

**THEMATIC SYNTHESIS OF
TRANSPORT RESEARCH RESULTS**

PAPER 8 OF 10

HUMAN FACTORS

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**European Commission
Transport RTD Programme
Fourth Framework Programme**

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EXECUTIVE SUMMARY

This paper provides a structured guide to the findings and policy implications of research relating to human factors carried out in the Transport RTD Programme¹. (See Section 1 for advice on how to use the paper.)

Efficient and safe transport systems in Europe need to put prominent focus on contributing human factors in all respects. Whether the behaviour of human operators or users of transport services is considered, or sometimes rapidly changing working conditions are causing problems, the required solutions cannot be limited to the technical side. Human centred approaches are encouraged for enhancing transport systems, in particular for those with the highest demand for technological improvement. RTD is delivering practical tools, guidelines and recommendations to underline the successful implementation of policy measures that respect the human element, and demonstrate the suitability and benefits of new concepts.

In this paper, results are reviewed for “clusters” of research projects in eight inter-related areas:

Education/qualification and training

In the waterborne sector recommendations for improved maritime education and training of seafarers were formulated, building on the existing Standards of Training, Certification and Watchkeeping for Seafarers. Furthermore, the use of tailor made simulator training exercises was promoted.

Practical guidelines for training of air traffic controllers were devised addressing future cognitive job profiles with respect to upcoming Air Traffic Management systems.

Human role

In waterborne transport human centred system design approaches were identified as a positive factor for job satisfaction of seafarers. Thus Maritime Education and Training schemes are recommended to focus on the context specific character of impacts from new technologies on human operators.

The transition to advanced Air Traffic Control systems heavily depends on the operational success of man/machine interfaces. The changing work allocation between humans and machines was evaluated based on typical ATM automation concepts using dedicated tools, and employing man-in-the-loop trials at ATC centres.

Technology acceptance

Recommendations on the appropriate distribution of responsibilities for upcoming new technologies among equipment manufacturers, vehicle manufacturers, aftermarket suppliers, purchasing agencies, contractors, installers and users, were articulated in a formal statement of responsibility.

The impact of new technologies was found to be significant for the number of employed workers, their working conditions, the quality of jobs, the time pressure dictated by efficiency considerations and the membership to trade unions.

¹ Part of the Fourth Framework Programme for Community activities in the field of research, technological development and demonstration for the period 1994 to 1998.

Driver/operator behaviour

For future accident and incident investigation in shipping a common and comprehensive European maritime accident database is recommended to adequately cover human and technical factors alike. The most important aspect of human factor related accident causes needs to be addressed by harmonised education focusing on improved maritime English, peculiar habits and principal cultural differences.

The character of work for an aircraft cockpit crew has significantly changed due to modern layouts, which will shortly be targeted in a booklet on 'Crew Resource Management' for 'glass cockpits'.

In the rail sector a practical toolkit of analysis techniques for railway operators was developed that allows to identify possible human errors, offers available failure recovery measures and risk reduction strategies related to cross-border rail operations.

Automation

Detailed and practical guidelines for designing air traffic controller training with respect to upcoming ATM systems were devised, incorporating all recent developments and trends in instructional theory and technology, computer-based training and simulation.

In order to pave the way for the introduction of a harmonised European Train Control System a wide set of interface specifications was reviewed and trialed at commercial rail lines in three major European countries.

Information management

New approaches were validated that are meant to support aircraft operations during flight, and while aircraft are moving on the ground. The widespread deployment of standards compliant in-flight proximity warning systems, and the demonstrated capabilities of advanced Surface Movement Guidance and Control Systems were encouraged and confirmed through feedback from pilots and air traffic controllers.

The interoperability of the planned European Train Control System (ETCS) was addressed by thoroughly looking at required technical system specifications in compliance with the Reliability, Availability, Maintainability and Safety documentation.

In the waterborne sector an integrated architecture for information, navigation and communication systems on-board vessels was devised, that addresses tactical, strategic and fairway information needs. Furthermore a dedicated 'communication layer' for satellite based communication systems was defined.

Operational procedures

Ground air traffic controllers and aircraft pilots alike are confronted with the need to accustom to new operational scenarios in conjunction with new automation concepts and advanced cockpit environments, respectively. For both issues detailed recommendations were formulated, that help to appropriately address the human operator's role.

Towards the implementation of the foreseen European Rail Traffic Management System a set of specifications for testing and initial contracts for pilot and demonstration sites on major commercial rail lines across Europe were agreed on.

Retaining skills

Fundamental changes to the design of aircraft cockpits have major impact on the required skills of flight crews. The transition from conventional to modern "glass cockpits" was tackled with the provision of a practical booklet on "Crew Resource Management" containing a set of real-life incident scenarios.

A similar task in shipping was addressed by developing a computer based training tool – in

compliance with the STCW 95 framework – that allows for adaptation and training of ship crews on new technology tactical bridge displays, which are anticipated to improve navigational safety.

1. INTRODUCTION – HOW TO USE THIS PAPER

This paper provides a structured guide to the results of Research and Technical Development (RTD) projects relating to *human factors*, carried out in the European Community's Transport RTD Programme. It is one of a series of papers:

| Paper no. | Theme |
|-----------|--|
| 1 | Sustainable mobility – integrated perspective |
| 2 | Sustainable mobility – economic perspective |
| 3 | Sustainable mobility – social perspective |
| 4 | Sustainable mobility – environmental perspective |
| 5 | Urban transport |
| 6 | Efficiency and quality |
| 7 | Safety and security |
| 8 | Human factors |
| 9 | Interoperability |
| 10 | Freight intermodality |

Of the 275 projects financed by the Programme, 25 dealt (partly or fully) with the issues of urban transport. Most of these projects were finalised in the year 2000.

How to use this paper:

You are recommended to use this paper to locate RTD results on topics where you have a particular interest, rather than reading the paper from start to finish:

- Start in Section 5 to get an overview of the topics addressed by “clusters” of RTD projects.
- Read the part of Section 6 that summarises the findings for each topic of interest to you.
- Use Annex 1 to identify the individual projects relating to that topic.
- Use Annex 2 to review the key results from each of these projects.

Further details on individual projects can be obtained from their web sites (noted in Annex 2, where available) and from the following Commission web sites:

- <http://europa.eu.int/comm/transport/extra/home.html>, which includes summaries and the full final reports of individual projects, as well as a variety of analyses and publications prepared by the EXTRA project;
- <http://cordis.lu/transport/src/project.htm>, which provides the project objectives and summary results as compiled by the RTD project teams.

The other Sections of this paper can help you to gain an overall picture of the human factors theme, associated policy issues and the objectives for RTD.

The analysis in this paper is the responsibility of the EXTRA project team, and does not represent the official viewpoint of the European Commission.

2. SCOPE OF THEME

2.1 Definition of human factors

The use and operation of means of transport always involves human individuals. This is often an interactive process, and is strongly influenced by “human factors” such as professional training and behavioural responses.

Human factors can refer to impacts on individuals who are directly concerned with transport system, such as drivers and operators. In this context, an important area is the working conditions of employees. Conversely, human factors also refer to the impacts of human behaviour on the performance of transport systems.

Human factors are strongly linked to the themes of safety, efficiency and social impacts of transport.

2.2 Topics included in the theme

Human factors cover a broad range of topics related to all modes within the transport sector.

Human performance in the transport system

- organisation and operation of traffic information and control centres
- operator (driver, pilot) capabilities
- automatic and semi-automatic vehicle control
- working across multi-modal and multi-country transport chains.

Working conditions

- human machine interfaces
- ergonomics, visibility
- safety and efficiency
- driver behaviour.

Technical and safety standards/regulations

- displays
- signalling and VMS (variable message signs)
- licensing
- training
- operational features.

Specific attention has to be given to the different cultures within Europe and hence the different human behavioural responses.

2.3 Significance of the theme

Driver behaviour is the most significant factor in accidents, responsible for over 45,000 persons killed and 1,600,000 injuries per year in the European transport system. The external costs as a consequence of these fatalities are estimated to be 50 - 85 billion Euros per year.

Human factors and the working conditions within the transport system are of decisive importance for the efficiency and safety of transport in Europe. An efficient transport system is considered to be essential for economic development and therefore for the prosperity of Europe. Transport provides services for industries and individuals to facilitate the production and distribution of goods and services. Moreover, transport itself represents a major economic activity and source of employment within Europe. These economic issues have positive benefits for quality of life, accessibility and social cohesion.

Further development of transport systems and transport policy now is guided by the long-term goal of sustainable development, where economic, environmental and social aspects are all taken into consideration – including human factors in its widest sense.

However, behavioural responses can be a limiting factor in the introduction of new policy approaches. Technological innovations depend on public and worker acceptance, while theoretically-beneficial measures designed to elicit a behavioural response (such as road pricing) will not be politically feasible if consumers and industry show strong resistance.

3. POLICY CONTEXT

3.1 Policy objectives related to the theme

Human factors within transport systems play an important role in defining policy options, and are directly or indirectly addressed in various EU papers dealing with transport policy:

- In the 1992 White Paper on the future development of the Common Transport Policy (CTP), sustainable mobility is addressed in terms of “*transport systems that will provide services efficiently and safely under the best social conditions....*”. The Paper underlines the necessity of considering human factors.
- In the Common Transport Policy Action Programme 1995-2000, CTP goals are formulated as follows. “*The economic well-being of citizens and businesses and social cohesion in Europe is to a considerable extent based on an efficient, accessible and competitive transport system which reconciles the need for mobility meeting user's needs with the imperatives of ensuring a high level of safety and of protection of the environment.*”
- The Green Paper “The Citizens’ Network” defines the role of the European Union *to inform, to promote and to enable public passenger transport*, but notes that *the decision has to be done on a local, regional or national level*. The EC supports this objective by RTD into human aspects.
- The Green Paper “Fair and Efficient Pricing” notes that *the external costs of transport, and as part hereof costs of transport fatalities, are strongly linked to human factors and safety, and therefore part of recommended pricing*.
- Within the White Paper “Towards a New Maritime Strategy”, the Commission requires the future maritime strategy on securing the competitiveness of EC shipping sector “*to foster maritime R&D within the current and future Community Framework Programmes, targeted at high technology in safety and environmental protection and human resources.*”
- The White Paper “A Strategy for Revitalising Railways in the Community” underlines the need for “*personnel policies including substantial programmes to retrain redundant workers*”.
- “Freeing Europe’s Airspace” is a White Paper concerned with growing air transport *by a higher grade of automation*.
- The OECD/ECMT is addressing human factors, e.g. through workshops concerning individual travel behaviour, resolutions on safety, etc.
- The EC support for initiatives like the “Road Safety Campaign” is addressing *driver behaviour to reduce fatalities in road transport*.

3.2 Policy issues related to the theme

The importance of human factors in transport policy discussion is growing. There is a realisation that policy options that appear beneficial in principle have to be checked for their feasibility of implementation. Human factors, such as user acceptance and the ability of employees to adopt new technologies and practices, may prove to be a primary constraint.

The integration of human factors is an essential ingredient for the development of sustainable mobility. A key policy target is *to ensure mobility for all citizens of the EU by fair and efficient pricing, increasing safety, improving comfort/efficiency and minimising ecological impacts*. However, the conditions for enabling sustainable mobility, which may differ across Europe, have to be supported by Member States as well as the EU. *Subsidiarity has to be guaranteed and can be in conflict with policy implementation for sustainable mobility*. Cultural differences are often at the source of problems in agreeing a common European approach.

Many policy objectives of the European Union address the human factors considered in this thematic paper. A specific emphasis is given to working conditions, related to the completion of the “Single Market”. The implementation of new technologies and procedures usually requires consideration of human factors.

In the maritime sector, specific attention is being given to research activities on human resource issues. These include *“improved simulation procedures for training, European requirements for the implementation of ISM (International Safety Management Code) and STCW (Standard on Training, Certification and Watchkeeping), as well as communication in a multi-cultural environment.”*

Policy objectives in the rail sector need a substantial consideration *of human elements in technology development as well as in operating procedures*, in order to facilitate the introduction of the European Rail Traffic Management System and improve safety. Similar attention is being given to human factors in the air sector, as Europe seeks to introduce higher levels of automation and new procedures to support future Air Traffic Management systems.

Owing to the complexity of interaction between human factors and other areas, further RTD is required to understand these interconnections and dependencies, and to achieve a more integrated view. For example, well-qualified and motivated employees are essential for an attractive and efficient public transport system, while human factors are still the main cause for fatalities in transport. Therefore these issues are being considered as a side issue in a wide range of RTD projects, as well as in the smaller number of projects that focus specifically on human factors.

4. RTD OBJECTIVES

Human factors are well addressed in the Transport Programme in pursuit of three main RTD targets:

- to improve the working conditions and user friendliness of transport means;
- to improve safety and efficiency of transport systems in relation to all affected individuals (operator, driver, user, non-user);
- to optimise the human machine interface.

These RTD targets are implemented in quite different ways in the different research sectors:

Strategic research

Within this area, human factors are addressed in connection with the formulation of strategies for the introduction of new technologies.

Rail

The emphasis in this area is the development of a safe and efficient European Rail Network with a high degree of interoperability across Member State borders. Topics such as human machine interfaces, ergonomics and the safety aspects of human management are addressed in order to reach the overall objectives in this sector.

Air

The extraordinary growth of air transport is causing increased congestion and inefficiency, with potential consequences for safety. Technical and operational improvements are being targeted. For the development of future ATM (Air Traffic Management), the human role in conjunction with advanced automation has to be investigated. For the improvement of air transport safety and environmental impacts, passenger survivability and human factors in flight operations have to be considered.

Waterborne

Within the objective of strengthening Europe's waterborne transport, the consideration of human factors has a broad dimension. Special emphasis is placed on working conditions, partly to improve safety and efficiency, and also for social reasons. In addition, a specific part of this research area is dedicated to human resources, to illuminate the domain of human error, to develop means to improve ship operations, to reach harmonised levels of Maritime Education and Training, and to improve interfaces with the human element by simulation.

Road

In this sector, human factors are mainly related to safety aspects. Studies have shown that human error is the dominant factor in over two thirds of accidents. Promotion of improvements in passive vehicle safety, standardised visual information, training and legal measures and safety campaigns are related to human factors. A further issue is the assessment of changes in driver behaviour resulting from the introduction of in-vehicle safety devices. The Transport Telematics Application Programme additionally is concerned with human factors. Various specific factors are addressed, such as human machine interfaces and ergonomics.

5. SUMMARY OF RESEARCH CLUSTERS

5.1 Overview

The RTD projects contributing to the human factors theme can be considered within eight clusters, each relating to one of the three main RTD target areas identified in Section 4.

The research on human factors is focused in three main areas:

- *Improved working conditions and user friendliness*
- *Increased safety and efficiency*
- *Optimised human machine interface*

All identified areas have strong interdependencies. Specific attention is given to HMI (human machine interfaces). Requirements for HMI are always combined with improvements in working conditions, safety and efficiency.

In this paper, the RTD projects in FP4 contributing to the understanding of human factors are considered within eight topic areas or “clusters”. These clusters are:

Clusters

Education/qualification and training

Human role

Technology acceptance

Driver/operator behaviour

Automation

Information management

Operational procedures

Retaining skills

5.2 RTD clusters

This Section defines the scope of research in each cluster. More specific objectives are given in Section 6. The titles and objectives of relevant RTD projects are listed in Annex 1, together with a Table identifying the cluster(s) to which each project contributes most strongly.

Education/qualification and training

In the area of *education/qualification and training*, research aims to harmonise the working conditions and education/qualification standards of staff within Europe. The main activities in this area are in the waterborne and air sectors.

Human role

The research area on the *human role* considers the actual and future role of employees in the transport sector. Research is concentrated on the waterborne and air transport sectors.

Technology acceptance

The area of *technology acceptance* covers all modes and deals primarily with the introduction of new technologies into the transport sector. Technology acceptance by individuals is an important success factor for the implementation of new technologies. Special attention has to be paid to cultural differences.

Driver/operator behaviour

In the area of *driver/operator behaviour*, the research aims to reduce human and organisational error, which are the main reasons for fatalities in transport.

Automation

The area of *automation* research aims to increase the efficiency and safety of transport. The introduction of automation has major impacts on employees, such as their working environment and requirements for skills.

In addition, ergonomics aspects are addressed, defining general requirements for the introduction of new technological components. This can include requirements concerning visibility, noise protection, and handling, e.g. in the specification of system tests for ERTMS.

Information management

The area of *information management* research aims to improve human-machine interactions. The emphasis is on the application of advanced telematics technologies. The research often makes use of simulators and demonstration facilities.

Operational procedures

In the area of *operational procedures*, research is aimed at determining new requirements for operations staff and improving the working environment. Optimised human-machine interactions and interfaces are of specific interest to ensure safe and efficient operation.

Retaining skills

Research into *retaining skills* investigates the necessary skills of staff to meet future requirements of advanced technologies and operational procedures.

6. SYNTHESIS OF FINDINGS FROM COMPLETED PROJECTS

This Section provides a synthesis of the research objectives and main findings from completed projects for each of the RTD clusters defined in Section 5. The key results, policy implications and achievements of individual projects are summarised in Annex 2.

Results from the following projects have been included in the current version of this thematic paper:

| Clusters | Sector | Relevant RTD projects |
|---|-----------------------------|-------------------------------------|
| <i>Education/qualification and training</i> | <i>Waterborne transport</i> | FSEA, HANDIAMI, MASSTER, METHAR |
| | <i>Air</i> | CAST |
| <i>Human role</i> | <i>Waterborne transport</i> | THALASSES |
| | <i>Air</i> | RHEA, SRATM |
| <i>Technology acceptance</i> | <i>Strategic research</i> | HINT, WORKFRET |
| | <i>Waterborne transport</i> | |
| <i>Driver/operator behaviour</i> | <i>Waterborne transport</i> | ATOMOS II, BERTRANC, CASMET, MARCOM |
| | <i>Air</i> | ECOTTRIS |
| | <i>Rail</i> | HUSARE |
| <i>Automation</i> | <i>Air</i> | CAST |
| | <i>Rail</i> | ERTMS Tests |
| <i>Information management</i> | <i>Air</i> | DEFAMM, GORAC, SAMS |
| | <i>Rail</i> | ERTMS Tests |
| | <i>Waterborne transport</i> | RINAC |
| <i>Operational procedures</i> | <i>Air</i> | ECOTTRIS, RHEA |
| | <i>Rail</i> | ERTMS Tests |
| | <i>Waterborne transport</i> | |
| <i>Retaining skills</i> | <i>Air</i> | ECOTTRIS, RHEA |
| | <i>Waterborne transport</i> | THALASSES |

6.1 Education/qualification and training

Research objectives

Objectives in this area are:

- to establish a common level of knowledge about impact assessment methods for ship transport and develop a risk analysis for European maritime transport, with emphasis on human factors;
- to develop common solutions for harmonising the training curricula and qualification of ships' staff, and adapting training courses to introduce advanced technologies;
- to specify ship's manoeuvres and operations to be exercised in simulators;
- to provide a framework of recommendations for the selection and training of air traffic controllers, suitable for their future working environment.

Main findings

In the waterborne sector a concerted action on formal safety and environmental assessment of ship operations produced an analysis of the integration of the human and organisational factors in safety and environmental assessments. Recommendations for improved crew training focused on better awareness of elderly and disabled passengers aboard vessels, and – on the other hand – proposed a bottom-up approach towards harmonisation of MET syllabi for seafarers. Both were based on the existing Standards of Training, Certification and Watchkeeping for Seafarers (STCW 95).

A further study highlighted simulator training exercises, e.g. for high speed vessels, on management aspects, or on the introduction of advanced bridge displays. Hence, a methodology for the development of operational and training scenarios, and the corresponding required exercises with particular focus on human factors related training was elaborated. The related comprehensive catalogue of scenarios, now provided as a Microsoft Access database, allows for searching of the whole set of training objectives, function levels and defined competences along the STCW 95 guideline.

Various considerations focused on integrated and harmonised training for all aspects of shipping and port operations by using advanced simulators and mutually recognising certificates and (national) regulations, in general paving the way for easier transition of seafarers from ship to shore. It is understood that measures are required to counteract the declining interest in job careers in the maritime sector, e.g. by looking at successful national approaches towards attracting young people to seafaring.

Future cognitive job profiles for air traffic controllers (ATCOs) were developed, in terms of intellectual processes, reference knowledge, relational interaction and relation to time and space. The main output were detailed and practical guidelines for designing ATCO training with respect to upcoming Air Traffic Management (ATM) systems. The guidelines incorporate all recent developments and trends in instructional theory and technology, computer based training and simulation.

6.2 Human role

Research objectives

Objectives in this area are:

- to define functional requirements for the role of human operators in future ATM systems and for automation assistance tools;
- to assess the socio-economic impacts of new technological concepts in maritime transport

on the human element on board;

- to compile an inventory of adverse factors and their effects on the physical and psychological characteristics of crews in maritime transport, and to recommend tools and models to be adopted for the design of new ships and for the improvement of existing ones.

Main findings

In waterborne transport human centred system design approaches – building on experience from other industries – were identified as a positive factor for job satisfaction of seafarers. In particular new technologies meant to enhance safety and working conditions are much easier accepted by crews than those aiming at customer demand and cost effectiveness. As a consequence a computer based training tool targeting the adaptation of crews to ECDIS tactical bridge displays was developed, which significantly helps to improve navigational safety.

It became clear that the impact of new technologies on human operators is very much context specific, which needs to be considered in further research. Integrated concepts and their application have considerable effects on Maritime Education and Training (MET) schemes, however it has to be stressed that the perception of socio-economic impacts of specific new technologies differs widely between maritime students and experienced ship officers.

The operational success of Human Machine Interfaces (HMI) in Air Traffic Management (ATM) systems led to a classified list of evaluation methods and techniques, targeting the work allocation between humans and machines, with outlined criteria such as safety, workload, usability, performance, situational awareness, knowledge use and complexity. 17 presented ATM scenarios and test situations were reflecting this, considering cognitive activities like communication, monitoring, planning, decision-making and negotiation. Furthermore an evaluation of 7 selected automation concepts that address the man/machine interface in Air Traffic Control (ATC) were performed. For several ATC environments the dynamic aircraft delegation and cognitive (assistance) tools were found most promising. Simulation runs in local working environments at major air traffic control centres provided significant knowledge about the positive effects of novel ATC systems on operators' stress, strain and workload. Man-in-the-loop trials helped to validate the effectiveness and usability of new technology in addressing the anticipated growth in air traffic and its effects on working conditions for controllers.

6.3 Technology acceptance

Research objectives

Objectives in this area are:

- to identify the characteristics of existing working cultures that affect intermodal freight transport;
- to determine the human factor and safety implications of new transport system technologies;
- to identify the impacts of new port technologies;
- to review existing knowledge on the acceptance and degree of acceptability of new technologies by operators and to survey the attitudes of relevant social partners;
- to recommend actions to prepare transport workers for technological and procedural changes;
- to recommend how to increase the likelihood of acceptance of new technologies;
- to develop a European strategy for managing the impacts of technologies likely to be

implemented over the next 10 - 20 years.

Main findings

Recommendations on the appropriate distribution of responsibilities for upcoming new technologies among equipment manufacturers, vehicle manufacturers, aftermarket suppliers, purchasing agencies, contractors, installers and users, were articulated in a formal statement of responsibility by the EU. Introduced guidelines at international and EU level, addressing obligations and responsibilities of involved stakeholders, shall help to improve and encourage the implementation of new technologies. Prompting suppliers and system integrators to self-certificate and subsequently test their products to outlined standards, covering human and organisational issues, is assumed to foster acceptance of innovative processes.

Changing 'working cultures', organisational structures and management structures in European intermodal freight transport were reviewed and analysed. The impact of new technologies was found to be significant for the number of employed workers, their working conditions, the quality of jobs, the time pressure dictated by efficiency considerations and the membership to trade unions. New logistics and production systems were highlighted with respect to reliability, integration, flexibility and cost reduction, and their impacts on 'working cultures'. A total of twelve policy areas addressing the barriers faced by intermodal developments were identified, comprising:

- the size of the freight sector work force, labour regulations, payment; social security, education and training, health and work safety, recruiting, organisational structures, behavioural codes, bargaining, employee and trade union involvement, and the general promotion of intermodal transport.

6.4 Driver/operator behaviour

Research objectives

Objectives in this area are:

- to demonstrate new communication methods to improve maritime safety;
- to review existing safety procedures, develop a common methodology to investigate maritime accidents, and develop a maritime version of the Confidential Hazardous Incident Reporting Programme;
- to improving the understanding of human elements related to accidents;
- to investigate international rules and regulations applying to bridge design and equipment and provide recommendations for the design of integrated ship control systems;
- to define a common method for evaluating and improving staff management in order to increase safety and reliability for European cross-border railway lines;
- to provide a framework of recommendations for the selection and training of air traffic controllers;
- to promote the development of non technical skills for flight crews, e.g. situation management;
- to identify training requirements for flight crews to enable the application of advanced technologies.

Main findings

In maritime operations a conceptual standard for Ship Control Centre (SCC) design, including layout recommendations for future ship bridges, was introduced that takes account of a harmonised Human-Machine Interface (HMI).

Accident and incident investigation in shipping has historically relied on self-standing technical databases but has widely neglected the human operator's contribution. The frequent

shortcoming in taking into account Human and Organisational Errors (HOE), or an inadequate treatment of these issues, was therefore addressed. A comparison of maritime accident investigation procedures outside Europe, and schemes employed in other industries, such as aviation, nuclear and off-shore operations, was found very helpful in this respect.

Now first remedial tools related to the human element in improving maritime safety, based on the implementation of a positive safety culture, that would draw on experience in other transport sectors – such as air and rail – have been identified. For future accident investigation a common, European-level, comprehensively structured, and thoroughly maintained maritime accident database is strongly recommended, that needs to adequately cover human elements as well.

The most important aspects of human factor related accident causes in waterborne transport are language deficiencies of multi-cultural crews and resulting misunderstanding. An in-depth study has revealed various examples of incidents and accidents related to communication problems in open seas or under pilotage, covering both ship to shore and on board communication. Besides language proficiency itself, peculiar habits and principal cultural differences do contribute to safety critical situations. Results from this detailed analysis point at the need to harmonise maritime English language education on the one hand, but more importantly to consider language and cultural issues for the selection and recruitment of ship crews on the other hand.

The transition from conventional to state-of-the-art "glass cockpits" in current civil aircraft was addressed through an accident and incident review, identifying factors related to automation/glass cockpits and poor transition training of crews. An in-depth investigation of glass cockpits skills, identifying seven different "skill-groups" relating to three principal types of individual behaviour, i.e. knowledge-based, rule-based and skill-based behaviour, was additionally performed. The outcome were recommendations for a "Crew Resource Management (CRM) for glass cockpits" booklet, containing a set of real-life incident scenarios, highlighting the need for proper CRM in glass cockpit environments.

The management of human factors in rail operations was thoroughly analysed based on eight test scenarios for hazards related to cross-border rail operations under typical, degraded and emergency situations. Suggestions for possible generic risk reduction measures are now available, based on the analysis of the specific test scenario. A practical toolkit of techniques for railway operators was developed which features the following aspects:

- data collection, comparison techniques and documentation forms for rules, procedures and operational practices, in order to identify differences in rail infrastructures and connected human factors issues; and
- human factor analysis techniques, to identify possible human errors, available failure recovery measures and risk reduction strategies.

6.5 Automation

Research objectives

Objectives in this area are:

- to elaborate human elements of the ERTMS (European Traffic Management System) to ensure safe and efficient cross-border rail transport;
- to identify the consequences for air traffic controller selection and training deriving from the automation strategy for future systems.

Main findings

Reviews of current selection criteria were performed as a baseline for deriving future Air Traffic Controller (ATCo) selection criteria, taking account of foreseen changes in ATM systems. Detailed and practical guidelines for designing ATCo training were brought up with respect to upcoming ATM systems, which incorporate all recent developments and trends in instructional theory and technology, computer-based training and simulation.

For the rail sector a harmonised European Train Control System (ETCS) is mandatory to ensure reliability, availability, maintainability and safety of increasingly automated train operations. To enable the desired interoperability and automation, a wide set of interface specifications between the elements of the system was reviewed, and subsequently trialed at commercial rail lines in three major European countries.

6.6 Information management

Research objectives

Objectives in this area are:

- to develop demonstration facilities for Airport Movement Guidance, Control and Management;
- to develop airport simulation facilities to enable tests of Airport Movement Guidance, Control and Management elements in order to define functional and operational requirements;
- to assess a new ground collision avoidance system and develop certification requirements for required system redundancy with regard to new human-machine interfaces
- to prepare an ERTMS simulation on a demonstrator;
- to assess the use of advanced technologies on inland waterways, together with the harmonisation of human-machine interfaces and control devices.

Main findings

In aircraft operations, one of the most urgent needs is to support cockpit crews in monitoring critical in-flight situations that result from close proximity to other vehicles or ground obstacles. Various collision avoidance systems are currently used or under development. The validation of new approaches to meet European Joint Airworthiness Requirements (JAR) is being covered by RTD initiatives. Large-scale implementation of Ground Collision Avoidance Systems (GCAS) is foreseen, once regulatory and certification requirements have been established. Automatic on-board alert systems that warn pilots and at the same time give guidance on possible countermeasures are expected to relieve crews from increasing workloads in congested skies.

Demonstrations of an Advanced Surface Movement Guidance and Control System (A-SMGCS) were implemented at four European airports, including the first large-scale demonstrator at Cologne/Bonn. A modular and open system architecture was built which can be used as a guideline for possible follow-on projects and realisation of a large-scale A-SMGCS implementation. Experience gained so far may be regarded as a basic guideline for on-going and future projects when making the step from demonstration to prototype systems. Various tools for information handling of airport surface operations were embedded in an A-SMGCS platform, integrating human/machine interfaces (HMI) with a cockpit simulator and a tower simulator. Man-in-the-loop simulation runs evaluated the benefits and technical feasibility of a multi-site, real-time platform, in particular highlighting the use of expensive simulation components that are typically scattered across several European research facilities.

Feedback from controllers and pilots provided evidence that identification and warning features are highly appreciated by controllers and voice communication is experienced as quite vital and valid. Planning features were not accepted by controllers because time and effort is needed to agree with the system on a common plan, but guidance features, whether ground based or on board, have been highly appreciated by pilots.

The interoperability of the planned European Train Control System (ETCS) was addressed by thoroughly looking at required technical system specifications in compliance with the Reliability, Availability, Maintainability and Safety (RAMS) documentation. Regular CD-ROMs were introduced to disseminate all important information to relevant stakeholders and actors in the rail sector.

For the waterborne sector an integrated architecture for information, navigation and communication systems on-board vessels was elaborated. Typical current communication situations aboard vessels were addressed, analysing tactical, strategic and fairway information needs. Recent developments in terrestrial and satellite based communication were reviewed to help define a dedicated 'communication layer'. In addition the new concept of River Information Services (RIS) was assessed.

6.7 Operational procedures

Research objectives

Objectives in this area are:

- to define functional requirements for the possible role of human operators in future Air Traffic Management systems;
- to develop improved operational procedures and training requirements for airline crews to support the transition from conventional to high technology cockpits;
- to optimise the human elements in human-machine interfaces and interactions to improve the safety of ships in emergency situations;
- to test and evaluate the operation of ERTMS on various test sites.

Main findings

An in-depth investigation of glass cockpits skills, identifying seven different "skill-groups" relating to three principal types of individual behaviour, i.e. knowledge-based, rule-based and skill-based behaviour was undertaken. The investigation was performed by distributing a targeted questionnaire to glass cockpit pilots in Europe; the most important skill-groups found in the evaluation related to knowledge of automation and decision-making. Finally, recommendations for a "Crew Resource Management (CRM) for glass cockpits" booklet, containing a set of real-life incident scenarios, highlighting the need for proper CRM in glass cockpit environments were promoted.

The evaluation of selected automation concepts that address the man/machine interface in Air Traffic Control (ATC) helped to draft requirements on automation of ATM reflecting on the two main dimensions automation related issues, and basic controller functions.

A set of specifications for testing the foreseen European Rail Traffic Management System (ERTMS) was elaborated, including scenarios for demonstration sites in different countries, and three contracts for pilot and demonstration sites on major commercial rail lines across Europe were agreed on.

6.8 Retaining skills

Research objectives

Objectives in this area are:

- to identify and evaluate functions that currently play a role in Air Traffic Management and add those ones that might become of interest in the future, e.g. human operator performance;
- to develop a proposal for an acceptable means of promoting non-technical skills in air transport;
- to produce a skill and training analysis in relation to accident and incident analysis in air traffic;
- to analyse the changes in the crew's role as a result of the introduction of new technologies and to assess improvements in ship operation through improved human-machine interfaces.

Main findings

The transition from conventional to "glass cockpits" was targeted by identifying seven different "skill-groups" relating to three principal types of individual behaviour, i.e. knowledge-based, rule-based and skill-based behaviour; the investigation was performed by distributing a targeted questionnaire to glass cockpit pilots in Europe. The most important skill-groups found in the evaluation related to knowledge of automation and decision-making. Recommendations for a "Crew Resource Management (CRM) for glass cockpits" booklet, containing a set of real-life incident scenarios, highlighting the need for proper CRM in glass cockpit environments in this context.

In the course of the implementation of future Air Traffic Management (ATM) scenarios and test situations a set of cognitive activities like communication, monitoring, planning, decision-making and negotiation were considered. This was accompanied by the evaluation of selected automation concepts that address the man/machine interface in Air Traffic Control (ATC).

Adapting and training ship crews on new technology tactical bridge displays ("ECDIS") is a major task, that was tackled by developing a computer based training tool, which helped to significantly improve navigational safety. Indeed, all technological innovation related to Maritime Educational Training (MET) needs to be seen in the context of the STCW 95 framework. Integrated concepts and their application have considerable effects on MET schemes, however it has to be stressed that the perception of socio-economic impacts of specific new technologies differs widely between maritime students and experienced ship officers.

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ANNEX 1 RTD PROJECTS CONTRIBUTING TO THE THEME

This Annex lists the titles and objectives of RTD projects relevant to the theme of human factors. The following Table identifies the RTD cluster(s) to which each project contributes significantly.

| Clusters | Sector | Relevant RTD projects |
|---|-----------------------------|-------------------------------------|
| <i>Education/qualification and training</i> | <i>Waterborne transport</i> | FSEA, HANDIAMI, MASSTER, METHAR |
| | <i>Air</i> | CAST |
| <i>Human role</i> | <i>Waterborne transport</i> | REWORD, THALASSES |
| | <i>Air</i> | RHEA, SRATM |
| <i>Technology acceptance</i> | <i>Strategic research</i> | ACCEPT, HINT, WORKFRET |
| | <i>Waterborne transport</i> | WORKPORT |
| <i>Driver/operator behaviour</i> | <i>Waterborne transport</i> | ATOMOS II, BERTRANC, CASMET, MARCOM |
| | <i>Air</i> | ECOTTRIS, JAR TEL |
| | <i>Rail</i> | HUSARE |
| <i>Automation</i> | <i>Air</i> | CAST |
| | <i>Rail</i> | ERTMS Tests |
| <i>Information management</i> | <i>Air</i> | DEFAMM, GORAC, SAMS |
| | <i>Rail</i> | ERTMS Tests |
| | <i>Waterborne transport</i> | RINAC |
| <i>Operational procedures</i> | <i>Air</i> | ECOTTRIS, RHEA |
| | <i>Rail</i> | ERTMS Tests |
| | <i>Waterborne transport</i> | MASIS II |
| <i>Retaining skills</i> | <i>Air</i> | ECOTTRIS, JAR-TEL, RHEA |
| | <i>Waterborne transport</i> | THALASSES |

| Project acronym | Title | Objective(s) |
|------------------------|---|--|
| ACCEPT | Action concerning acceptance of new technologies and procedures in transport | The main objective of this concerted action is to review and pool together existing knowledge on the acceptance of new technologies and ways to measure the degree of acceptance. It will provide recommendations for actions to prepare transport workers for technological and procedural changes as well as to increase the acceptance by operators and other workers. |
| ATOMOS II | Advanced technology to optimise maritime operational safety, integration and interfaces | The aim is to develop conceptual standards for a safe and efficient ship control centre and an open integrated ship control system. The aim will be towards fast cost-effective operation and interconnection between system modules for improved command, control, alarm and information systems. |
| BERTRANC | Methodology of safety in marine operations | The aim is to improve maritime safety by gaining a thorough understanding of the existing safety procedures and methodologies currently employed by Member States; and by gaining an appreciation of other transport systems and modes of operation that could be employed in the maritime sector. |
| CASMET | Casualty analysis methodology for maritime operations | This project is concerned with establishing a common methodology for safety in maritime operations and for analysing the impact of the human element on maritime safety. |
| CAST | Consequences of future ATM systems for air traffic controller selection and training | The main objective of the CAST project is to identify the consequences for future selection and training of air traffic controllers due to the new working environment, functions and system automation strategy. In particular, the change in tasks will be addressed, and a framework provided for future selection and training processes. In addition, the transition phase will be investigated. As an output, illustrative examples for future selection and training will be presented. |
| DEFAMM | Development of demonstration facilities for airport movement guidance control and management | The main objective of the DEFAMM project is to demonstrate the major AMGCM functions with real facilities in a near-operational environment. Based on existing requirements and tested technologies and subsystems, the demonstration scenarios, systems and facilities will be defined. Key results will be validated and system functions and draft procedures tested at 4 airports for improved safety and efficiency. |
| ERTMS Tests | ERTMS test preparation | The project addresses the full range of preparation activities leading to full-scale trial tests of the European Rail Traffic Management System in a number of pilot sites to be located in France, Germany and Italy. This includes the functional, system and subsystem specification as well as an overall safety concept. Aspects on ergonomics and automation will be addressed. |
| FSEA | Concerted action on formal approaches to risk assessment for sea-borne transport in European waters | The Concerted Action aims to establish a common level of knowledge within European shipping of systematic methods to assess the levels of safety and the environmental impact of shipping. Further, the action |

| Project acronym | Title | Objective(s) |
|-----------------|--|--|
| | | deals with the risk associated with human factors. The project will bring together experts from all relevant parties involved in European shipping, to establish a unique knowledge on the subject. |
| GORAC | GCAS operational requirements and certification | The main objectives of the GORAC project are to identify the requirements for a Ground Collision Avoidance System (GCAS), and to elaborate acceptable certification requirements and procedures utilising a terrain database, predictive algorithms and introducing a new human-machine interface. |
| HANDIAMI | Investigation of the employment of disabled persons in the maritime industry e.g. new shore based jobs and the problems of disabled passengers in access and emergency situations. | The main objectives of the HANDIAMI project are: <ul style="list-style-type: none"> • to undertake a detailed comparative analysis of the level of existing provisions for disabled passengers in the maritime and other transport sectors; • to develop introductory training material for managers and staff in the maritime industry; • to promote the employment and retention of disabled maritime workers; • to highlight any safety specific issues that impact on ship design, operation and training. |
| HUSARE | Human safe rail in Europe - managing the human factor in multi-cultural and multi-lingual rail environments | The main objective of this project is to establish a common method for evaluating and improving human management in order to increase safety and reliability for European cross-border railway lines. A risk based approach will be adopted to ensure that the effort associated with standardising rules and operational procedures will be directed at those aspects of railway operations which are most critical in terms of the risks that could arise if human errors occur. |
| JAR TEL | Joint Aviation Regulations - translation and elaboration of legislation | The main objective of the JAR TEL project is to improve human factors related requirements laid down in JAA regulations. This could be done by a proposal for a harmonised application of these rules, which could be laid down in an Acceptable Means of Compliance (AMC). The project finalises testing work not finished in the previous NOTECHS project. |
| MARCOM | The impact of multi-lingual and multi-cultural crewing on maritime communications | The main objective is the achievement of successful communications and the related improvement in maritime safety, through the provision of language training packages and guidelines on shipboard management. |
| MASIS II | Human element in man/machine interface and interaction to improve safety and effectiveness of transport for the European fleet | The main objective is the improvement of human behaviour and performance on board ships, particularly in an emergency. Practical tools and procedures will be developed for effective man/machine interfaces so as to reduce the impact of the human element in marine accidents. |
| MASSTER | Maritime standardised simulator training exercises register | The aim is to harmonise maritime education and aid the standardisation of simulator exercises. |
| METHAR | Harmonisation of European | The aim is to contribute to the improvement of maritime |

| Project acronym | Title | Objective(s) |
|------------------------|---|--|
| | MET Schemes | education and training standards in Europe. |
| REWORD | Research for enhancement of work conditions aboard ships | The REWORD project aims at improving understanding of the influence of the ship's environment on crews and passengers. Observations in simulated conditions and during full-scale sea trials form an important part of the project. The project will contribute to the inclusion of human element specifications in ship design, operation and management. |
| RHEA | Role of the human in the evolution of ATM systems | The main objective of the RHEA project is to provide automation strategies to guide systematically the decision process for automating functions in an Air Traffic Management System of the future. Based on currently important functions within ATM, future ones will be identified in qualitative and quantitative terms. In addition, the future functional requirements of human operators and automation assistance tools will be addressed. |
| RINAC | River based information, navigation and communication | The project seeks to identify the functional requirements for the introduction of a control centre on board an inland navigation vessel that integrates shore-based radar and transponder systems. |
| SAMS | SMGCS airport movement simulator | The main objectives of the SAMS project are to design and develop a platform for a real time, man in the loop A-SMGCS evaluation including the test and demonstration of new support tools and new procedures in all weather conditions. For evaluation the Heathrow and Schiphol airports will be used, as well as the 747 simulator. |
| SRATM | Stress reduction, safety and efficiency in future ATM through flight progress information | The main objective of the project is to measure the stress and strain of air traffic controllers when using air traffic systems with future technology. Real-time simulations will include two different ATM systems and controllers from three European countries to assess whether stress reduction is achieved as planned. |
| THALASSES | Evaluation of the impacts of new technologies in maritime transport in the human element through the creation of a constructive technology assessment network | The THALASSES project will assess the impacts of new technologies on the human element in maritime transport. It includes: <ul style="list-style-type: none"> • a 'working cultures' approach to allow an evaluation of the changes induced in terms of work content, workload, safety, job security and job satisfaction; • socio-economic cost-benefit analysis; • identification of trends in technology. |
| WORKFRET | Working cultures in the face of intermodal freight transport systems | The aim is to contribute to the development of an efficient freight transport system in Europe, taking into account the interests and requirements of the people who actually operate them. |
| WORKPORT | Work organisation in ports | Relentless technological innovation continues to change the port work environment with far-reaching implications for work organisation and management. WORKPORT aims to assess the impact of new |

Project acronym

Title

Objective(s)

technology on the port work environment and to consider the application of new organisational and management concepts to meet new demands for ports.

ANNEX 2 MAIN FINDINGS FROM COMPLETED RTD PROJECTS

This Annex summarises the findings from completed projects for which the Final Report has been approved or made available (in alphabetic order of project acronyms). Project web page references are provided where known. Summaries of all projects are available from the two web sites given in Section 1 of this paper.

Index of available RTD project results:

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Project acronym and title**ATOMOS II:**

Advanced Technology to Optimize Maritime Operational Safety, Integration and Interface

Key results and policy implications**KEY RESULTS**

ATOMOS II has produced:

- a conceptual standard for Ship Control Centre (SCC) design, including layout recommendations for future ship bridges, and a so-called 'tactical display' combining anti-grounding and anti-collision information tools;
- an Advanced Information Processing;
- the verification of the conceptual standard for SCC design in relation to efficiency (cost-benefit analysis) and safety, performing a risk assessment for collision route and fire ignition scenarios;
- a conceptual standard for Integrated Ship Control (ISC) systems;
- a harmonised Human-Machine Interface (HMI);
- a standardised process network; and
- a conceptual standard for ISC Systems versus interoperability and interconnectivity.

The project website can be found at <http://www.atomos.org>

POLICY IMPLICATIONS

The project's brought up conceptual standard for SCC design and contributions to the ISC standard have provided the called-for framework and standard architecture. Appraisal of key output documents from the ATOMOS II project by the chairman of the current IEC (International Electrotechnical Commission) working group on the standardisation of ship bridges has been very positive and found the results visionary.

BERTRANC:

Methodology of Safety in Marine Operations

KEY RESULTS

BERTRANC has:

- held ten meetings of experts in the so-called Concerted Action Committee (CAC);
- analysed and assessed current working practices and methodologies for accident investigation, which commonly are based on setting up self-standing accident/incident databases;
- identified best practice examples for training of accident investigators, found considerably varying among EU member states;
- identified best practice examples of methodologies for accident investigation, which have been synthesised into a guideline document, that compares various experts' opinions;
- defined a framework to adopt the aviation Confidential Hazardous Incident Reporting Programme (CHIRP) for maritime accident investigation;
- drafted guideline documents addressing the requirements for accident data gathering and obtaining vessel and traffic statistics, respectively;
- specified a pan-European Common Maritime Accident Investigation Methodology, building on a complementary framework for data collection and analysis; and
- identified remedial tools related to the human element in improving maritime safety, based on the implementation of a positive safety culture, that would draw on experience in other transport sectors, such as air and rail.

POLICY IMPLICATIONS

The BETRANC concerted action has outlined three major in-depth tasks to be considered in the 5th Framework Programme. Firstly, a pilot project to test the CHIRP concept has been proposed, focusing on incident reporting rather than just analysing maritime accidents. A further proposal targeted the training of accident investigators, based on a pilot scheme of an Open Flexible Learning (OFL) approach. Finally, a study has been suggested concentrating on the human factor in maritime and other accidents. The basic idea has been to allow accident investigators to understand and assess the human element, drawing on a database set up to provide the suitable questions required for analysis.

Project acronym and title**Key results and policy implications****CASMET:****Casualty Analysis Methodology for Maritime Operations****KEY RESULTS**

CASMET has:

- carried out a critical assessment of current (European) practices for maritime accident investigation and analysis;
- found existing practices for casualty investigation considerably varying, even though common features could be identified as well;
- discovered a frequent shortcoming in taking into account Human and Organisational Errors (HOE), or an inadequate treatment of these issues, respectively;
- compared maritime accident investigation procedures outside Europe, and schemes employed in other industries, such as aviation, nuclear and off-shore operations;
- described a comprehensive methodology for accident recording and analysis, while in a complementary step a structure for coding information in a database was elaborated;
- tested and validated the project's approach by considering a set of typical accident scenarios and occurred, well documented casualties, that had been attributed to technical as well as HOE factors; and
- performed a simplified cost-benefit analysis aimed to assess the actual benefits of implemented risk reduction measures, however with respect to a rather limited availability of significant cost figures.

POLICY IMPLICATIONS

One of the key findings from CASMET is that a common, European-level, comprehensively structured, and thoroughly maintained maritime accident database is strongly recommended. Such a database would allow for the detailed individual assessment and analysis of accidents, as well as the statistical evaluation of the entire casualty record.

CAST:**Consequences of future ATM systems for air traffic controller selection and training****KEY RESULTS**

CAST has produced:

- a description of the future cognitive job profile for air traffic controllers (ATCOs), in terms of intellectual processes, reference knowledge, relational interaction and relation to time and space;
- a review of current selection criteria as a baseline for deriving future ATCO selection criteria, taking account of foreseen changes in ATM systems, identifying general requirements (e.g. medical, age, education, national obligations, security), cognitive abilities (e.g. memory, problem solving/reasoning, prioritising/filtering information, mathematical/ mental arithmetic, scanning/vigilance/monitoring, perception/spatial ability, multi-tasking, communication) and personality characteristics (e.g. personal relations, thinking style, emotions, teamwork and flexibility) as primary issues;
- a selection process model, structured in the three stages pre-filtering (general requirements), pre-selection (cognitive criteria) and finally selection, to ensure picking those candidates that are most suited to deliver their cognitive abilities in specific job related situations; and
- detailed and practical guidelines for designing ATCO training with respect to upcoming ATM systems. The guidelines incorporate all recent developments and trends in instructional theory and technology, computer based training and simulation.

POLICY IMPLICATIONS

The generic future ATCO training design, integrating theory and practice, brought up by the project will lead to a shortened duration of on-the-job training for air traffic control personnel. While implementing future ATM systems, ATCO training will have to integrate team training aspects and teamwork changes as proposed in the course of the

Project acronym and title**Key results and policy implications****DEFAMM:****Demonstration facilities for airport movement management**

CAST project.

KEY RESULTS

DEFAMM demonstrations of A-SMGCS (Advanced Surface Movement Guidance and Control System) have been implemented at four European airports including the first large-scale A-SMGCS demonstrator in Cologne/Bonn. A modular and open system architecture has been built which can be used as a guideline for possible follow-on projects and realisation of a large-scale A-SMGCS implementation. The experience gained from DEFAMM may be regarded as a basic guideline for on-going and future projects when making the step from demonstration to prototype systems.

Feedback from controllers and pilots have provided the following evidence:

- identification and warning features have been highly appreciated by controllers because they can be implemented without disturbing their current working habits;
- voice communication is experienced as quite vital and valid even if data on certain aircraft accidents might prove the opposite;
- planning features have not been accepted by controllers because time and effort is needed to agree with the system on a common plan; and
- guidance features, whether ground based or on board, have been highly appreciated by pilots

Insight has been provided on the acceptance of a tool by controllers based on the acceptance of functions in the controller's mental model (relating to organisation of work, identification of which tasks to execute and how). Three types of functions are identified:

- those forming a backup for functions the controller is already executing;
- those forming new elements in the model and very helpful to use;
- those requiring completely new working habits.

The first two are easily accepted, the third type is hardly accepted. The combined use of the following three strategies is suggested to achieve success:

- invent only functions which can be easily implemented;
- slowly change and expand the controller's mental model;
- change the regulations under which the controller works.

POLICY IMPLICATIONS

A specific issue for future gate-to-gate co-ordination of air traffic is the additional investigation with respect to the planning functions. These functions cannot be provided by the A-SMGCS if the related interaction with the system is not accepted by the controllers. The controller's new role and working habit in an A-SMGCS supported environment will only be accepted if a compatible transition training is performed. Preparation and performance of controller training shall be a key issue for future projects.

The experience gained in DEFAMM will be used to industrialise the prototype subsystems that were demonstrated in order to perform the next step towards operationally serviceable subsystems.

ECOTTRIS:**European Collaboration on Transition Training Research for Improved Safety****KEY RESULTS**

ECOTTRIS has produced:

- an accident and incident review, identifying factors related to automation/glass cockpits and poor transition training of crews;
- an in-depth investigation of glass cockpits skills, identifying seven different "skill-groups" relating to three principal types of individual behaviour, i.e. knowledge-based, rule-based and skill-based behaviour; the investigation was performed by distributing a targeted questionnaire to glass cockpit pilots in Europe; the most important skill-groups found in the evaluation related to knowledge of automation and decision-making;
- an assessment of current training and transition activities at prominent airlines

Project acronym and title**Key results and policy implications**

(British Airways, Lufthansa) and the aircraft manufacturer Airbus;

- recommendations for a "Crew Resource Management (CRM) for glass cockpits" booklet, containing a set of real-life incident scenarios, highlighting the need for proper CRM in glass cockpit environments;
- an assessment of PC-based simulation software by performing tests with sample pilots from British Airways and later evaluating feedback by means of a questionnaire; and
- a set of specific recommendations concerning training content, training methods and the associated training media.

POLICY IMPLICATIONS

The project's results – in particular the detailed set of recommendations for pilot training and performance – will be used to enhance future transition training initiatives for glass cockpit pilots. The transition of crews from conventional or hybrid cockpits to state-of-the-art glass cockpits (with the underlying automation process) will influence working conditions to a considerable extent and thus have to be addressed in coming studies on human factor related safety of flight operations.

ERTMS Tests:***KEY RESULTS*****ERTMS Proof of Feasibility and Preparation of Tests**

ERTMS Tests has produced:

- a System Requirement Specification (SRS), which describes all technical details and integrates the Reliability, Availability, Maintainability and Safety (RAMS) documentation;
- a set of specifications for testing the system, including scenarios for demonstration sites in different countries;
- three contracts for pilot and demonstration sites, taking account of the need to upgrade existing commercial lines; the selected trial sites comprised an approx. 40 km long TGV link between Paris CDG airport and Tournan (SNCF), an approx. 40 km long section of the Berlin – Halle/Leipzig main line (DB), and a 70 km long high speed line between Arezzo and Firenze (FS);
- regular CD-ROMs to disseminate all project results to relevant stakeholders and actors.

POLICY IMPLICATIONS

The project's results contribute to the implementation of the whole ERTMS/ETCS concept by proofing the feasibility of new common approaches towards rail traffic management systems. From elaborating all relevant technical specifications the project helped bridge the gap to pilot and demonstration applications of existing railway environments.

FSEA:***KEY RESULTS*****Concerted action on Formal Safety and Environmental Assessment of ship operations**

The FSEA Concerted Action has:

- produced an evaluation of the current state-of-the-art of present methodologies, including in particular the following:
 - Formal Safety Assessment methodology, which is seen as a valuable tool for establishing a general overview of risks and risk control, covering people, property and the environment, for rule-making purposes,
 - the Green Award System which emphasises the environmental aspects in particular; compliance with (inter)national laws and regulations, technical and operational standard on-board the individual ship and management standard on-shore are audited and scored,
 - the International Marine Safety Rating System (IMSRS) which constitutes an approach based on management system audits and physical condition checks

**Project acronym
and title****Key results and policy implications**

- human and organisational factors assessment, in which several approaches were identified, mainly concentrating in human errors on the one hand and emphasising the importance of management and environment on the other hand;
- produced an analysis of the integration of the human and organisational factors in safety and environmental assessments; and
- ascertained that a common safety and environmental assessment approach needs to be further developed and identified a number of areas within this framework in which research and development is also necessary, in particular risk acceptance criteria, risk management, risk communication, organisational changes, human and organisational factors and databases to provide relevant data for the common approach.

The project website can be found at <http://www.germanlloyd.org/fsea>

POLICY IMPLICATIONS

The Concerted Action recommends to focus on the development of a common approach to safety and environmental assessment, common to all major actors, and consisting of several complementary suitable methods to be applied according to the user needs, rather than a single common methodology.

The crucial step to succeed concerning the common approach is that of obtaining a profound understanding of the decision problems and needs within shipping involving all actors. Collaboration should therefore be promoted with the range of relevant actors at European as well as national and international level to understand the decision mechanisms in shipping and the kind of assessments needed.

GORAC:**GCAS operational
requirements and
certification****KEY RESULTS**

GORAC has produced:

- specifications for possible Ground Collision Avoidance Systems (GCAS) simulation facilities and identification of five suitable simulators in France, Germany and the Netherlands that apply both to validation requirements and the necessary implementation verification;
- a survey of applicable existing specifications and regulations, in particular following European Joint Airworthiness Requirements (JAR), and the determination of regulatory gaps linked to GCAS features;
- proposals for validation methods, seeking compliance with certification requirements, for the three main areas of data base integrity, dynamic algorithms and HMIs, which address the interaction between cockpit crews and GCAS visual and aural outputs;
- guidelines for GCAS data base certification, specified for Terrain Elevation Data Bases, Obstacle Data Bases and Airport Runway Data Bases; and
- a preliminary regulation document for the "Preparation of the Certification Requirements" which describes the certification methodology for GCAS and proposes corresponding Means of Compliance.

POLICY IMPLICATIONS

The project has set the framework for establishing regulatory and certification requirements to be included in JAA's airworthiness requirements to ensure large-scale implementation of GCAS in commercial aircraft. This effort can be seen in the context of several new developments addressing in-flight safety, e.g. like the Traffic Alert and Avoidance System (TCAS).

In co-operation with aviation authorities, the EC's R&D initiatives will contribute to increased flight safety while coping with rapidly growing overall air traffic.

Project acronym and title**Key results and policy implications****HANDIAMI:**

An investigation into the problems of disabled passengers in access and emergency situations when using marine transport and the employment of disabled persons in the maritime industry

KEY RESULTS

HANDIAMI has produced:

- the first scientific overview of specific needs of disabled people with a surprisingly blunt set of pragmatic and cheap to implement suggestions for change in design and operation of vessels;
- an outline of demographic findings underlining the growing relevance of addressing the needs of disabled passengers as a major target group, e.g. in cruise travel, thereby highlighting the sound economic basis of desired modifications;
- recommendations for improved crew training focused on better awareness of elderly and disabled passengers onboard vessels with reference to existing Standards of Training, Certification and Watchkeeping for Seafarers (STCW 95);
- an overview of obstacles preventing quick and efficient evacuation of disabled passengers; recommendations on how to overcome those barriers, and a qualitative appraisal of associated costs if considered from the initial stage in the design process of ships;
- an assessment of re-employment opportunities for disabled seafarers, leading to the conclusion that a switch to shore-based jobs, in maritime or related sectors, remains most likely due to inevitable safety constraints; only a dramatic shortfall in the supply of seafarers might create the possibility of re-employing disabled crew members; and
- a comparison of equal opportunities in employment in land-based jobs shows that this issue is widely neglected in the maritime industry.

The project website can be found at <http://www.solent.ac.uk/handiami/>

POLICY IMPLICATIONS

Three aspects as discussed in the study may benefit from actions to be initiated by the EU. The exchange of information and experience between, for example, disability organisations and technical experts (ship designers, naval architects, and lawyers) should be facilitated. Secondly existing and effective IMO recommendations on addressing the needs of elderly and disabled people should be enhanced and promoted. Finally the anticipated shortfall in the supply of seafarers may offer some opportunities for re-employment of crew members with impaired fitness if safety, operational and organisational regulations are slightly adapted.

JAR TEL:

Joint Aviation Regulations – Translation and Elaboration of Legislation

The final results of this project were not available when this Thematic Paper was prepared.

HINT:

Human Implications of New Technologies

KEY RESULTS

HINT has produced:

- a strategic approach towards effective technology watch related to feeding into standards development, information provision to the legislative process, and influencing of research;
- a tactical approach at application level to cover human and organisational issues by:
 - introducing guidelines at international and EU level addressing obligations and responsibilities of involved stakeholders for upcoming new technologies,
 - encouraging and enforcing the recommended procedures – involving system suppliers and integrators to certificate their products and services – on a national (legislative) level,

**Project acronym
and title****Key results and policy implications**

- ensuring compliance with best practice experience at regional and local level through tendering procedures where suppliers have to prove their qualification and their compliance with current standards, regulations and procedures,
- prompting suppliers and system integrators to self-certificate and subsequently test their products to outlined standards;
- recommendations on the appropriate distribution of responsibilities among equipment manufacturers, vehicle manufacturers, aftermarket suppliers, purchasing agencies, contractors, installers and users, articulated in a formal statement of responsibility by the EU; and
- recommendations on stimulating actions, triggered by the EU, for data collection and failure investigation in order to identify, in particular, safety problems of new technologies.

POLICY IMPLICATIONS

The study's findings highlight the need to further encourage public/private partnerships on regional and local level to promote the implementation of new technologies in transport service. The related organisational changes have to be backed and enforced by policy actions. More important, a co-ordinated approach at EU level is needed to harmonise the pace of technology innovation in the transport sector and the connected regulatory process.

HUSARE:**Human Safe Rail in Europe (Managing the Human Factor in Multicultural and Multilingual Rail Environments)*****KEY RESULTS***

HUSARE has produced:

- selected human factor analysis techniques which were applied to eight test scenarios comprising hazards related to cross-border rail operations under typical, degraded and emergency situations;
- a practical toolkit of techniques for railroad operators including the following main features: (a) data collection, comparison techniques and documentation forms for rules, procedures and operational practices, in order to identify differences in rail infrastructures and connected human factors issues, (b) human factor analysis techniques, to identify possible human errors, available failure recovery measures and risk reduction strategies; and
- suggestions for possible generic risk reduction measures, based on the analysis of the specific test scenarios.

POLICY IMPLICATIONS

The main output of the study was the practical toolkit for the management of human factors related risks in cross-border rail operations. Responsibility for the actual use of this toolkit lies with the European railway companies who need to ensure safe operations. Dedicated (policy) measures to promote the implementation of the toolkit and to foster its introduction as a common European rail standard should be promoted.

MARCOM:**The Impact of Multicultural and Multilingual Crews on Maritime Communication*****KEY RESULTS***

MARCOM has:

- studied language and misunderstanding from a socio-linguistic point of view;
- gathered examples of incidents and accidents related to communication problems in open seas or under pilotage, covering both ship to shore and on board communication;
- investigated into the importance of language and cultural issues for the selection and recruitment of ship crews, based on a survey of ship operators' views;
- analysed observations – attributed to misunderstanding, peculiar habits and cultural differences – of vessels under pilotage, made by researchers and pilots themselves, respectively;

**Project acronym
and title****Key results and policy implications**

- analysed specific patterns of ship to ship and ship to shore communication, the latter involving Vessel Traffic Services (VTS) meant to reduce the potential for ambiguity;
- studied communication at the social level, meaning the actual communication difficulties among multicultural and multilingual crew, hinting at principal aspects of social life aboard ships;
- highlighted education and training requirements for basic and maritime English based on feedback from questionnaires, that had been distributed to maritime colleges;
- analysed the background of English teachers in maritime institutions, the origin of current syllabi, and issues such as motivation to learn a language, course contents, available material for preparation of manuscripts and books, tools for teaching (e.g. computers, videos, internet access, etc.), and the assessment of the exit levels at the end of courses;
- made recommendations on how to integrate modern teaching tools, like those mentioned above, and in particular the use of internet resources, into updated educational schemes; and
- produced the outline of an up to date pilot syllabus for the teaching of maritime English, based on the latest rules and standards as communicated by the International Maritime Organization (IMO).

POLICY IMPLICATIONS

The project's findings support the conclusion that one single syllabus for maritime English is unlikely to cover all the needs identified in the specific seafarers' context. The basis for improvements is seen in sharing and adopting best practice curricula and material, and in choosing a modular approach towards comprehensive syllabi for teaching maritime English.

Taking into account the rapidly changing maritime environment, owed to commercial aspects, globalisation and constantly evolving standards and regulations, those future syllabi will have to allow for regular updates in an easily accessible way.

**MASIS II:
Human Element in
Man/Machine
Interface and
Interaction to
Improve Safety and
Effectiveness
Transport for the
European Fleet**

The final results of this project were not available when this Thematic Paper was prepared. The project website can be found at
http://www.isl.org/english/text/projekt/project.show.php?p_num=2189&lang=en

**MASSTER:
Maritime
Standardised
Simulator Training
Exercises Register**

KEY RESULTS

MASSTER has:

- prepared an overview of existing simulators – both full-mission and part-task types –, their capabilities, foreseen future developments, simulator availability and suitability for desired training schemes;
- listed training objectives based on the Standards of Training, Certification and Watchkeeping for Seafarers (STCW 95) guideline;
- highlighted simulator training exercises, addressing STCW 95 objectives and additional training objectives, e.g. for high speed vessels, on management aspects, or about the introduction of advanced bridge displays, such as ECDIS;
- elaborated a methodology for the development of operational and training scenarios, and the corresponding required exercises with particular focus on human factors related training;

Project acronym and title**Key results and policy implications**

- developed sample assessment tools supplementing the set of assessment criteria connected to training objectives, as initially identified; and
- developed a comprehensive catalogue of scenarios, provided as a Microsoft Access database, which allows for searching of the whole set of training objectives, function levels and defined competences along the STCW 95 guideline.

The project website can be found at http://www.issus.fh-hamburg.de/iss_web/masster/

POLICY IMPLICATIONS

The project MASSTER has build on experience from the METHAR project, which had been preparing harmonised European curricula reflecting the STCW 95 requirements. Hence, MASSTER was a major step in ensuring the implementation of STCW 95 conventions in EU member states and outside the community. The latter aspect must not be neglected because tendencies towards moving training programmes to low wages countries tend to put the successful implementation of STCW standards at risk.

METHAR:**Harmonization of European Maritime Education and Training Schemes****KEY RESULTS**

METHAR has produced:

- recommendations to foster mobility of seafarers by mutual recognition of certificates and (national) regulations;
- proposals to improve the attractiveness of the maritime industry and its public image concerning safety and environmental protection;
- an analysis of the contributing factors for the declining interest in job careers in the maritime sector, and has proposed to look at successful national approaches towards attracting young people to seafaring (e.g. in France, the Netherlands and Norway);
- proposals for a bottom-up approach towards harmonisation of MET syllabi based on the requirements of the STCW 95 (Standards of Training, Certification and Watchkeeping) convention;
- recommendations to intensively use advanced simulators in MET schemes, and to ensure access of participants from all 15 involved countries to those facilities;
- an proposal to establish a European institution for maritime lecturers and the promotion of international cooperation of lecturers such as exchange programmes;
- considerations on the transition from ship to shore, as often desired by employees, in terms of integrated and harmonised training on all aspects of shipping and port operations.

POLICY IMPLICATIONS

The project's findings highlight the need for political intervention to improve the use of existing MET resources in terms of the number of Europe-wide institutions, the applicable training standards, and the range of covered activities in comprehensive MET schemes.

REWORD:**Research for Enhancement of work conditions aboard ships**

The final results of this project were not available when this Thematic Paper was prepared.

RHEA:**Role of the Human in the Evolution of ATM Systems****KEY RESULTS**

RHEA has produced:

- an overview of conclusions from literature surveys to be used by a wider audience, such as the operational success of Human Machine Interface (HMI) enhancements and machine aided evaluation, the current testing of co-operative tools and dynamic

**Project acronym
and title****Key results and policy implications**

allocation, and the finding that complete automation happens to fail before complete simulation does;

- a classified list of evaluation methods and techniques, targeting the work allocation between humans and machines, with outlined criteria such as safety, workload, usability, performance, situational awareness, knowledge use and complexity;
- a presentation of 17 ATM scenarios and test situations considering cognitive activities like communication, monitoring, planning, decision-making and negotiation;
- an evaluation of 7 selected automation concepts that address the man/machine interface in Air Traffic Control (ATC): controller as supervisor, machine proposal strategy, machine-aided evaluation, dynamic allocation with human delegation, dynamic allocation with machine delegation, dynamic aircraft delegation and cognitive (assistance) tools, which have been found most promising for several ATC environments; and
- requirements on automation of ATM reflecting on the two main dimensions automation related issues, and basic controller functions.

POLICY IMPLICATIONS

The project's results have provided a framework on ATM automation allowing for predictions about the achievable success when implementing particular automation concepts. Further validation of the RHEA framework on the evaluation of automation concepts is necessary. A real time simulation of the four most promising automation concepts – cognitive tools, dynamic allocation with human delegation, machine-aided evaluation, and machine proposal – is recommended. Fast time simulations could be carried out as well in order to gain more accurate information about the most promising ATM automation concepts.

RINAC:**River based
Information,
Navigation and
Communication*****KEY RESULTS***

RINAC has produced:

- an integrated architecture for information, navigation and communication systems on-board vessels, introducing four main building blocks: user layer, application layer, distribution layer and communication layer;
- a review of River Information Services (RIS) as defined in the course of the INCARNATION project; RIS comprise the functional definition of information flows, distinguishing between tactical and strategic traffic images at the user level;
- an overview of the typical current communication situation aboard vessels, analysing tactical, strategic and fairway information needs; recent developments in terrestrial and satellite based communication have been reviewed to help define the RINAC communication layer;
- an inventory of requirements in data management focusing on the development of inland Electronic Chart Display Information Systems (ECDIS), reviewing recent activities in Austria, Germany, the Netherlands and France, and providing input for the definition of the distribution layer;
- an overview of requirements of the Human Machine Interface (HMI), decomposed to two levels (tactical and strategic information);
- an overview of present training and certification requirements for skippers of inland water vessels; and
- recommendations on future education and training of personnel onboard inland water ships and the certification requirements for equipment providing enhanced information services to improve safety and efficiency.

POLICY IMPLICATIONS

The project has delivered an architecture on information, navigation and communication systems on-board inland ships, discussing it on a rather theoretical

Project acronym and title**Key results and policy implications**

level. The proposed equipment should be field tested to evaluate true improvements in collaboration between the vessel and the RIS environment. Further investigations are recommended to analyse the effects on workload and operator performance as a basis for one-man operation, when combining radar equipment and ECDIS.

SAMS:**SMGCS Airport Movement Simulator****KEY RESULTS**

SAMS has produced:

- brought up the so-called SAMS platform: an Advanced Surface Movement Guidance and Control System (A-SMGCS) integrating human/machine interfaces (HMI) with a cockpit simulator and a tower simulator, both backed by several datalinks providing all relevant information for real-world simulation;
- performed simulations with the A-SMGCS platform at Amsterdam-Schiphol and London-Heathrow airports, with interconnection to DERA's LATCH aircraft simulator at Bedford, UK and DLR's ATS tower simulator at Braunschweig, Germany;
- gathered a variety of comments, observations and proposals for improvement of involved simulation tools from potential end users, such as air traffic controllers and pilots. Feedback covered handling aspects of new components (HMI), technical and operational issues, and the principle realism and transferability of performed simulations; and
- evaluated benefits and technical feasibility of an A-SMGCS multi-site, real-time, man-in-the-loop simulation platform, in particular highlighting the use of expensive simulation components that are typically scattered across several European research facilities.

POLICY IMPLICATIONS

The availability of a simulation platform – capable of integrating various simulation tools for man-in-the-loop runs – is considered vital for further research and development on novel surveillance, guidance and control systems for surface traffic at airports. The SAMS project has established a first such platform, which should be the basis for future activities aiming at increased safety and efficiency in airport surface traffic. More in-depth evaluation and assessment of advanced SMGCS should be based on the SAMS experience, as well as taking into account perceived shortcomings of this novel approach.

SRATM:**Stress reduction, safety and efficiency in future ATM through flight progress information****KEY RESULTS**

SRATM has:

- performed measurements in local working environments at ATC centres in Budapest and Athens, with 41 operators participating;
- conducted corresponding simulation runs with 42 controllers from Hungary, Greece and Germany, to provide a representative comparison with the measurements;
- found that new technology ATC systems show a general good tendency to reduce stress, strain and workload for controllers, in particular for an assumed traffic increase of 50%;
- indicated that – owing to the expected traffic increase in the future – strain and workload for controllers will be higher than today, and only partly compensated by the introduction of advanced ATC systems; and
- validated state-of-the-art air traffic simulation tools, and found a good reflection of real-life working conditions with respect to physiological measurements, fast time simulation and subjective strain measurements.

POLICY IMPLICATIONS

Backed by the findings from SRATM, further evaluation, validation and eventual implementation of future ATC systems will be able to rely on modern simulation tools.

Project acronym and title**Key results and policy implications**

In the overall context of enhancements to air traffic management, studies to broaden the knowledge about the effects of new ATC technology on controllers' strain and workload are considered valuable. SRATM has set up the methodological and scientific framework for such in-depth investigation.

THALASSES:**New Technologies in Maritime Transport Interacting with the Human Element Assessment of Impacts****KEY RESULTS**

THALASSES has:

- identified human centred system design – building on experience from other industries – as a positive factor for job satisfaction of seafarers;
- developed a framework assessment tool comprising Preference Analysis (SPA), Multi Criteria Analysis (MCA) and the Social Impact Table (SIT), and validated it;
- found that new technologies meant to enhance safety and working conditions are much easier accepted by crews than those aiming at customer demand and cost effectiveness;
- developed a computer based training tool targeting the adaptation of crews to ECDIS tactical bridge displays, which significantly help to improve navigational safety;
- stated that technology innovations related to Maritime Educational Training (MET) need to be seen in the context of the STCW framework.

POLICY IMPLICATIONS

From the findings of THALASSES it became clear that the impact of new technologies on human operators is very much context specific, which needs to be considered in further research. Integrated concepts and their application have considerable effects on MET schemes, however it has to be stressed that the perception of socio-economic impacts of specific new technologies differs widely between maritime students and experienced ship officers.

WORKFRET:**Working Cultures in the Face of Intermodal Freight Transport Systems****KEY RESULTS**

WORKFRET has:

- reviewed and analysed 'working cultures', and organisational and management structures in current European (intermodal) freight transport;
- identified and assessed the impacts of new technologies in freight transport on the number of employed workers, their working conditions, the quality of jobs (e.g. a shift to more high skill jobs), the time pressure dictated by efficiency considerations and the membership to trade unions;
- highlighted new logistics and production systems – with respect to reliability, integration, flexibility and cost reduction – and their impacts on the initially defined working cultures;
- produced a ranking of ten key issues in the development of freight transport systems;
- analysed five national case studies for the implementation of specific technological and/or organisational developments;
- identified twelve policy areas addressing the barriers faced by intermodal developments, namely: the size of the freight sector work force, labour regulations, payment; social security, education and training, health and work safety, recruiting, organisational structures, behavioural codes, bargaining, employee and trade union involvement, and the general promotion of intermodal transport; and
- derived a set of ten policy suggestions based on identified problem areas and policy fields.

POLICY IMPLICATIONS

Based on the outlined topics for policy action and the suggestions derived, the

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implementation of measures needs to be specified in further research studies, in particular focusing on social impacts of organisational and operational changes in the freight transport sector.

WORKPORT:

**Work organisation in
ports**

The final results of this project were not available when this Thematic Paper was prepared. The project website can be found at http://hermes.civil.auth.gr/workport/left_frame.html