurocontrol Safety R&D Perspectives - AGAS and Safety R&D
Barry Kirwan (EEC)
15:00 – Stakeholder Views
Job Brügggen (CANSO)
[coffee]
Billy Josefsson (LFV)
Martyn Richards (NATS)
Giancarlo Ferrara (ENAV)
Rudi den Hertog (JSSI/FAST)
17:45 - Q&A
18:00 – Close

Day 2: Wednesday, 19 October 2005

(09:00 – 18:00)

Session 3

- 09:00 - CAATS Target Projects - perspectives on best practice and Safety R&D needs
Eric Perrin (EEC)
Mónica García Medina (ISDEFE)

Date: 19.12.2005
Classification: PUBLIC
Page: A.2

Identification: ISCASE-053177-11L
Version: 1.1
Reference: WP1.1-EEC-V1.0-D-PU



- 09:40 - US FAA Vision on Safety R&D priorities
Dino Piccione (FAA)
- 10:40 - Stakeholder Views continued
Anthony Smoker (IFATCA)
- 11:00 - Coffee Break
- 11:30 - Aviation Safety R&D Organisations Views
Michel Piers (NLR)
Sylvie Figarol (DTI/SDER)

Session 4

- 12:15 - Aviation Safety Departments at Universities Views
Prof. Hartmut Fricke (Dresden University)
Prof. Peter Brooker (Cranfield University)
Prof. Andrew Hale (Delft University)
- 13:15 - Q&A
- 13:30 - Lunch

Session 5

- 14:30 - Clinics Session 1, three parallel clinics:
- How to carry out a PSSA - a Case Study, Ground Based Augmentation System (a local augmentation to GPS to support precision approach and landing operations, Eric Perrin, EEC)
 - Human Error Identification using Task Analysis, HAZOP and TRACER - Case Study, Airborne Separation Assistance System (Rachael Gordon, EEC)
 - FAST Hazard Identification and Management Process - an ATM & Airborne Case Study
(Brian Smith & Tim Porter, JSSI/FAST)
- 16:00 - Clinics Session 2, three parallel clinics:
- TLS application to safety cases in ATM (Mario Lenitz, CEATS / Austrocontrol)
 - TOPAZ - Case Study, TOPAZ risk assessment methodology (Henk Blom, NLR)
 - Human Factors Case (Michael Woldring, EEC)
- 17:30 - Discussion points
- 18:00 - Close
- 20:00 - **Social Event**
Restaurant La Vierge Noire, Brussels centre

Day 3: Thursday, 20 October 2005

(09:00 – 13:00)

Session 6

- 09:00 - Workshops - six sub-groups to discuss:
The Top 10 Safety R&D priorities for European ATM
How to better coordinate European ATM Safety R&D
- 11:00 - Rapporteurs meeting/coffee break

Session 7

- 11:30 - Workshops and Clinics Conclusions – Rapporteur reports
Survey Team (NLR, BR&TE, EEC & ISDEFE)
- 12:15 - General discussion on the way forward
Barry Kirwan (EEC)
- 13:00 - Close of workshop



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Annex B. CAATS Safety R&D Workshop Attendance List.



Surname	First Name	Company / Organisation	Country
Begault	Véronique	EUROCONTROL Experimental Centre	France
Bekier	Marek	Skyguide - swiss air navigation services ltd	Switzerland
Blom	Henk	National Aerospace Laboratory NLR	The Netherlands
Brooker	Peter	Helios Technology Ltd.	United Kingdom
Brüggen	Job	LVNL	The Netherlands
Den Hertog	Rudi	Fokker Services BV	Germany
Deharvengt	Stéphane	DGAC-F/DAST/SEA	France
Drogoul	Fabrice	EUROCONTROL Experimental Centre	France
Dusire	Sophie	EUROCONTROL CRDS	Hungary
Everdij	Mariken	National Aerospace Laboratory NLR	The Netherlands
Ferrara*	Giancarlo	ENAV	Italy
Figarol	Sylvie	CENA	France
Fletcher*	Robert	Nav Canada	Canada
Fricke	Hartmut	Dresden University	Germany
Garcia	Felipe	INECO	Spain
García Medina	Mónica	Isdefe	Spain
Gautier	Regis	THALES ATM	France
Glauser	Hans Ulrich	Skyguide	Switzerland
Gordon	Rachel	EUROCONTROL Experimental Centre	France
Grippa	Daniela	EUROCONTROL HQ	Belgium
Guraly	Roland	Slot Consulting Ltd.	Hungary
Hale	Andrew	TU Delft	The Netherlands
Hudson	Patrick	Leiden University	The Netherlands
Humphreys	Paul	EUROCONTROL Experimental Centre	France
Jansen	Roy	National Aerospace Laboratory NLR	The Netherlands
Jensen	Morten	European Commission	EC
Jorna	Peter	National Aerospace Laboratory NLR	The Netherlands
Josefsson	Billy	LFV	Sweden
Kennedy	Richard	Boeing R&T Europe	Spain
Kirwan	Barry	EUROCONTROL Experimental Centre	France
Krastev	Alexander	EUROCONTROL HQ	Belgium
Kuijper	Jos	EUROCONTROL HQ	Belgium
Lenitz	Mario	AUSTROCONTROL	Austria
Makins	Nigel	EUROCONTROL Experimental Centre	France
Mancini	Maurizio	ENAV S.p.A.	Italy
Masson	Michel	Boeing R&T Europe	Spain
Nollet	Jos	DGTL	The Netherlands
Oliver	Mervyn	EUROCONTROL IANS	Luxembourg



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Surname	First Name	Company / Organisation	Country
Paries	Jean	<i>Dedale</i>	<i>France</i>
Pasquini	Alberto	<i>Deep Blue</i>	<i>Italy</i>
Perrin	Eric	<i>EUROCONTROL Experimental Centre</i>	<i>Belgium</i>
Piccione	Dino	<i>FAA</i>	<i>USA</i>
Piers	Michel	<i>National Aerospace Laboratory NLR</i>	<i>The Netherlands</i>
Porter	Tim	<i>Boeing Commercial</i>	<i>USA</i>
Portier	Michel	<i>DGTL</i>	<i>The Netherlands</i>
Prahl	Christer	<i>EUROCONTROL HQ</i>	<i>Belgium</i>
Richards	Martyn	<i>National Air Traffic Services</i>	<i>United Kingdom</i>
Rutten	Alex	<i>National Aerospace Laboratory NLR</i>	<i>The Netherlands</i>
Save	Luca	<i>Deep Blue s.r.l</i>	<i>Italy</i>
Scherzer	Hans	<i>APAC GesmbH</i>	<i>Austria</i>
Smith	Brian	<i>National Aeronautics and Space Administration (NASA)</i>	<i>USA</i>
Smith	Steeve	<i>FAA</i>	<i>USA</i>
Smoker	Anthony	<i>IFATCA</i>	<i>Canada</i>
Straeter	Oliver	<i>EUROCONTROL HQ</i>	<i>Belgium</i>
Suárez Fernández	Natalia	<i>Isdefe</i>	<i>Spain</i>
Szucs*	Laszlo	<i>Scientific Association for Transport</i>	<i>Hungary</i>
Van Doorn	Jan	<i>EUROCONTROL Experimental Centre</i>	<i>France</i>
Vinagre	Lluís	<i>Isdefe</i>	<i>Spain</i>
Völckers	Uwe	<i>DLR</i>	<i>Germany</i>
Woldring	Michiel	<i>EUROCONTROL Experimental Centre</i>	<i>France</i>
Zoógrafos*	Konstantinos	<i>RCAUEB</i>	<i>Greece</i>

* Registered but not attended



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Annex C. Acronyms.



Term	Definition
ACARE	Advisory Council for Aeronautics Research in Europe
ACAS	Airborne Collision Avoidance System
ADVISES	Analysis Design and Validation of Interactive Safety-critical and Error-tolerant Systems
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider
AoC	Area of Change (FAST)
APAC GesmbH	Austrian Product Assurance Company
APJ	Absolute Probability Judgement
APP	Approach Control Office
ARDEP	ATM R&D Activities in Europe
ARP	Aerospace Recommended Practice
ASAS	Airborne Separation Assistance System
ASMGCS	Advanced Surface Movement Guidance & Control System
AT	Air Transport
ATCo	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
BR&TE	Boeing Research and Technology Europe
CAA	Civil Aviation Authority
CAATS	Cooperative Approach to Air Traffic Services
CANSO	Civil Air Navigation Services Organisation
CAT	Category
CC	Common Cause
CCA	Common Cause Analysis
CD&R	Conflict Detection & Resolution
CEATS	Central European Air Traffic Services Programme Directorate
CFIT	Controlled Flight Into Terrain
CRDS	EUROCONTROL CEATS Research, Development and Simulation
CS	Certification Specification
DGAC	Direction Générale de l'Aviation Civile, France
DG-RES	General Directorate of Research (European Commission)
DGTL	Directorate General of Civil Aviation and Freight Transport, The Netherlands
DG-TREN	General Directorate of Transport And Energy (European Commission)
DTI/SDER	Direction de la Technique et de l' Innovation, Sous Direction des Etudes et de la Recherche Appliquée
EASA	European Aviation Safety Agency
EC	European Commission
EEC	Eurocontrol Experimental Centre

Term	Definition
ENAV	Società Nazionale per l'Assistenza al Volo
ERRIDS	European Regional Renegade Information Dissemination System
ESARR	Eurocontrol Safety Regulatory Requirement
ETTO	Efficiency Thoroughness Trade-Off
EXANET	Network of Excellence on Air transport Safety Research
FAA	Federal Aviation Administration
FAST	Future Aviation Safety Team (JSSI, JAA)
FHA	Functional Hazard Analysis
FMEA	Failure Mode & Effect Analysis
FP6	Sixth Framework Programme
GBAS	Ground Based Augmentation System
HAZOP	Hazard & Operability Study
HE	Human Error
HEART	Human Error Assessment and Reduction Technique
HERA	Human Error Reduction in ATM
HF	Human Factors
HFACS	Human Factors Analysis and Classification System
HFP	Human Factors Programme
HIFA	Human Factors Integration in Future ATM System
HILAS	Human Integration in the Lifecycle of Aviation Systems
HTA	Hierarchical Task Analysis
ICAO	International Civil Aviation Organisation
IFATCA	International Federation of Air Traffic Controllers' Association
ILS	Instrument Landing System
INECO	Ingeniería y Economía del Transporte, S.A, Spain
IRP	Integrated Risk Picture (Eurocontrol)
ISDEFE	Ingeniería de Sistemas para la Defensa de España, Spain
JAA	Joint Aviation Authorities
JANUS	Harmonised HERA HFACS Technique
JPDO	Joint Planning and Development Office
JRC	Joint Research Centre (EU)
JSSI	Joint Aviation Authorities Safety Strategy Initiative
LFV	Luffartsverket
LOSA	Line Operations Safety Audits
MET	Meteorology
MFF	Mediterranean Free Flight
MTBF	Mean Time Between Failure
NASA	National Aeronautics and Space Administration, USA
NATO	North Atlantic Treaty Organisation



Term	Definition
NATPRO	National Air Traffic Professionalism (FAA)
NATS	National Air Traffic Services, UK
NLR	National Aerospace Laboratory NLR, The Netherlands
NOSS	Normal Operations Safety Survey (FAA)
OCVM	Operational Concept Validation Methodology
OPTIMAL	Optimised Procedures and Techniques for Improvement of Approach and Landing
PAL	Procedure Assurance Level (Eurocontrol)
PC	Paired Comparisons
PFHA	Preliminary Functional Hazard Analysis
PSSA	Preliminary System Safety Assessment
R&D	Research & Development
RC-AUEB	Research Centre, Athens University Of Economics And Business, Greece
RISC	RWY Incursion Severity Categorisation Model (FAA)
RWY	Runway
SAFEE	Security of Aircraft In the Future European Environment
SAM	Safety Assessment Methodology (Eurocontrol)
SC	Severity Class
SES	Single European Sky
SIR	Safety Issues Register (NATS)
SKE	Safety Key Element
SME	Small & Medium Enterprise
SMS	Safety Management System
SRA	Strategic Research Agenda
SRC	Safety Regulation Commission
SRU	Safety Regulation Unit
SSA	System Safety Assessment
SSAP	Strategic Safety Action Plan
STCA	Short Term Conflict Alert
TCAS	Traffic Collision Avoidance System
TEM	Threat and Error Management
THERP	Technique for Human Error Rate Prediction
TLS	Target Level of Safety
TOPAZ	Traffic Organisation and Perturbation Analyzer
TRACEr	Technique for the Retrospective and Predictive Analysis of Cognitive Errors
TRS	Task Requirement Sheet (Eurocontrol)
TWR	Aerodrome Control Tower